

From Chief Editor's Desk



Dear Readers,

I am very happy to present the third edition of Agriculture Today Yearbook 2010. The huge response received for the Year Book in the last two years from all sections of the readers was quite overwhelming for us, and which inspired us to work on the 3rd edition. I am grateful to all the readers for their continued support and encouragement to Agriculture Today. With their patronage, the magazine has today emerged as the voice of stake-holders in agriculture. The magazine is not only creating awareness and opinions and providing effective link to the stake holders in the agriculture system at the national level, but also influencing policies, related to agriculture and agribusiness.

Like the earlier editions, the Year Book 2010 also contains a pool of informative articles, contributed by most eminent persons in Indian agriculture. As we all have realized in the past few years that achieving or creating grounds for sustaining Food security has become a prime need of the country. This issue focuses and implements its strategy to create awareness among us. Articles on various topics are presented in a lucid way for better reading. Data and analysis is juxtaposed through out the Book, balancing the presentations of the contents.

I whole heartedly thank all the eminent persons for their contributing informative and time relevant articles for the Year Book. These are the pearls that we have beaded together to shape this Year Book. I hope that the Year Book will serve as a useful guide and reference material to all those related to the agriculture sector, including Government officials, policy makers, scientists, agribusiness companies, NGOs, institutions, agri researchers, professionals, planners etc.. Despite our best efforts, I realize that there is still scope for further improvement and we shall better our efforts in the next edition.

I request all the esteemed readers to lend their valuable support by way of sending comments and suggestions. I promise to continuously improve and come out next edition, further better in quality and contents in our strive to reach new heights and continuously live up to the expectations of our readers.

At the end, I would like to thank our beloved Prof. M.S. Swaminathan, Pioneer of India's Green Revolution, for his constant encouragement and support. I may also like to thank the entire Agriculture Today team, especially, Ashima Colvin and Abdul Rehman for their untiring efforts in completion of this year book.

With best wishes

M.J. Khan

Major Concerns

*You take those pictures in your mind
Skin draped over mere skeletons,
The mother giving up her food to keep children alive,
Watching as most of the crops she harvest are exported to countries who can afford it.
Let them absorb you
As you run to Wendy's for a burger.
Think now of how easy it is for you to be filled,
Think now of those 798 million starving people- they are your brothers, your sisters-*

*The world is your family
And you are ignoring them.*

*I hope their faces haunt you
Every time you
Crack open a box of cereal
Cram a handful of cookies down your throat.
I hope you choke
On the way you ignore your family*

Like I said, its hard to swallow

*I hope you do something.
I hope you do it now.*

*So, Come on! Fellow leaders
Give up our greed and our egos
For a better earth without poverty and hunger
And the best future of our children*

FOOD SECURITY

A long Term Perspective



Food Security

The World Food Summit of 1996 defined food security as existing “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life”. Commonly, the concept of food security is defined as including both physical and economic access to food that meets people’s dietary needs as well as their food preferences.

Food security is built on three pillars:

- Food availability: sufficient quantities of food available on a consistent basis.
- Food access: having sufficient resources to obtain appropriate foods for a nutritious diet.
- Food use: appropriate use based on knowledge of basic nutrition

and care, as well as adequate water and sanitation.

Food security is a complex sustainable development issue, linked to health through malnutrition, but also to sustainable economic development, environment, and trade. There is a great deal of debate around food security with some arguing that:

- There is enough food in the world to feed everyone adequately; the problem is distribution.
- Future food needs can - or cannot - be met by current levels of production.
- National food security is paramount - or no longer necessary because of global trade.
- Globalization may - or may not - lead to the persistence of food insecurity and poverty in rural

communities.

Issues such as whether households get enough food, how it is distributed within the household and whether that food fulfils the nutrition needs of all members of the household show that food security is clearly linked to health.

Agriculture remains the largest employment sector in most developing countries and international agriculture agreements are crucial to a country’s food security. Some critics argue that trade liberalization may reduce a country’s food security by reducing agricultural employment levels. Concern about this has led a group of World Trade Organization (WTO) member states to recommend that current negotiations on agricultural agreements allow developing coun-

tries to re-evaluate and raise tariffs on key products to protect national food security and employment. They argue that WTO agreements, by pushing for the liberalization of crucial markets, are threatening the food security of whole communities.

"The analysis points to the misleading nature of the concept of subsistence as Malthus originally used it and as it is still widely used today. Subsistence is not located at the edge of a nutritional cliff, beyond which lies demographic disaster. Rather than one level of subsistence, there are numerous levels at which a population and a food supply can be in equilibrium in the sense that they can be indefinitely sustained. However, some levels will have smaller people and higher normal mortality than others."

Global water crisis-

Water deficits which are already spurring heavy grain imports in numerous smaller countries, may soon do the same in larger countries, such as China or India. The water tables are falling in scores of countries (including Northern China, the US, and India) due to widespread overpumping using powerful diesel and electric pumps. Other countries affected include Pakistan, Afghanistan, and Iran. This will eventually lead to water scarcity and cutbacks in grain harvest. Even with the overpumping of its aquifers, China is developing a grain deficit. When this happens, it will almost certainly drive grain prices upward. Most of the 3 billion people projected to be added worldwide by mid-century will be born in countries already experiencing water shortages. After China and India, there is a second tier of smaller countries with large water deficits—Afghanistan, Algeria, Egypt, Iran, Mexico, and Pakistan. Four of these already import a large share of their grain. Only Pakistan remains self-sufficient. But with a population expanding by 4 million a year, it will also likely soon turn to the world market for grain.

Land degradation-

Intensive farming often leads to a

vicious cycle of exhaustion of soil fertility and decline of agricultural yields. Approximately 40% of the world's agricultural land is seriously degraded. In Africa, if current trends of soil degradation continue, the continent might be able to feed just 25% of its population by 2025, according to UNU's Ghana-based Institute for Natural Resources in Africa.

Land deals-

Rich governments and corporations are buying up the rights to millions of hectares of agricultural land in developing countries in an effort to secure their own long-term food supplies. The head of the Food and Agriculture Organisation (FAO), Jacques Diouf, has warned that the controversial rise in land deals could create a form of "neocolonialism", with poor states producing food for the rich at the expense of their own hungry people. The South Korean firm Daewoo Logistics has secured a large piece of farmland in Madagascar to grow maize and crops for biofuels. Libya has secured 250,000 hectares of Ukrainian farmland, and China has begun to explore land deals in Southeast Asia.[36] Oil-rich Arab investors, including the sovereign wealth funds, are looking into Sudan, Ethiopia, Ukraine, Kazakhstan, Pakistan, Cambodia and Thailand.

Some countries are using the acquisition of land for agriculture in return for other gains. Egypt is seeking land acquisition in Ukraine in exchange for access to its natural gas. Qatar has plans to lease 40,000 hectares of agricultural land along Kenya's coast to grow fruit and vegetables, in return for building a £2.4 billion port close to the Indian Ocean tourist island of Lamu.

Agriculture-

In other parts of the world a big effect will be low yields of grain according to the World Food Trade Model, specifically in the low latitude regions where much of the developing world is located. From this the price of grain will rise, along with the developing nations trying to grow the grain. Due to this, every 2-2.5% price hike will increase the number of hungry people 1%. And low crop yields is just one of the problem facing farmers in the low latitudes and tropical regions. The timing and length of the growing seasons, when farmers plant their crops, are going to be changing dramatically, per the USDA, due to unknown changes in soil temperature and moisture conditions.

Children-

On 2008-04-29, a UNICEF UK report found that the world's poorest



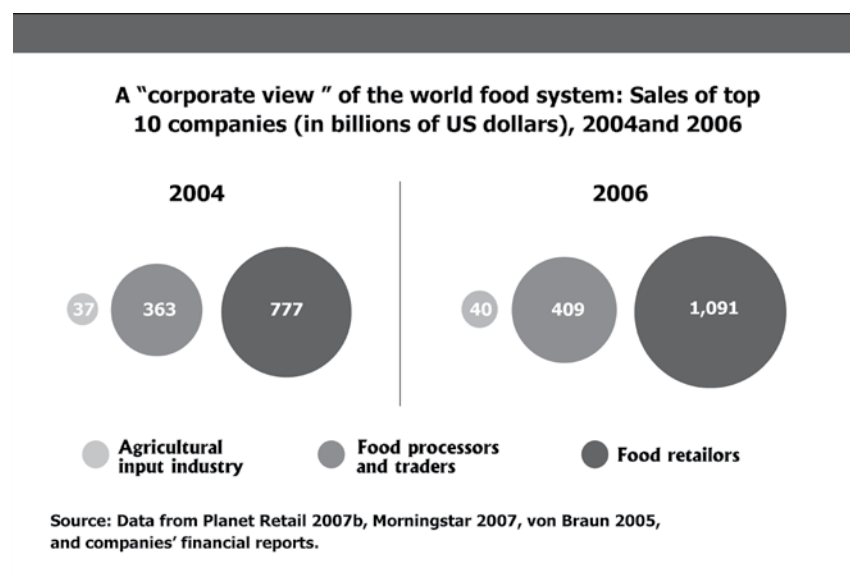
and most vulnerable children are being hit the hardest by the impact of climate change. The report, "Our Climate, Our Children, Our Responsibility: The Implications of Climate Change for the World's Children," says access to clean water and food supplies will become more difficult, particularly in Africa and Asia.

Dictatorship and kleptocracy

As the Nobel Prize-winning economist Amartya Sen has observed that "there is no such thing as an apolitical food problem." While drought and other naturally occurring events may trigger famine conditions, it is government action or inaction that determines its severity, and often even whether or not a famine will occur. The 20th century is full of examples of governments undermining the food security of their own nations—sometimes intentionally.

When governments come to power by force or rigged elections, and not by way of fair and open elections, their base of support is often narrow and built upon cronyism and patronage. Under such conditions "The distribution of food within a country is a political issue. Governments in most countries give priority to urban areas, since that is where the most influential and powerful families and enterprises are usually located. The government often neglects subsistence farmers and rural areas in general. The more remote and underdeveloped the area the less likely the government will be to effectively meet its needs. Many agrarian policies, especially the pricing of agricultural commodities, discriminate against rural areas. Governments often keep prices of basic grains at such artificially low levels that subsistence producers can not accumulate enough capital to make investments to improve their production. Thus, they are effectively prevented from getting out of their precarious situation."

Further dictators and warlords have used food as a political weapon, rewarding their supporters while denying food supplies to areas that oppose their rule. Under such conditions food becomes a currency with



which to buy support and famine becomes an effective weapon to be used against the opposition.

Governments with strong tendencies towards kleptocracy can undermine food security even when harvests are good. When government monopolizes trade, farmers may find that they are free to grow cash crops for export, but under penalty of law only able to sell their crops to government buyers at prices far below the world market price. The government then is free to sell their crop on the world market at full price, pocketing the difference. This creates an artificial "poverty trap" from which even the most hard working and motivated farmers may not escape.

When the rule of law is absent, or private property is non-existent, farmers have little incentive to improve their productivity. If a farm becomes noticeably more productive than neighboring farms, it may become the target of individuals well connected to the government. Rather than risk being noticed and possibly losing their land, farmers may be content with the perceived safety of mediocrity.

As pointed out by William Bernstein in his book *The Birth of Plenty*: "Individuals without property are susceptible to starvation, and it is much easier to bend the fearful and hungry to the will of the state. If a [farmer's] property can be arbitrarily threatened by the state, that power will inevita-

bly be employed to intimidate those with divergent political and religious opinions."

Economic approaches

There are many economic approaches advocated to improve food security in developing countries. The first is typical of what is advocated by most governments and international agencies. The other two are more common to non-governmental organizations (NGO's).

Westernized view

Conventional thinking in westernized countries is that maximizing the farmers profit is the surest way of maximizing agricultural production; the higher a farmer's profit, the greater the effort that will be forthcoming, and the greater the risk the farmer is willing to take.

Place into the hands of farmers the largest number and highest quality tools possible (tools is used here to refer to improved production techniques, improved seeds, secure land tenure, accurate weather forecasts, etc.) However, it is left to the individual farmer to pick and choose which tools to use, and how to use them, as farmers have intimate knowledge of their own land and local conditions.

As with other businesses, a percentage of the profits are normally reinvested into the business in the hopes of increasing production, and hence

increase future profits. Normally higher profits translate into higher spending on technologies designed to boost production, such as drip irrigation systems, agriculture education, and greenhouses. An increased profit also increases the farmer's incentive to engage in double-cropping, soil improvement programs, and expanding usable area.

Food justice-



An alternative view takes a collective approach to achieve food security. It notes that globally enough food is produced to feed the entire world population at a level adequate to ensure that everyone can be free of hunger and fear of starvation. That no one should live without enough food because of economic constraints or social inequalities is the basic goal. This approach is often referred to as food justice and views food security as a basic human right. It advocates fairer distribution of food, particularly grain crops, as a means of ending chronic hunger and malnutrition. The core of the Food Justice movement is the belief that what is lacking is not food, but the political will to fairly distribute food regardless of the recipient's ability to pay.

Food sovereignty

A third approach is known as food sovereignty; though it overlaps with food justice on several points, the two are not identical. It views the business practices of multinational

corporations as a form of neocolonialism. It contends that multinational corporations have the financial resources available to buy up the agricultural resources of impoverished nations, particularly in the tropics. They also have the political clout to convert these resources to the exclusive production of cash crops for sale to industrialized nations outside of the tropics, and in the process to squeeze the poor off of the more productive lands. Under this view subsistence farmers are left to cultivate only lands that are so marginal in terms of productivity as to be of no interest to the multinational corporations. Likewise, food sovereignty holds it to be true that communities should be able to define their own means of production and that food is a basic human right. With several multinational corporations now pushing agricultural technologies on developing countries, technologies that include improved seeds, chemical fertilizers, and pesticides, crop production has become an increasingly analyzed and debated issue. Many communities calling for food sovereignty are protesting the imposition of Western technologies on to their indigenous systems and agency. Those who hold a "food sovereignty" position advocate banning the production of most cash crops in developing nations, thereby leaving the local farmers to concentrate on subsistence agriculture. In addition, they oppose allowing low-cost subsidized food from industrialized nations into developing countries, what is referred to as "import dumping". Import dumping also happens by way of food aid distribution through programs like the USA's "Food for Peace" initiative.

World Food Summit-

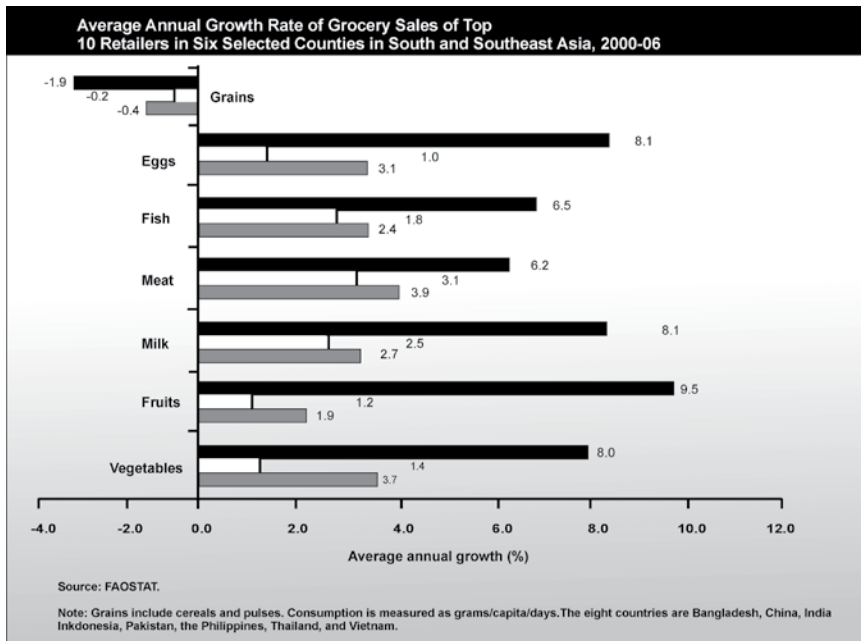
The World Food Summit was held in Rome in 1996, with the aim of renewing glob-

al commitment to the fight against hunger. The Food and Agriculture Organization of the United Nations (FAO) called the summit in response to widespread under-nutrition and growing concern about the capacity of agriculture to meet future food needs. The conference produced two key documents, the Rome Declaration on World Food Security and the World Food Summit Plan of Action. The Rome Declaration calls for the members of the United Nations to work to halve the number of chronically undernourished people on the Earth by the year 2015. The Plan of Action sets a number of targets for government and non-governmental organizations for achieving food security, at the individual, household, national, regional and global levels.

Achieving food security-

The number of people without enough food to eat on a regular basis remains stubbornly high, at over 800 million, and is not falling significantly. Over 60% of the world's undernourished people live in Asia, and a quarter in Africa. The proportion of people who are hungry, however, is greater in Africa (33%) than Asia (16%). The latest FAO figures indicate that there are 22 countries, 16 of which are in Africa, in which the undernourishment prevalence rate is over 35%." In its "The State of Food Insecurity in the World 2003", FAO states that 'In general the countries that succeeded in reducing hunger were characterised by more rapid economic growth and specifically more rapid growth in their agricultural sectors.





riculture the most. (MDG 1 calls for halving hunger and poverty by 2015 in relation to 1990.)

Notably, the gathering of wild food plants appears to be an efficient alternative method of subsistence in tropical countries, which may play a role in poverty alleviation

The agriculture-hunger-poverty nexus

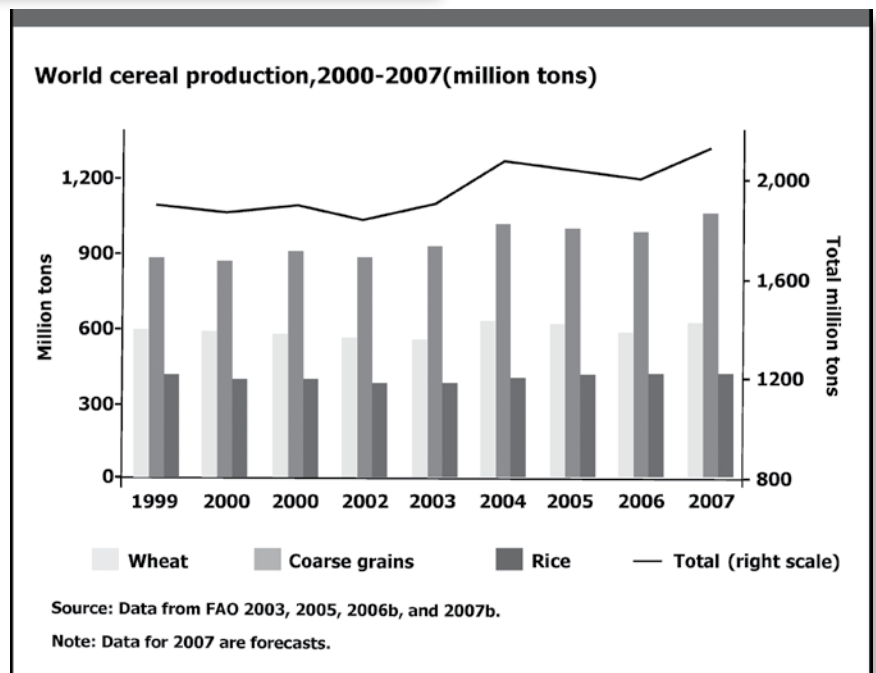
Eradicating hunger and poverty requires an understanding of the ways in which these two injustices interconnect. Hunger, and the malnourishment that accompanies it, prevents poor people from escaping poverty because it diminishes their ability to learn, work, and care for themselves and their family members. Food insecurity exists when people are under-

They also exhibited slower population growth, lower levels of HIV and higher ranking in the Human Development Index'

As such, according to FAO, addressing agriculture and population growth is vital to achieving food security. Other organisations and people (e.g. Peter Singer, ...) too have come to this conclusion and advocate improvements in agriculture, and population control.[55]

USAID[56] proposes several key steps to increasing agricultural productivity which is in turn key to increasing rural income and reducing food insecurity. They include:

- Boosting agricultural science and technology. Current agricultural yields are insufficient to feed the growing populations. Eventually, the rising agricultural productivity drives economic growth.
- Securing property rights and access to finance.
- Enhancing human capital through education and improved health.
- Conflict prevention and resolution mechanisms and democracy and governance based on principles of accountability and transparency in public institutions and the rule of law are basic to reducing vulnerable members of society.



The UN Millennium Development Goals are one of the initiatives aimed at achieving food security in the world. In its list of goals, the first Millennium Development Goal states that the UN "is to eradicate extreme hunger and poverty", and that "agricultural productivity is likely to play a key role in this if it is to be reached on time".

"Of the eight Millennium Development Goals, eradicating extreme hunger and poverty depends on ag-

nourished as a result of the physical unavailability of food, their lack of social or economic access to adequate food, and/or inadequate food utilization. Food-insecure people are those individuals whose food intake falls below their minimum calorie (energy) requirements, as well as those who exhibit physical symptoms caused by energy and nutrient deficiencies resulting from an inadequate or unbalanced diet or from the body's inability to use food effectively be-

cause of infection or disease. An alternative view would define the concept of food insecurity as referring only to the consequence of inadequate consumption of nutritious food, considering the physiological utilization of food by the body as being within the domain of nutrition and health. Malnourishment also leads to poor health hence individuals fail to provide for their families. If left unaddressed, hunger sets in motion an array of outcomes that perpetuate malnutrition, reduce the ability of adults to work and to give birth to healthy children, and erode children's ability to learn and lead productive, healthy, and happy lives. This truncation of human development undermines a country's potential for economic development for generations to come.

There are strong, direct relationships between agricultural productivity, hunger, and poverty. Three-quarters of the world's poor live in rural areas and make their living from agriculture. Hunger and child malnutrition are greater in these areas than in urban areas. Moreover, the higher the proportion of the rural population that obtains its income solely from subsistence farming (without the benefit of pro-poor technologies and access to markets), the higher the incidence of malnutrition. Therefore, improvements in agricultural productivity aimed at small-scale farmers will benefit the rural poor first.

Increased agricultural productivity enables farmers to grow more food, which translates into better diets and, under market conditions that offer a level playing field, into higher farm incomes. With more money, farmers are more likely to diversify production and grow higher-value crops, benefiting not only themselves but the economy as a whole."

Researchers suggest forming an alliance between the emergency food program and CSA Farms, as currently food stamps cannot be used at

farmer's markets and places in which food is less processed and grown locally.]

Biotechnology for smallholders in the (sub)tropics

The area sown to genetically engineered crops in developing countries is rapidly catching-up with the area sown in industrial nations. According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA), genetically engineered (biotech, GM) crops were grown by approximately 8.5 million farmers in 21 countries in 2005, up from 8.25 million farmers in 17 countries in 2004. The largest increase in



biotech crop area in any country in 2005 was in Brazil, provisionally estimated at 44,000 km² (94,000 km² in 2005 compared with 50,000 km² in 2004). India had by far the largest year-on-year proportional increase, with almost a threefold increase from 5,000 km² in 2004 to 13,000 km² in 2005

Current high regulatory costs imposed on varieties created by the more modern methods are a significant hurdle for development of genetically engineered crops well suited to developing country farmers by modern genetic methods. Once a

new variety is developed, however, seed provides a good vehicle for distribution of improvements in a package that is familiar to the farmer..

Apart from genetic engineering, other forms of biotechnology also hold promise for enhancing food security. For instance, perennial rice is being developed in China, which could dramatically reduce the risk of soil erosion on upland smallholder farms.

Risks to food security

Fossil fuel dependence

While agricultural output increased as a result of the Green Revolution, the energy input into the process (that is, the energy that must be expended to produce a crop) has also increased at a greater rate, so that the ratio of crops produced to energy input has decreased over time. Green Revolution techniques also heavily rely on chemical fertilizers, pesticides and herbicides, some of which must be developed from fossil fuels, making agriculture increasingly reliant on petroleum products.

Between 1950 and 1984, as the Green Revolution transformed agriculture around the globe, world grain production increased by 250%. The energy for the Green Revolution was provided by fossil fuels in the form of fertilizers (natural gas), pesticides (oil), and hydrocarbon fueled irrigation. [61]

David Pimentel, professor of ecology and agriculture at Cornell University, and Mario Giampietro, senior researcher at the National Research Institute on Food and Nutrition (IN-RAN), place in their study Food, Land, Population and the U.S. Economy the maximum U.S. population for a sustainable economy at 200 million. To achieve a sustainable economy and avert disaster, the United States must reduce its population by at least one-third, and world population will have to be reduced by two-thirds, says the study.

The oncoming peaking of global oil



production (and subsequent decline of production), along with the peak of North American natural gas production will very likely precipitate this agricultural crisis much sooner than expected.[13] Geologist Dale Allen Pfeiffer claims that coming decades could see spiraling food prices without relief and massive starvation on a global level such as never experienced before.[63]

However, one should take note that, (numbers taken from the CIA World Factbook), the country of Bangladesh achieved food self-sufficiency in 2002 with both a far higher population density than the USA (~1000 inhabitants per square kilometer in comparison to just 30/km² for the USA - so this is more than 30 times as many), and at only a tiny fraction of the USA's usage of oil, gas, and electricity. Also, pre-industrial Chinese mini-farmers/gardeners developed techniques to feed a population of more than 1000 people per square kilometer (cf. e.g. F.H. King's 1911 report, "Farmers of Forty Centuries"). Hence, the dominant problem is not energy availability but the need to stop and revert soil degradation

Hybridization, genetic engineering and loss of biodiversity

In agriculture and animal husbandry, the green revolution popularized the use of conventional hybridization to increase yield by creating "high-yielding varieties". Often the handful of hybridized breeds originated in developed countries and were further hybridized with local varieties in the rest of the developing world to create

high yield strains resistant to local climate and diseases. Local governments and industry have been pushing hybridization which has resulted in several of the indigenous breeds becoming extinct or threatened. Disuse because of unprofitability and uncontrolled intentional and unintentional

cross-pollination and crossbreeding (genetic pollution), formerly huge gene pools of various wild and indigenous breeds have collapsed causing widespread genetic erosion and genetic pollution. This has resulted in loss of genetic diversity and biodiversity as a whole.

Genetically Modified (GM) crops today have become a common source for genetic pollution, not only of wild varieties but also of other domesticated varieties derived from relatively natural hybridization

Genetic erosion coupled with genetic pollution may be destroying unique genotypes, thereby creating a hidden crisis which could result in a severe threat to our food security. Diverse genetic material could cease to exist which would impact our ability to further hybridize food crops and livestock against more resistant diseases and climatic changes

Genetic erosion in agricultural and livestock biodiversity-

Genetic erosion in agricultural and livestock biodiversity is the loss of genetic diversity, including the loss of individual genes, and the loss of particular combinants of genes (or gene complexes) such as those manifested in locally adapted landrac-

es of domesticated animals or plants adapted to the natural environment in which they originated. The major driving forces behind genetic erosion in crops are: variety replacement, land clearing, overexploitation of species, population pressure, environmental degradation, overgrazing, policy and changing agricultural systems.

The main factor, however, is the replacement of local varieties of domestic plants and animals by high yielding or exotic varieties or species. A large number of varieties can also often be dramatically reduced when commercial varieties (including GMOs) are introduced into traditional farming systems. Many researchers believe that the main problem related to agro-ecosystem management is the general tendency towards genetic and ecological uniformity imposed by the development of modern agriculture.

Challenges ahead

India's food security policy has a laudable objective to ensure availability of food grains to the common people at an affordable price and it has enabled the poor to have access to food where none existed. The policy has focused essentially on growth in agriculture production (once India used to import food grains) and on support price for procurement and maintenance of rice and wheat stocks. The responsibility for procuring and stocking of food grains lies with the FCI and for distribution with the public distribution system (PDS). Minimum support price: The FCI procures food grains from the farmers



at the government announced minimum support price (MSP). The MSP should ideally be at a level where the procurement by FCI and the off take from it are balanced. However, under continuous pressure from the powerful farmers lobby, the government has been raising the MSP and it has now become higher than what the market offers to the farmers. Also, with quality norms in the procured grains not strictly observed, farmers pressurise the FCI to procure grains beyond its procurement target and carrying capacity. The MSP has now become more of a procurement price rather than being a support price to ensure minimum production. The rich farmers and traders have cornered most of the benefits under the support price policy. The small farmers lack access to FCI and being steeped in poverty resort to distress selling. Constricted warehousing facility has further aggravated their miseries. At times, the same farmers later pay more to buy it from PDS.

Input subsidies: Over the years, to keep food grain prices at affordable levels for the poor, the government has been imposing restrictions on free trade in food grains. This has suppressed food grain prices in the local market, where the farmers sell a part of their produce and as compensation; they are provided subsidies on agriculture inputs such as fertilizers, power and water. These subsidies have now reached unsustainable levels and also led to large scale inefficiencies in the use of these scarce inputs. Overuse of fertilizer and water has led to water logging, salinity, depletion of vital micronutrients in the soil, and reduced fertility. The high subsidies have come at the expense of public investments in the critical agriculture infrastructure, thereby reducing agriculture productivity. Besides the high MSP, input subsidies and com-

mitted FCI purchases have distorted the cropping pattern with wheat and paddy crops being grown more for the MSP they fetch, despite there being relatively less demand for them. Punjab and Haryana are classic examples here. This has also led to a serious imbalance in inter-crop parities despite no significant increase in the yield of wheat and paddy.

Issue price: The people are divided into two categories: below poverty line (BPL) and above poverty line (APL), with the issue price being different for each category. However, this categorization is imperfect and a number of deserving poor have been excluded from the BPL fold. More-

market rates and to BPL category beyond their purchasing power, resulting in plummeting of off take from the PDS.

Also, the low quality of PDS grains and the poor service at PDS shops have forced many people to switch over to market, which offers better quality grains, allows purchase on credit and ensures flexibility to purchase in small quantities.

Also, the high-priced, low-quality Indian rice and wheat find little place in the international market. Recently, two Indian consignments were rejected even by Iraq on quality considerations. The result is bulging stocks with FCI amidst widespread starvation.

Market demand: The PDS entitlement meets only around 25 per cent of the total food grain requirement of a BPL family and it has to depend more on the market for meeting its needs. Also with the APL families essentially opting for market purchases, the market demand has risen. However, the massive FCI procurement has crowded out the market supplies, resulting in a relative rise in rates. The poor are



over, some of the so called APL slips back to BPL say with failure of even one crop and it is administratively difficult to accommodate such shifts.

To reduce the fiscal deficit, the government has sought to curtail the food subsidy bill by raising the issue price of food grains and linking it to the economic cost at which the FCI supplies food grains to the PDS. The economic cost comprises the cost of procurement, that is, MSP, storage, transportation and administration and is high mainly because of the artificially inflated MSP and also due to the operational inefficiencies of the FCI. This has pushed the issue price to APL category higher than the

the most hurt in this bargain.

Food-for-work scheme: The government is running food-for-work scheme to give purchasing power to the poor who get paid for their labour in cash and food grains. The scheme is, however, not successful, since the Central Government is required to meet only the food grain component and the cash strapped States are expected to meet the cash component (almost 50 per cent of the total expenditure). In many States the scheme has even failed to take off.

Recommendations

There is a need to shift from the existing expensive, inefficient and cor-

ruption ridden institutional arrangements to those that will ensure cheap delivery of requisite quality grains in a transparent manner and are self-targeting.

Futures market and free trade: The present system marked by input subsidies and high MSP should be phased out. To avoid wide fluctuations in prices and prevent distress selling by small farmers, futures market can be encouraged. Improved communication systems through the use of information technology may help farmers get a better deal for their produce. Crop insurance schemes can be promoted with government meeting a major part of the insurance premium to protect the farmers against natural calamities.

To start with, all restrictions on food grains regarding inter-State movement, stocking, exports and institutional credit and trade financing should be renounced. Free trade will help make-up the difference between production and consumption needs, reduce supply variability, increase efficiency in resource-use and permit production in regions more suited to it.

Food-for-education programme: To achieve cent per cent literacy, the food security need can be productively linked to increased enrolment in schools. With the phasing out of PDS, food coupons may be issued to poor people depending on their entitlement.

Modified food-for-work scheme/ direct subsidies: With rationalization of input subsidies and MSP, the Central Government will be left with sufficient funds, which may be given as grants to each State depending on the number of poor.

The State government will in turn distribute the grants to the village bodies, which can decide on the list of essential infrastructure, work the village needs and allow every needy villager to contribute through his labour and get paid in food coupons and cash.

Community grain storage banks: The FCI can be gradually dismantled and procurement decentralised through the creation of food grain banks in

each block/ village of the district, from which people may get subsidized food grains against food coupons. The food coupons can be numbered serially to avoid frauds. The grain storage facilities can be created within two years under the existing rural development schemes and the initial lot of grains can come from the existing FCI stocks. If culturally acceptable, the possibility of relatively cheap coarse grains, like bajara and ragi and nutritional grains like millets and pulses meeting the nutritional needs of the people can also be explored. This will not only enlarge the food basket but also prevent such locally adapted grains from becoming extinct. The community can be authorized to manage the food banks. This decentralised management will improve the delivery of entitlements, reduce handling and transport costs and eliminate corruption, thereby bringing down the issue price substantially. To enforce efficiency in grain banks operation, people can also be given an option to obtain food grains against food coupons from the open market, if the rates in the grain banks are higher, quality is poor or services are deficient. A fund can be set up to reimburse the food retailers for the presented coupons. This competition will lead to constant improvement and lower prices. It must also be mandatory to maintain a small buffer stock at the State level, to deal with exigencies.

Enhancing agriculture productivity: The government, through investments in vital agriculture infrastructure, credit linkages and encouraging the use of latest techniques, motivate each district/ block to achieve local self-sufficiency in food grain production. However, instead of concentrating only on rice or wheat, the food crop with a potential in the area must be encouraged. Creation of necessary infrastructure like irrigation facilities will also simulate private investments in agriculture.

The focus on accelerated food grains production on a sustainable basis



and free trade in grains would help create massive employment and reduce the incidence of poverty in rural areas. This will lead to faster economic growth and give purchasing power to the people.

A five-year transitory period may be allowed while implementing these. Thus, India can achieve food security in the real sense and in a realistic timeframe.

Conclusion:

With the rapid pace of globalization and new economic reforms, way – through planning for future strategies to combat the problems of food security, malnutrition and poverty-linked hunger entails sustainable development with economy and equity. This, implies realignment of research priorities and programmes that would have to rely heavily on sustainable and precision farming approaches, with considerable emphasis on ecotechnology, diversification and commercialization of farm enterprises, post harvest technology and value addition of food, export venture, sound networking and improved delivery systems for public distribution of food, convergence of developmental programmes that address food-for-all and health-for-all, empowerment of vulnerable sections of the rural poor, including landless labourers, women and children, forging interinstitutional linkages with non government organizations, co-operatives and financial institutions in the areas of social engineering. Along term perspective view of food security improvement should be established and institutionalized.

Ashima Colvin

Tackling the Adverse Effects of Global Warming on Indian Agriculture

Dr. Anil Kumar Singh¹ and Dr. B. Venkateswarlu²

Climate change, as defined by the Intergovernmental Panel on Climate Change (IPCC), refers to a change in the state of the climate that can be identified (e.g. using statistical tools) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. The usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity and that is in addition to natural climate variability observed over comparable time periods (IPCC, 2007).

Changing temperature and rainfall

The 4th Assessment Report (2007) of IPCC reported change on earth's climate in an unprecedented manner in past 400,000 years, but greatly accelerated during the last century, due to rapid industrialization and indiscriminate destruction of natural

environment. The report categorically projected that by 2100 earth's mean temperature will rise by 1.4 to 5.8 °C, precipitation will decrease in the sub-tropical areas, and frequency of extreme events will increase significantly. As of now, in reality, in the past 100 years, the global mean temperature has increased by 0.74 °C (Fig 1), which has already started affecting the climatic phenomenon in different parts of world. Melting of glaciers, rising sea level are some of the most important manifestations of it.

IPCC (2007) have further reported change in their frequency and /or intensity of extreme events over the last 50 years. The report makes the following significant observations:

- It is very likely that cold days, cold nights and frosts have become less frequent over most land areas, while hot days and hot nights have become more frequent
- It is likely that heat waves have become more frequent over most land areas.
- It is likely that the frequency of

heavy precipitation events has increased over most areas.

- It is likely that the incidence of extreme high sea level has increased at a broad range of sites worldwide since 1975.

However, climate change impacts are already being felt, as the last 60 years were the warmest in the last 1000 years. Since beginning of 21st century India has experienced droughts in quick succession, of which the 2009 one was the most recent causing significantly affecting kharif crop production. Incidentally, 2009 has achieved the unwanted distinction of being the warmest year in past several centuries across the world. It was the 2nd largest all India monsoon rainfall deficit since 1972 (23% below normal). Apart from that, 1998 was one of the warmest years, 2003 experienced unprecedented heat and cold waves across the globe, occurrence of high temperature in March 2004 adversely affected crops like wheat, apple, potato etc. across northern India; 2005 witnessed destructive hurricanes/cyclones across the globe. Again, 2007 was as warm as 1998 in the entire northern hemisphere and unusual summer rains and floods were experienced in many parts of India. Besides that, the amount and distribution of rainfall is becoming more and more erratic which is causing greater incidences of drought and flood globally. The increase in frequency of heavy rainfall events in last 50 years over Central India (Fig.2) points towards a significant change in climate pattern in India (Goswami, 2006). Lal (2001) reported that annual mean area-averaged surface warming over the Indian sub-continent is to likely to range between 3.5 and 5.5 °C by 2080s (Table 1). These projections showed more warming in winter season over summer. The spatial distribution of surface warming suggests a mean annual rise in surface tem-

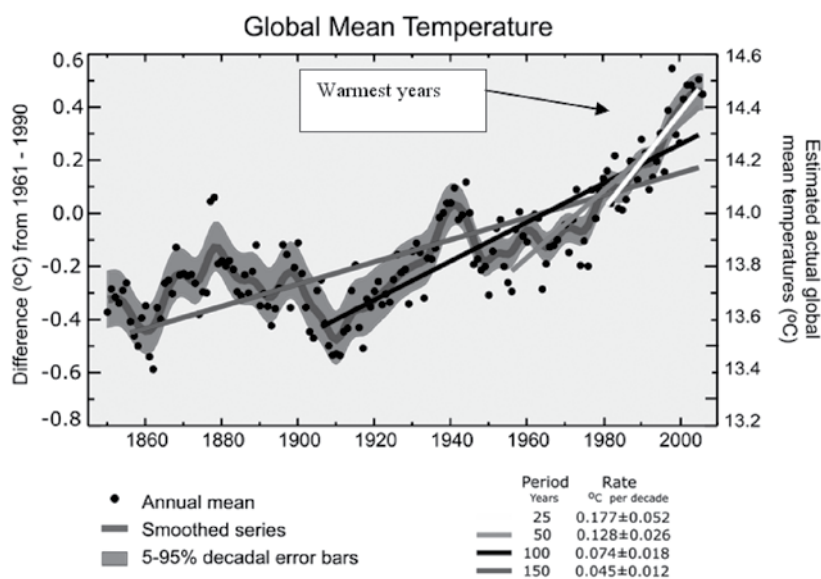


Fig 1. Increase of global mean temperatures during last 100 years (IPCC, 2007)

Table 1. Projected mean temperature changes over the Indian sub continent (Lal, 2001)

Year	Season	Temperature change (°C)		Rainfall change (%)	
		Lowest	Highest	Lowest	Highest
2020s	Annual		1.41	2.16	5.97
	Rabi	1.08	1.54	-1.95	4.36
	Kharif	0.87	1.17	1.81	5.10
2050s	Annual	2.23	2.87	5.36	9.34
	Rabi	2.54	3.18	-9.22	3.82
	Kharif	1.81	2.37	7.18	10.52
2080s	Annual	3.53	5.55	7.48	9.90
	Rabi	4.14	6.31	-24.83	-4.50
	Kharif	2.91	4.62	10.10	15.18

peratures in North India by 3 °C or more by 2050. The study also indicated that during winter, the surface mean air temperature could rise by 3 °C in Northern and Central parts, while it would rise by 2 °C in Southern parts by the same period. In case of rainfall, a marginal increase of 7-10% in annual rainfall is projected over the sub-continent by 2080. Nevertheless, the study suggests a fall in rainfall by 5-25% in winter, while it would be a 10-15% increase in summer. Marked variability is seen even in the onset and withdrawal of monsoon over the period.

Role of green house gases

The increasing levels of green house gases (GHG's) in the atmosphere have been attributed as one of the major driving force behind the rapid climate change phenomenon. The main GHG's contributing to this phenomenon are CO₂, CH₄ and N₂O. Apart from fossil fuel burning, the frequent volcanic eruptions are also contributing in increasing this concentration, in the atmosphere (Fig 3). Though the increase in the level of CO₂ is expected to produce some beneficial effects on crop drymatter production but it may soon be nullified by associated water and thermal stresses leading to overall deterioration of agro-climatic conditions for food production systems. At the global scale, the historical temperature-yield relationships indicate that warming from 1981 to 2002 is very

likely to offset some of the yield gains from technological advance, rising CO₂ and other non-climatic factors (Lobell and Field, 2007). The management and labour costs of farm production will rise to a great level owing to increasing incidences of pests and diseases as well as weeds making farming a less attractive and non-profitable profession. Additionally, extreme events like hails and frosts will also negatively impact crop production. As of now, most of the developing countries, including India, are yet to be fully prepared to deal with the adverse impacts expected as a consequence of climate change

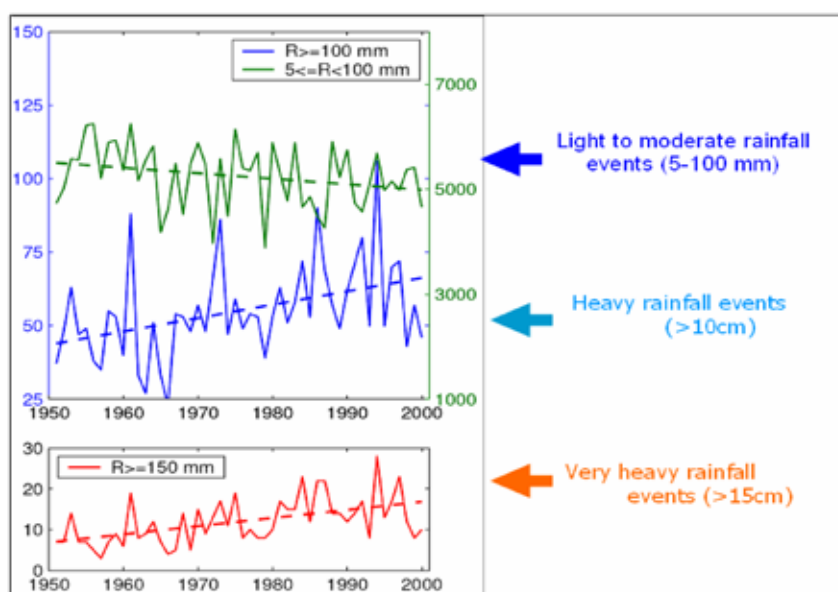


Fig 2. Change in intensity of rainfall over Central India in last 50 years (Goswami, 2006)

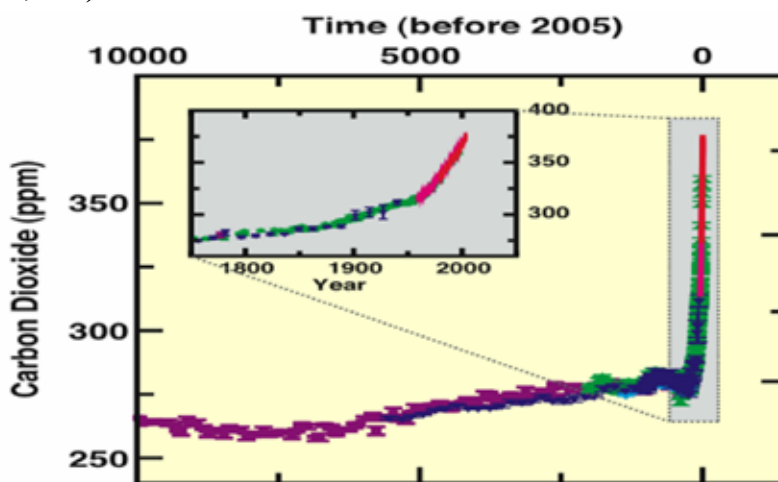


Fig 3. Build up of concentration of global atmospheric CO₂ over time (IPCC, 2007)

and are therefore relatively vulnerable.

Impact on water resources

At present, available statistics on water demand show that the agriculture sector is the largest consumer of water in India using more than 80% of the available water. The quantity of water used for agriculture has increased progressively through the years as more and more areas were brought under irrigation. Since 1947, the irrigated area in India rose from 22.60 to 80.76 million ha up to June 1997. Contribution of surface water and groundwater resources for irrigation has played a significant role in India attaining self-sufficiency in food production during the past three decades, but water is likely to become more scarce and critical input in future. By judicious utilization, the demand for water from farm sector can be pegged at 68% by the year 2050, but agriculture will still remain the

largest consumer. In order to meet this demand, augmentation of the existing water resources by development of additional sources of water or conservation of the existing resources through impounding more water in the existing water bodies and their conjunctive use will be needed (Mall et al., 2006). Table 2 (adopted from Mall et al., 2006) shows possible impact of climate change on water resources during the next century over India. The enhanced surface warming over the Indian subcontinent by the end of the next century would result in an increase in pre-monsoonal and monsoonal rainfall and no substantial change in winter rainfall over the central plains. This would result in an increase in the monsoonal and annual run-off in the central plains, with no substantial change in winter run-off and increase in evaporation and soil wetness during the monsoon on an annual basis.

Impact on agriculture, livestock and fisheries

The impact of climate change on agriculture will be one of the major deciding factors influencing future food security of the world including India. A major part of the agriculture in India is rainfed (80 million ha out of 141 million ha net cultivated area) and will remain so for at least for a foreseeable future. Rainfed agriculture in India contributes 44% of total foodgrain production. Around 66% of livestock population is also dependent on rainfed areas. The crop losses due to climate variability will vary from region to region depending on regional climate, crop and cropping systems and soils and management practices. Rainfed crops are likely to be worst hit by climate change because of the limited options for coping with variability of rainfall and temperature. The major crops like wheat and rice are expected to undergo all the weather aberrations and their sustainability will be determined by crop's capacity of natural adaptability as well as appropriate mitigation measures adopted.

The impact of climate change on agriculture may accentuate at regional level creating more vulnerability in food security rather than global level as a whole. The potential impact will be felt in shifts of sowing time and length of growing seasons, which may necessitate effective adjustment in sowing and harvesting dates, change in genetic traits of cultivars and sometimes total adjustment of cropping system itself. With warmer environment associated with erratic rainfall distribution, the rate of evapotranspiration will increase and quick depletion of soil nutrient reservoir would call for much greater efficiency in use of water and nutrients to sustain crop productivity. Apart from these, tackling with frequent and more intense extreme events like heat and cold waves, droughts and floods may become a norm of the day for common farming community (IPCC, 2001). Such phenomena will impact agriculture considerably through their direct and indirect effects on crops, livestock, and inci-

Table 2. Impact of climate change on water resources during the next century over India (adopted from Mall et al., 2006)

Region/location	Impact
Indian subcontinent	<ul style="list-style-type: none"> • Increase in monsoonal and annual run-off in the central plains • No substantial change in winter run-off • Increase in evaporation and soil wetness during monsoon and on an annual basis
Orissa and West Bengal	One metre sea-level rise would inundate 1700 km ² of prime agricultural land
Indian coastline	One metre sea-level rise on the Indian coastline is likely to affect a total area of 5763 km ² and put 7.1 million people at risk
All-India	Increases in potential evaporation across India
Central India	Basin located in a comparatively drier region is more sensitive to climatic changes
Kosi Basin	Decrease in discharge on the Kosi River Decrease in run-off by 2–8%
Southern and Central India	Soil moisture increases marginally by 15–20% during monsoon months
Chenab River	Increase in discharge in the Chenab River
River basins of India	General reduction in the quantity of the available run-off, increase in Mahanadi and Brahmini basins
Damodar Basin	Decreased river flow
Rajasthan	Increase in evapotranspiration

dences of pest-disease-weeds, increasing deterioration of soil health in totality and thereby threatening the food security like never before.

The Indian Council of Agricultural Research instituted an All India Network Project in 2004 to study in detail the possible impact of climate change on major crops, livestock, fisheries, soils and other biotic factors as well as to understand different natural adaptation capabilities of both flora and fauna. The possible interventions to increase the adaptability of crop-livestock systems and mitigation measures to minimize the adverse impacts were studied across length and breadth of different agro-ecosystems of India. The output of the studies (Aggarwal, 2009) so far indicated that a marginal 1 °C increase in atmospheric temperature along with increase in CO₂ concentration would cause very minimal reduction in wheat production of India if simple adaptation strategies like adjustment of planting date, increased fertilizer use, irrigation water availability and varieties are adopted uniformly. But in absence of any adaptive mechanism the yield loss in wheat may cross 4-5 million tons.

The availability of viable pollen, sufficient numbers of germinating pollen grains and successful growth of pollen tube to the ovule are of funda-

mental importance in grain formation. The Network study on wheat and rice suggested that high temperature around flowering reduced fertility of pollen grains as well as pollen germination on stigma. These effects are more pronounced in *Basmati* rice as well as *Durum* wheat cultivars. A positive finding of the study was that the *Aestivum* wheat cultivars are more or less tolerant to such adverse affects. But differential impact of increasing temperature is observed with respect to grain quality of wheat where it is found that *Aestivum* wheat cultivars are more prone to reduced grain quality due to increasing temperature during the fruit setting stage than *Durum* cultivars.

Field experiments using advanced 'Temperature gradient tunnels' with different dates of sowing to study impact of rising temperature on growth and development of different crops revealed that an increase of temperature from 1 to 4 °C reduced the grain yield of rice (0-49%), potato (5-40%), green gram (13-30%) and soybean (11-36%). However, one of the important pulses, chickpea, registered 7-25% increase in grain yield by an increase in temperature up to 3 °C, but was reduced by 13% with further 1 °C rise in temperature.

A significant decrease in average productivity of apples in Kullu and



Simla districts of Himachal Pradesh have been reported which is attributed mainly to inadequate chilling required for fruit setting and development. Reduction in cumulative chill units of coldest months might have caused shift of apple belt to higher elevations of Lahaul-Spitti and upper reaches of Kinnaur districts of Himachal Pradesh. However, results from simulation models suggest that climate change could benefit coconut crop. Coconut yields are likely to increase by 4, 10, and 20% by 2020, 2050 and 2080, respectively, in the western coastal areas of Kerala, Maharashtra, Tamil Nadu and Karnataka. But the impact may be negative in east coast areas as they are already facing a much warmer atmospheric thermal regime than western coast. The increase in crop productivity due to higher CO₂ in the atmosphere is likely to be negated by rising temperature. The impact of rising temperature and CO₂ are also likely to change insect pest dynamics. Dilution of critical nutrients in crop foliage may result in increased herbivory of insects. For example, Tobacco caterpillar (*Spodoptera litura*) consumed 39% more castor foliage under elevated CO₂ conditions than controlled treatments (Srinivasa Rao *et al.*, 2009). The advancement of breeding season of major Indian carps to as early as March has been reported from West Bengal, which was extended from 110 to 120 days due to increase





in environmental temperature. Enhanced temperature stimulates the endocrine glands of fish and helps in the maturation of the gonads. This brings about a possibility to breed these fishes twice a year at an interval of 30 to 60 days. Increased heat stress associated with rising temperature may, however, cause distress to dairy animals and possibly impact milk production. A rise of 2 to 6 °C in temperature due to climate change is expected to negatively impact growth, puberty and maturation of crossbred cattle and buffaloes. As of now, India losses 1.8 million tones of milk production annually due to climatic stresses in different parts of the country. The low producing indigenous cattle are found to have high level of tolerance to these adverse impacts than high yielding crossbred cattle.

Besides, the nutrient loss from soil through high rate of mineralization, CO₂ emissions from soil could be accelerated as a result of increase in temperature. Low carbon soils of mainly dryland areas of India are likely to emit more CO₂ compared to high or medium carbon temperate region soils. Simulation of water balance using Global and Regional Climate Models revealed likely increase in annual as well as seasonal stream-flows of many Indian river basins pointing to the need for adoption of more effective runoff and soil loss control measures to sustain crop production across the country.

Adaptation/mitigation strategies

A comprehensive strategy of utilization of existing knowledge, strength-

ening R&D in key areas and evolving a policy frame work that builds on risk management and providing incentives to sustainable use of natural resources will be required for successful adaptation by farm sector to climate. The goal of this strategy is to minimize as risks associated with farming

and enable farms to cope with these risks (Singh et al., 2009).

The main adaptation strategies include development of new genotypes; intensifying search for genes for stress tolerance across plant and animal kingdom; intensifying research efforts on marker aided selection and transgenics development for biotic and abiotic stress management; development of heat and drought tolerant genotypes; attempt conversion of C3 plants to C4 plants; development of new land use systems; evolving new agronomy for climate change scenarios; explore opportunities for restoration of soil health; use multi-purpose adapted livestock species and breeds; development of spatially differentiated operational contingency plans for weather related risks, supply management through market and non-market interventions in the event of adverse supply changes; enhancement research on applications of short, medium and long range weather forecasts for reducing production risks; development of knowledge based decision support system for translating weather information into operational weather management sources; development of pest and disease forewarning systems covering range of parameters for contingency planning; conducting an integrated study of 'climate change triangle' and 'disease triangle', especially in relation to viruses and their vectors. Development of a compendium of indigenous traditional knowledge and explore opportunities for its utilization forms an important part of this strategy.

While adaptation measures are important, we must also focus simultaneously on mitigation measures so that we contribute to a reduction in the pace of global climate change (Venkateswarlu and Arun Shanker, 2009). The important mitigation options include efficient water and nutrient management options to enhance use efficiency; evaluate carbon sequestration potential of different land use systems including opportunities offered by conservation agriculture and agro-forestry; identify cost effective opportunities for reducing methane emission in ruminants by modification of diet, and in rice paddies by water and nutrient management. Renewed focus on nitrogen fertilizer use efficiency with added dimension of nitrous oxide mitigation. However, we need to assess the socio-economic implications of proposed mitigating options before developing a policy frame work.

Building state of the art infrastructure for research and training of scientists in frontier areas and tools, increasing climate change literacy to different levels of stakeholders, mainly farmers; enhancement of national capacity on decision support systems developing best weather insurance products for vulnerable areas and farmers and carbon trading in agriculture; and international collaboration are some other key areas through which we can tackle challenges of climate change and global warming. The Indian Council of Agricultural Research (ICAR) recently formulated a major project on climate resilient Indian agriculture which includes all these components of strategic research, strengthening R&D infrastructure, capacity building and technology demonstration on farmers fields.

Finally, there is a need to make climate change adaptation and mitigation measures as an integral part of overall planning and development strategy of the country on long term. (Venkateswarlu and Shanker, 2009).

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Addressing Challenges and Harnessing Growth Opportunities in Indian Agriculture

Indian Agriculture is one of the success stories of application of science and policy for ensuring food security and reducing poverty. The country witnessed the 'rainbow revolutions' meeting diversified food needs of the growing population. However, there have been some recent developments which have again brought food security issues up front. Most important among these is agricultural growth falling short of a target growth rate of four percent set by the Planning Commission. This is in spite of the fact that there is substantial investment by the government for rural infrastructure development and special schemes like Rashtriya Krishi Vikas Yojana and Food Security Mission in XI Plan. Part of the problem could be attributed to adverse weather conditions, including deficit rainfall in the current year. It is expected that kharif food grain production will fall short of about 15 million tonnes this year. The long term trend also indicates some concern on food security front. The country will need about 250 million tonnes of foodgrains by 2020. This implies that the country needs to produce addition two million tonnes of food grains every year during the next decade. Some analysts maintain that additional requirement of food grain will be much higher than this and required growth in pro-

ductivity to meet the demand will be about 2 percent per annum. This coupled with a much higher growth in consumption of high value products like fruits, vegetables and livestock products, required growth in agriculture will be much higher and meeting this growth target will be a major challenge. Much of the growth has to be contributed by small and marginal farmers who constitute 80 percent of the total holdings in the country and occupy 40 percent of agricultural lands.

Sustainability of production systems Ensuring sustainability of agricultural production systems is another major challenge. The important factors threatening the sustainability are depletion and degradation of natural resources. Much of land degradation takes place due to water and wind erosion and salt concentration. Agricultural practices like shifting cultivation, intensive tillage of marginal lands, deforestation, and overgrazing also contribute to land degradation. Nearly 20 percent of geographical area is subject to severe degradation by various factors and on an average 16 tonnes/ha soil is lost annually. This degradation not only lowers crop productivity but also creates environmental problems like sedimentation of river bodies, water pollution water etc. As regards groundwater



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development, currently 58 percent of the national potential is currently exploited, and in some area this exploitation is more than net availability. For example, in Punjab, annual water draft (31 BCM) is more than net annual groundwater availability (21 BCM), and out of 138 blocks in the state, 103 blocks are designated overexploited and five of them are critical. Similarly in Haryana, annual groundwater draft is 9 BCM against net availability of 8.6 BCM. Overall, it is estimated that water needs in the country will increase by 20 percent by 2025 and given current low level of water use efficiency (30 percent), it would be impossible to meet this demand. Therefore water use efficiency should at least be increased by 20-30 percent to maintain current level of water resources. Water pollution and poor soil health are other negative environmental externalities due to imbalance use of chemical fertilizers and pesticides. Since there is increasing demand for environmental services and quality products, agricultural practices should restore health of natural resources and promote their sustainable use. Agricultural diversification, use of biological inputs like biofertilizers and biopesticides, and resource conservation technologies hold great potential to promote sustainability of production systems. The production systems should not only be economically viable but also environmentally sound.



Impact of climate change

The adverse impacts of climate change on crop productivity are increasingly felt. Increase in temperature, alteration water cycle and glacier melt in Himalayas are posing threat to agriculture growth and it has to be insulated against the vulnerability. Climate change can bring negative impacts to agriculture in India. It is estimated that 1-3°C change in temperature can reduce crop yield by 10 percent by 2020. Wheat crop is more sensitive to changes in temperature and every degree increase in temperature can reduce yield by 5-7 percent. Furthermore, resource poor farmers who don't have adequate resources to investment in the adaptation and mitigation measures will be worst affected. These changes

in crop yields due to climate change will not only have significant implications for the national food security, but also make small producers vulnerable. A two-pronged strategy will be needed to address this challenge. First is to strengthen research to develop technologies which can tolerate adverse weather conditions. Crop varieties and animal breeds tolerant to heat, package of practices to reduce plant canopy temperature and maintain soil moisture, changes in cropping systems, water saving technologies, etc are some of the suggested technological options. The second element of the strategy could be management of the impacts through storing more food and water for deficit years, putting in place advance weather forecasting and information system, and insurance schemes for risk management. In addition, there are global efforts to reduce greenhouse gas emissions through better technologies and establishment of development funds to promote these technologies in developing countries, as agreed in the recently concluded summit on climate change.

There are however opportunities for farmers to increase their income through carbon trading—a mecha-

nism now developing gradually. They can, for example, rehabilitate degraded crop and pasture land, use minimum tillage, and improve forestry and livestock management and can reduce carbon which can be traded. Coordinating action and sharing of knowledge among different stakeholders are required to make small farmers in carbon trading. It is also an opportunity for policy makers to make efforts to promote and support the capacity of smallholder farmers with insurance products to cope with the impacts of climate change. Resource poor farmers must be encouraged by providing green payments for adopting agricultural practices that secure ecosystem conservation and restoration.



Small farmers and markets

Increasing marginalization of land holdings and their access to markets, technology and credit is becoming a major challenge. The average size of holding decreased from more than two hectare in 1970 to 1.5 ha in 1990 which further reduced to 1.3 ha in 2000. It is further expected to decrease and expected to be about one hectare currently. This marginalization process not only reduces farmers' capacity to invest but also reduce their bargaining power in the market. They must be provided the power of scale economy through aggregation of their production and various institutional arrangements like contract farming, cooperatives, resource sharing etc. There are very few success-

ful examples in this regard, with their limited replicability. The immediate implication of small size of production is limited access to credit required for adapting high value agriculture and limited access to product market. Price realized by small farmers is not often adequate. This disadvantage is more pronounced when there is high price volatility as seen in the recent past. Policy options for increasing opportunities for smallholders include reducing transaction costs (e.g. through infrastructure), creating safety nets, boosting productivity through public research, extensions services, and better credit delivery. It is important to increase small holders' volumes going to the markets so as to increase their bargaining power in the value chain.

Food grain prices have shown volatile trends. The international prices rose sharply due to global shortfall in the production. These became rather stable and started declining with significant increase in food grain production in some countries, particularly in India. However, likely shortfall in food grain production in India due to deficit rainfall has further given rise to food prices. This coupled with speculative nature of trade has fueled food inflation which currently stands at 18 percent in domestic market. This unexpected double-digit inflation is a

major concern in view of its adverse impact on consumers and wage bills. Experts believe that global commodity prices will remain high in the coming decade due to the structural evolution of supply and demand, which includes rapid urban population growth; improvements in the living standards and changes in consumption patterns. The rising commodity prices could improve the incomes of farmers but the key is to ensure that price increases are transmitted to the level of smallholder producers which could be possible with appropriate policy and institutional support.

Buffer stock operations keep domestic market insulated from sharp changes in international markets. This provides some stability to both

consumers and producers. However, producers are at disadvantage due to rising cost of inputs and therefore shrinking farm income. In addition, there are areas where benefits of minimum support prices scheme of the government are not realized because of lack of procurement facilities. This erodes incentives for farmers to spend on modern inputs, land improvement and technology, and those who do may not get remunerative prices leading of distress. There is a need for expanding scope of government intervention here incentives is needed. In areas where markets are developed, private trade may be encouraged with adequate monitoring of their activities, especially those related with speculation.

Growth opportunities

Diversification of agriculture has provided new growth and income earning opportunities in Indian agriculture. Rising income level, urbanization, changing life style etc are major factors for diversification of the consumption pattern. The demand for high value products is rising 4-6 percent. Farmers' are responding to this growth opportunity and now high value products account nearly 44 percent of total value of agriculture (Fig 2). This trend must be sustained. Policy options to develop infrastructure like cold chains, allow access to

international market for processing technologies, credit for farmers to invest for high value agriculture, legal framework for value chain development through contract farming, amendment in market regulation etc should be put in place. These options are especially needed to attract private sector.

Secondly, there should be adequate investment to promote technological options to increase productivity of high value crops. This should be followed by the efforts to increase productivity of food grains so that some land is leased for diversification.

The second major growth opportunity is huge untapped potential. The Planning Commission maintains that 60-100 percent yield gap currently exists and any effort to bridge this will pay high growth dividends. Immediate yield gains could be realized in eastern India which has high growth potential. Increasing supply of quality inputs, especially seed and fertilizers, can provide immediate yield gains. This should be followed by technical backstopping with investment in technology transfer programs. Management of surface water for reducing moisture stress and raising sec-



ond crop on residual moisture, weed control, and strengthening markets are other measures needed.

Third major opportunity is high income potential of quality products. There is a large part of the country like hill areas, where limited chemical fertilizers and pesticides are used. These areas could be developed as organic or pesticide free production zones. Since there is increasing demand both in domestic and international markets for such products, farmers can benefit from price premium offered by the consumers. These areas could also be used for ecotourism as these have scenic landscape and rich bio-resources.

Finally, most of the agricultural growth will accrue through increase in productivity, which in turn will be driven by technological advancements. Therefore, adequate investment in agricultural research and extension is needed. First priority should be given to state agricultural universities which have low expenditure. This should be followed by strengthening of extension system through more funds, manpower and technical skills. Biotechnology in agriculture has ample potential to give a push and production shift. It is therefore necessary to increase investment for agricultural biotechnology. It is important that biotech research is directed to addressing the national priorities like stress management in crops, impact of climate change and bio-fortification. This technology should be backed with needed policy and institutional support for raising agricultural productivity.

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A NEW DEAL FOR INDIAN FARMERS?

1. Introduction

Over 6 billion out of the world's population live in abject poverty and over 30% of these are from India. Poor people who maintain a hand to mouth existence are exposed to extreme risks and deprivation. Poor people tend to migrate to urban areas from rural regions in search of employment and live in slums and shanty towns, eking out a sub-marginal living. The major challenges for India for the next 10 years are:-

- (i) Food security.
- (ii) Financial Inclusion.
- (iii) Poverty Eradication.
- (iv) Environmental Sustainability.

There is increasing awareness that growth and development of the national economies do not always lead to poverty alleviation homogenously. Today, there is consensus that inclusive development growth is needed with financial inclusion for all! All Asian countries must join to promote harmony, peace, co-operation and sustainable inclusive growth in the region.

2. Problems of Indian Farmers:-

Let us praise the poor Indian farmer. On his frail shoulders rest the continent's hopes of food security. A delayed or poor monsoon due to climate change and the distress result in farmer's suicides and spurs urban migration with elusive security. Today, economic growth cannot rest on industries and services sectors alone as it is the agrarian sector that feeds and sustains the people. The woes of farmers can be attributed to information non-availability, poor storage/marketing facilities, poor communications, lack of transportation and poor collective bargaining power. Lack of affordable credit, technological inputs, quality inputs (like seeds, fertilizers, pesticides etc.) at affordable prices coupled with global warming, climate changes, groundwater depletion etc. make farming in India, one of the riskiest professions. Small land holding does not ensure better finan-

cial margins for small and marginal farmers and thus it is a technological challenge to provide sustenance with 1 hectare land holding.

3. Innovations and Initiatives:-

Dr. APJ Abdul Kalam, Ex-President of India and a true visionary with his PURA (Provision of Urban Amenities in Rural Areas) approach, has advocated that the rural people, including farmers must have:-

- (i) Physical Connectivity,
- (ii) Electronic Connectivity,
- (iii) Knowledge Connectivity, and
- (iv) Economic Connectivity

if they are to contribute substantially to their country's growth. The farmer's multiple risks need to be mitigated so that he can maintain his family and also contribute to the country's food security. The on-farm and off-farm incomes need to be stabilized for risk mitigation. The Mahatma Gandhi National Rural Employment Guarantee Act is an excellent innovation which ensures some income for the rural people, during off-season especially rural women-folk. Enduring assets, such as rainwater harvesting devices like check dams, ponds etc. need to be created so as to harness available labour as per approved rural infrastructure plan. Micro-level planning especially over a 5-year horizon with agricultural development plans and implementable rural infrastructure plan will be useful.

The four major areas for interventions and innovations are set out below:-

- i. Credit and Insurance,
- ii. Technology and It's Transfer,
- iii. Innovations in Farming Systems, and
- iv. Other Options

These innovations and practical approaches for boosting sustainable and viable agricultural practices will be described in detail.

4. Credit and Insurance:

Credit is the major input and insur-



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ance is the basic risk mitigation measure and an important area of intervention and innovation:

4.1 Farmers' Credit Card:-

The farmer needs adequate credit at affordable rates without much documentation. Credit Cards should be supplied by all banks and credit limits should be available over the agricultural crop cycle of 5 years with 2 years of above average crops, 1 year of below average crops and 2 years of average crops, for consumption credit, crop loans and term loans. It should be a chip-based, biometric card which obviates the farmer from resorting to cash payments for his major input purchases. 100% financial inclusion for all farmers owning land must be attempted and Farmers Credit Card should contain all relevant banking data including the UID number when available. This will enable Rural Credit Bureaus to be set up and facilitate loans for farmers and other rural self-employed persons. However, it is not just credit alone but a series of developmental measures which help farmers. The "Credit plus approach" of banks will help the small/marginal farmers who may not adhere to commercial farming norms.

4.2 Joint Liability Groups:-

A large number of small/marginal farmers or tribal farmers may not have clear land titles or land is held by the Community and not by individ-

uals. This ensures that bank loans are not available due to lack of documentation. Tenant farmers or share croppers or oral leasees have little or no access to bank credit. The formation of Joint Liability Groups of farmers upto 5 members ensures that they access individual loans or joint loans but stand guarantee for each other's repayment for loans taken, as these loans are collateral free.

4.3 Micro Insurance

Various insurance companies (both life and non-life) have developed multiple products over the years to cover the risks faced by farmers. However, these products have remained confined to assets acquired with bank loans mainly to ensure recovery of the loans i.e. to protect the interest of banks. The interests of the farmer or his family are rarely protected. The need of the farmer is therefore to choose from an array of insurance products available as part of a package, bundled with the Farmers' Credit Card and made available at the credit society or bank branch or through the village post office. Such credit/insurance products should be available at the farmers' doorsteps. The micro-insurance package appeals to those farmers with some assets and should cover all insurance requirements – crop farm, equip-

ments/machines, animals, accidents, health, life, etc. Premia should be on a group basis to lower costs.

4.4 Micro Pensions

Micro pension schemes appeal to those without land or other assets especially agricultural labourers or the landless or unorganized labour in rural areas who need a safety net when their income stops due to old age. The poor rarely have access to regular savings and need very flexible pension products if the micro-pension product is to succeed. Contributions should be on an annual/quarterly/monthly basis and should be flexible to take into account the client's needs.

5. Technology and its Transfer

In most Asian countries, the training and visit system or the lab to land programs by agricultural extension workers, have not kept up with the times. There is a need to transfer technology to farmers of low cost so that they implement to ensure better productivity, higher production levels and better financial margins..

5.1 Farmers Clubs and Associations

There is a need to strengthen the Farmers Clubs through Banks and NGOs, with suitable incentives.

These Farmers Clubs should stress on capacity building and leadership training, formation of Joint Liability Groups and Self Help Groups, developing linkages with banks/Govt. officials/institutions/technology providers and markets, farming federations and associations of farmers for the aggregator role in grading, sorting, packaging, transportation and marketing. These Clubs should concentrate solely on farmers' core issues.

5.2 Seed Villages

The advent of costly hybrid seeds along with the package of practices, determine the production levels attained by farmers. To ensure good seed replacement ratio of 15% and ensure that seed germination levels are above 90%, quality seeds of improved varieties of cereals, pulses and oilseeds must be used. The centralised seed production and distribution system is against bio-diversity and groups of farmers should take up village level seed production to ensure good quality and create self-sufficient communities. Promotion of local seed enterprises also generates village level employment opportunities. Seed availability of the right quality ensures benefits of research investment, higher income and nutritional security.

5.3 SRI Techniques

Rice plays a major role in the Indian diet, economy and employment and more than 70% of the rice is consumed domestically. With declining rice productivity, increasing input costs of cultivation and depleting sources like water, labour availability, there is a need to manage the traditional rice production system but with a modern set of scientific practices to reduce input costs of seeds and water by 40% enhance productivity levels by over 30% and utilise the agronomic and genetic potential of rice with a better growing environment and enhance soil health. The set of 6 simple practices such as planting 10-12 day old seedlings, at wider spacing (25 x 25 cm), 5 alternate wettings and dryings during vegetative period to keep the soil moist, applying or-



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ganic manure, weeding with cono weeder and incorporating the weed biomass besides crop protection by pesticides and bio-control means are emphasized. Research is on for similar techniques for wheat, barley and sugarcane.

(iv) ICT Techniques for Farmers

Application of Information and Communication Technologies for enhancing agricultural production whereby technology ensures extending timely and accurate information services to facilitate appropriate technology interventions, leading to productivity enhancement. Various models have emerged in the last 10 years utilizing computers, handsets, mobiles, laptops, etc, for transferring essential marketing information including commodity prices, weather advisories, innovative technologies, soil testing, Govt. schemes and subsidies, etc. These are done by Agricultural Universities, NGOs, private sector companies, MNCs like Reuters, ITC, etc., State/Central Govts., - private enterprises, etc. However, the awareness levels and the willingness of farmers for adoption of new technologies based on knowledge and awareness is yet to be assessed. Some of the ICT innovations are e-kutir (Orissa), e-choupal (MP/AP) and e-sagu(AP).

5.5 Scientific Farming

To harness science and technology and ramp up productivity biotechnology can create new varieties of highly productive plants which are resistant to major pests. Bt-cotton, modified rice, colored cotton crops, BT brinjals, etc., are all easily available due to the tremendous advances made by Science. Organic farming is the need of the hour especially when over use of chemical fertilizers has damaged soil productivity and even affected the groundwater quality. Use of manure, green-manure, vermi-compost, etc. is all being increasingly taken up to restore soil-health affected by overdose of chemical fertilisers, pesticides and hormones. The Yasunari Kawabata classic book "The One-straw Revolution" needs to be made a part of essential training of all



farmers. The NATUECO system of farmers or holistic farming advocated by LATE Prof. Dabholkar, an Indian mathematician, is another important system of organic farming.

6. Innovations in Farming Systems

The Asian system of farming is essentially based on intensive farming practices which enhance soil productivity on a long-term basis if properly nurtured. Every bit of land and water can be used for cropping practices and hence the ingenuity of the farmer and his understanding of farming practices and techniques, are relevant.

6.1 ORCHARD (WADI) FARMING

Tribals dwell in difficult regions of the globe and are at different stages of development. Some are nomadic, while some are into settled farming. Their agricultural skills vary according to the tribes and the available resources locally. Their attitude towards innovation is one of suspicion, but once they understand and trust, tribal's are as good as any other farmer. His ability to respond to innovative technologies is limited as he has no support system if a single

crop fails. The need to wean these farmers away from the destructive 'slash and burn' farming practices all over India, needs to be understood. Various organic farming practices on one acre orchards with multi-tiered horticultural plants via., mangoes or jackfruits, lemons or cashews, medicinal herbs or plants, papaya, gooseberries, etc. are being practiced in orchards by tribal farmers. They harvest these fruits for domestic/export marketing. This model has worked well with tribal communities in different regions, responding to their economic development.

6.2 Watershed and Rain Water Harvesting

With rainfall a prey to El Nino or La Nina effects, global warming and various climatic changes, this has had a disastrous effect on farmers as there are heavy floods or cloud bursts in some areas while recurring droughts in some parts for over 4 – 5 years at a stretch. It is extremely difficult to predict a normal or abnormal rainfall. In water- scarce regions of India, rainwater is carefully stored and utilized. Communities thrive in difficult areas by storing available water resources in underground

aquifers. 'Harvest every raindrop' is the slogan and there is a need to revert to these traditional techniques of storing rainwater and not allowing rain to carry away precious top soil. Gully plugs, gabions, contour bunding, check dams, check weirs, sunken ponds, water absorption trenches, farm ponds, field bunds, compartment bunds, terracing, etc. are some of the common technologies used for rain-water harvesting. In view of the wastage of fresh water, we must conserve our water resources.

6.3 Animal Husbandry and Fish farming

Mono-cropping is the bane of our farmers and the secret of crop rotation to enhance soil fertility by growing legume crops, letting field lie fallow, use of green manures and organic fertilizers, were all aspects of the farmers' repertoire. Farmers need to be innovative and adaptable to climatic changes and suitably change the crops to be sown and harvested as a hedge against adversity as farming is one of the riskiest of professions. Indian farmers have always supported a host of farming practices, a variety of agricultural and horticultural crops besides rearing animals like cows, pigs, buffaloes, sheep, goats, camels and horses and raising fish in ponds for harvesting in dry seasons. This system of risk management is essential to master the vagaries of climatic change.

7. Micro Irrigation Devices

Good quality water will not be scarce after 10 years and there is need for frugality in water use in a variety of ways. SRI techniques, drip irrigation, sprinkler systems, etc. are all needed if we are to save precious water for the future. The Indian farmer is naturally eco-friendly and abstemious and a great re-cycler.

7. Other options

To assist farmers, various States have experimented in diverse ways, to create an enabling environment. Some innovations are given below:

7.1 Rural Infrastructure Develop-

ment Fund (RIDF)

Over 15 years, the RIDF in India has created 3.05 million km of rural roads, hundreds of bridges, 15.67 million ha. of irrigation potential and a vast number of primary health centers, schools and training institutes, created enormous rural employment opportunities, provided access to rural markets and availability of institutional finance, augmented agricultural output and enhanced gross household income by 28%. Access to better health services and education also inevitably follows. There is a need for more grain storage warehouses and cold storages, micro-irrigation systems, watershed development, etc. to be created by utilizing the Fund.

7.2 Grain Banks

The Grain Bank concept has evolved in tribal farming communities as an effective tool for food security where



access to food is a major concern especially in monsoon seasons. The Scheme ensures grain diversity and the aim was to mobilize and organise the seed production of tribal farmers. The process involves the farmers extending a part of their own produce to a common pooled resource, managed by village elders in safe storages called the village grain bank, for collective use during food stress. Poor and needy villagers can avail of grain loans for seed or for consumption in the lean seasons, to be repaid back with interest in grain after the next harvest. This also helps tribal farmers to keep away from the clutches of village money-lenders with their exploitatively high interest rates.

7.3 Renewable Energy options

For rural areas, the option in India has been to depend either on human labour or animal power. These options are becoming obsolete, time-taking and plainly non-viable. With high cost of fossil fuels, the search is on for massive sources of renewable rural energy. In sugar factories, co-generation of power is a viable but wasteful option. Ethanol can be created from sugarcane which provides Brazil, 40% of its fuel requirements. Solar lamps, wind power, biomass conversions, biogas, geothermal energy sources, micro-hydel plants, tidal power, bio-diesel (jatropha and pongamia) etc. are also being created for contributing to rural power use on an off gridline model. Solar Bio-gas and pongamia bio-diesel are sources of cheap rural power worth examining. India needs to have efficient generation of renewable power as there will be massive of rural energy requirements within the next 10 years.

8. Conclusion

The road to agricultural development is one which invites critics, self-styled activists and so-called experts as fellow travellers. The poor production levels and low productivity levels of farmers reveal the state of continuing neglect of farms and farmers. Food security is of utmost importance and all initiatives in agricultural development are welcome. Sustainable, low-cost innovations can unleash the hidden potentials of our farmers. The need for restructuring the Indian agricultural economy is acute and we are running short of time. Access to timely and hassle free credit as also insurance is the need of farmers as is access to the latest technology. India needs to assist in building up essential rural infrastructure so as to develop resource-poor regions which could fall prey to forces out to destabilize our march towards peace and progress. An inclusion model of agricultural development must enable growth for all rural sectors with none left behind.

Managing Director, Nabard



से दोस्ती रंग लाएंगी!



Bollgard II

एक बढ़िया, भरोसेमंद साथी मिल जाएं, तो ज़िंदगी संवर जाती है। **बोलगार्ड II** को बनाएं अपनी तरक्की का साथी, क्योंकि यही है कपास की सर्वोत्तम तकनीक, जो दे कपास के बीजों को वैज्ञानिक शक्ति, जिससे कपास की फसल रहे पूरे चक्र में सुरक्षित—तीनों डेन्ड्र इल्लियों (अमेरिकन, गुलाबी और चित्तेदार) एवं तंबाखू/लश्करी इल्ली से और आप पाएं उच्च गुणवत्ता कपास, साथ ही ये तकनीक बचाएं पौधे पर ज्यादा डेन्ड्र, जिससे मिले आपको प्रति एकड़ ज्यादा पैदावार। **बोलगार्ड II** और आप “ये दोस्ती रंग लाएंगी”!!!!

जेनेटिक इंजीनियरिंग अनुविकास कमेटी (जी.ई.ए.सी.), पर्यावरण एवं मन संबंधित, भारत सरकार के निर्देश अनुसार इस विधि का पालन करें— एक एकड़ बोलगार्ड II/बोलगार्ड II। बीटी कपास के खेत के चारों ओर परती किरण की गॉन बीटी कपास की पौध बतारे सुरक्षा फसल (फेरेबंदी) के रूप में लगाएं, फेरेबंदी के क्षेत्र में गॉन बीटी कपास की न्यूनतम 5 बतारे होनी चाहिए या हुआई बले कुल खेत का 20% हिस्सा फेरेबंदी वाला होना चाहिए, जो भी ज्यादा हो.



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In Focus

Safeguarding National Food Security in an Era of Climate Change

Threats to agriculture, food and water security and the loss of livelihoods will be the most serious consequences of climate change. Even a one degree Celsius rise in mean temperature will affect wheat yield in the heartland of the green revolution, because of a reduction in duration, and reduced grain weight. **Climate Refugees** comprising of fisher and coastal communities will become internally displaced persons, in the event of sea level rise. The situation will be particularly serious in States like Kerala and Goa and cities like Mumbai where a large percentage of the populations live very near the shoreline. Anticipatory research and development are essential to strengthen our coping capacity to meet such challenges. I will like to indicate briefly some of the steps which should be included under the proposed National Mission for Sustainable Agriculture.

Climate Change and Agriculture: Factors to cope with

- Unfavorable changes in temperature.
- Unfavorable changes in precipitation.
- Snow Melt and floods.
- Higher carbon dioxide levels in the atmosphere.
- Sea level rise.

A. Temperature: Impact of a rise in mean temperature by 1 to 2 degree Celsius (Copenhagen Accord)

- Wheat yield is a gamble in temperature. Major consequence of 1 degree Celsius rise in mean temperature will be a reduction in the growing period in the case of wheat, and greater risk of vector borne diseases in crops like potato.
- Response measures should include shifting the breeding strategy to per-day rather than per-crop productivity in the case of wheat, and developing and spreading the True Potato Seed

(TPS) methodology in the case of potato.

- Rice has a wide range of adaptation. Short duration varieties or hybrids together with efficient agronomic practices like SRI should be promoted. Hybrid rice strains characterized by hybrid vigour in the development of the root system should be recommended.
- In all crops, the problem of pests and diseases may become more serious. Plant protection measures should particularly be tailored to meet the threat to crops and farm animals arising from the outbreak of vector-borne diseases.

B. Unfavorable alterations in precipitation.

- Both drought and floods may become more serious. Building a sustainable water security system and spreading more crop and income per drop of water technologies should receive priority attention. Drought and high temperature tolerant crop varieties should be developed through Marker Assisted Selection, as well as genetic engineering. A good example is the work done at MSSRF, Chennai in transferring to crop plants genes for drought tolerance from *Prosopis juliflora* and for salinity tolerance from *Avicennia Marina*.
- In the case of floods, post-flood agricultural rehabilitation mea-



Prof. M S Swaminathan

sure as well as flood tolerant rice varieties with the submergence (Sub) tolerant genes should be developed. After flood waters recede, crops like yellow-flesh sweet potato (rich in Vitamin A) Sathi maize (short duration) and sunflower, as well as fodder crops can be introduced.

- To implement alternative cropping strategies based on different weather conditions, seed reserves should be built. Seed reserves are as important for crop security, as food grain reserves are for food security.
- Drought and Flood Codes indicating the scientific strategies needed for reducing to the extent possible the adverse impact of drought on agriculture should be developed based on computer simulation models. The codes should spell out in implementable terms alternative cropping strategies and contingency plans. Along with Drought and Flood Codes, a Good Weather Code should be developed for each agro-climatic region, in order to help in maximizing production during good monsoon season.

C. Meeting the challenge of sea

level rise

The strategy should include the following components.

- Developing Mangrove and non-mangrove **bio-shields** to minimize the impact of coastal storms and sea water inundation.
- Promoting **Sea Water Farming** through agri-aqua farms.
- Promoting **Below Sea Level Farming**, as already practiced by farmers in the Kuttanad area of Kerala.
- Breeding salinity tolerant crop varieties for cultivation in coastal areas, based on genetic engineering techniques.
- Preparing contingency plans for the resettlement of climate refugees.

2010 marks the 80th anniversary of Gandhiji's Dandi March (Salt Satyagraha), which emphasized that sea water is a social resource. 97% of the global water is sea water. We should launch a dynamic programme in the area of sea water farming involving salt tolerant crop varieties, agro-forestry and marine aquaculture.

D. Livestock

A Food and Fodder Security Plan should be developed to safeguard our Dairy, Poultry, Sheep and Wool and other animal based enterprises which are the ones coming to the rescue of families living in the desert and semi-arid areas. Fodder and Food Banks should be developed with the help of local self-help groups (SHGS).

Mitigation and Adaptation strategies

Mitigation efforts should include both carbon sequestration through green plants and building Soil Carbon Banks through fertilizer trees, which enhance soil nutrient status. Soil carbon enrichment will help to enhance **fertilizer use** efficiency and thereby help to reverse diminishing factor productivity. A Farm Pond to collect rain water, a biogas plant and a few fertilizer trees in each farm should be promoted in rainfed areas.

Adaptation Measures should include the steps already indicated. In addition, green house horticulture should



be promoted to take advantage of higher carbon dioxide content in the atmosphere. Arid and semi-arid horticulture combined with animal husbandry, and agro-forestry systems of land use, will help to enhance both livelihood and nutrition security.

Lord Linthgow who chaired the Royal Commission on Agriculture in 1925 mentioned

"However efficient the organisation which is built up for demonstration and propaganda be, unless that organisation is based on the solid foundation provided by research, it will be merely a house built on sand"

It is hence important that we pay attention to strengthening the research and development infrastructure essential for sustainable food security in an era of climate change.

Research and Development Infrastructure:

Research and Training Centres for Climate Risk Management.

According to ICAR, there are 15 major agro-climate zones and 128 mini-agro-climatic zones. We **should establish in each of the 128 zones, a Research and Training Centre for Climate Risk Management**. These can be virtual centres headed by an agricultural scientist with computer simulation capability. He/she should prepare computer simulation models of alternative weather probabilities and suggest how to checkmate the

adverse effect. Each of these Centres should have the following facilities to convert plan into action.

- a) A village Resource Centre with Satellite Connectivity established with the help of ISRO.
- b) A Meteorological Station, capable of facilitating farm decisions on the basis of integrated weather forecasts.
- c) A Seed Bank containing seeds of the alternative crops to be sown, if the first crop fails due to drought or flood.
- d) A Fodder and Feed Bank to cater to the needs of Farm Animals.
- e) A Grain Bank should be established adjoining each Centre particularly with reference to underutilized crops like millets, ragi etc as well as bajra, jowar and maize.

Capacity Building : The Research and Training Centre for Climate Risk Management should train at least one woman and one male member of every Panchayat as **Climate Risk Managers**. They should be well versed in the art and science of climate risk management.

In each of the major agro-climate zones, there should be warehousing and safe storage facilities at least for a million tonnes of food grains. Such a decentralised network of Grain Banks will help to respond quickly to urgent needs.

Noted Agriculture Scientist and MP (Rajya Sabha)

Horticulture

Keeping Health and Happiness

A look at horticultural scenario in India gives a picture of tradition, diversity a highly demanding sector. It has gained its credibility for providing sustainable income, nutritional security and for providing employment opportunities, both in rural and urban areas, besides contributing about 30 per cent of the GDP in agriculture. Changing dietary habits of the Indian population with improved standard of living has increased the demand for horticultural products. It contributes

respectively. With the growth trend, horticulture is expected to play a dominant role in the overall development of agriculture in the country in the coming years. Moreover, the farmers of the country are eagerly looking for avenues for diversifying their crops through interventions in horticulture.

Fruits and vegetables, together, constitute about 92.4% of the total horticultural production in the country. The area under fruit crops is 6.48



Dr. Gorakh Singh



the sector by developing innovative models, linking farm to fork.

Growth trend in Horticulture

Production base of horticultural crops has increased considerably as compared to the situation a couple of decades ago. Area under horticulture crops has increased from 12.77 million ha in 1991–92 to 21.15 million ha in 2009–10 with the corresponding increase in production from 96.52 million tonnes to 226.87 million tonnes, with a productivity level of 11.35 tonnes/ha. Thus, there has been a phenomenal increase in area and production during this period amounting to 65 and 135 per cent,

million ha with a production of 73.52 million tonnes, which contributes 32.40% share in total production. While India is the second largest producer of fruits in the world, it is the largest producer of fruits likes mango, banana, papaya, sapota, pomegranate and aonla. In terms of productivity of grapes, India ranks first in the world.

Among the horticulture produce, vegetable is one of the very important sector, which occupies 8.21 million ha with total production of

136.19 million tonnes having a productivity of 16.58 tonnes/ha. The area under vegetables in India increased from 5.59 million ha in 1991–92 to 8.21 million ha during 2009–10. The production in this period increased from 58.53 to 136.19 million tonnes, which contributes approximately 60.0 per cent share of total horticulture production.

India is the second largest producer of vegetables after China and is a leader in the production of peas and okra. Besides, India occupies the second position in the production of brinjal, cabbage, cauliflower, onion, potato and third in tomato in the world. Vegetables that are produced in abundance are potato, onion, tomato, brinjal, okra, cucurbits, etc.

India has made noticeable advancement in the production of flowers, particularly cut flowers, which have a high potential for exports. Floriculture





during 2009-2010 covered an area of 0.18 million ha with a production of 10.17 million tones of loose and 5076.0 million numbers of cut flowers.

India is the largest producer, consumer and exporter of spices and spice products in the world. Over 100 plants spices are known to yield spices and spice products among which around 50 are grown in India. The spice production in India is of the order of 4.01 million tonnes from an area of about 2.46 million ha.

The total production of plantation crop during 2009-10 has been 11.24 million tonnes from an area of 3.25 million ha. Coconut accounts for the major share of the production of plantation crops, followed by cashew nut and areca nut. There has been consistent increase in import of cashew nut, which is providing good remuneration to the farmers.

In terms of bio-diversity, India is considered a treasure house of valuable medicinal and aromatic plants, which provide raw material for formulation of indigenous medicines apart from exports. The Government of India has identified and documented over 9,500 plant species considering their importance in the pharmaceutical industry. Of these, about 65 plants have huge and consistent demand in world trade. There has been appreciable increase

in the area and production of medicinal and aromatic plants over the years.

The Department of Agriculture and Cooperation (DAC) identified some of the fruits (mango, grapes, litchi, mandarins, kinnow, cashew, walnut, pomegranate, aonla), vegetables (potato, onion, chilli, bitter

gourd, okra), spices (black pepper, ginger, turmeric, cumin, large cardamom) and floriculture crops / items (rose, cymbidium orchid, anthurium, cutgreens and dry flowers) for export promotion. In the processed products sector, mango pulp, canned mushroom and gherkins, banana puree, tomato puree, tomato paste, aonla, bael, cashew and apple juice are identified as having good export potentials.

In India, the level of processing has been low, being only 2 per cent of fruits and vegetables. As processing is becoming increasingly important to help farmers to realize a better price, certain indigenous value added products like fruit drinks from lesser known fruits including health drinks have been developed.

Important Initiatives in Horticul-



ture Development

The development of horticulture in the country is mainly through developmental programmes of the Department of Agriculture & Cooperation (DAC). Recognizing the importance of the horticulture sector in the overall growth of the agriculture sector, a major boost was given for the development of horticulture during the VIII Plan by increasing the outlay for the sector from 27 crore to 1000 crore. Consequently 11 Central / Centrally Sponsored Schemes were launched to cover almost all the major horticultural crops. Special interventions were taken up for increasing productivity through use of plastics in agriculture, including drip irrigation and pollination support through bee keeping.

Horticulture Mission for North East and Himalayan States

The focus of the erstwhile schemes, remained on production and productivity improvement by way of supply of quality planting material, area expansion and disease management. Practically, no emphasis was laid on post harvest management and marketing. This approach was modified during the year 2001-02 (end of IX plan) with the launch of the Technology Mission for Integrated Development of Horticulture in the North Eastern (TMNE) States which was further extended to the Himalayan States of Himachal Pradesh, Jammu & Kashmir and Uttarakhand in 2003-04.

The Technology Mission addressed each of the segments of horticulture development covering horticulture research, production & productivity improvement, post harvest management (PHM), marketing and processing through four Mini Mission (MM) i.e. MM – I for Research, MM – II for Production, MM –

III for PHM & Marketing and MM – IV for processing. The scheme aimed at the holistic development of all the horticulture crops in all the districts of the North Eastern and Himalayan States. The scheme has now been renamed as Horticulture Mission for North East and Himalayan States (HMNEH) with effect from 2010-11. Horticulture mission for North East and Himalayan States has emerged as the most significant contributing factors to bring about a revolutionary change in the entire horticultural scenario of the regions and it has become a people's programme now. Under the scheme, 1000 new nurseries have been setup, an area of about 5.19 lakh ha has been brought under new gardens of various horticulture crops, about 0.05 lakh ha of old and senile plantations has been rejuvenated to regain the production potential from these plantations. An area of 0.49 lakh ha has been covered under organic farming and 17862 Vermi Compost Units have been established. Total numbers of 10979 community water harvesting bodies have been created. Under the Post Harvest Management component, 35 cold storage units, 10 refrigerated vans, 64 processing units have been set up. Besides, 47 Wholesale markets and 344 rural primary markets/ apni mandies have already been established which helps in proper handling and marketing of horticulture produce.

National Horticulture Mission

Looking into the success of the mission mode approach vis-à-vis schematic mode, the National Horticulture Mission (NHM) was launched during 2005-06 for the holistic development of horticulture in the country. The NHM envisages an end to end approach for the holistic development of horticultural crops having potential for development and marketability in identified clusters. The idea is to pool the available resources for overall development in identified pockets within a stipulated period of time rather than spreading it thinly over large areas. The major thrust areas under NHM

and HMNEH are setting up nurseries for production of quality planting materials, area expansion, rejuvenation of old orchards, high density planting, canopy management, protected cultivation, organic farming, IPM, INM, creation of packhouse / on farm handling, collection and storage unit, pre cooling unit, mobile pre cooling unit, cold storage units (construction / expansion / modernization), CA/MA storage units, refervans, containers, primary / mobile / minimal processing unit, ripening chamber, evaporative / low energy cool chamber, preservation unit, low cost onion storage, Pusa zero energy cool chamber and market infrastructure development as planned activities.

Under NHM, 2205 new nurseries have been setup, additional area of about 16.56 lakh hectare has been brought under new gardens of various horticulture crops and 2.78 lakh hectare of old and senile orchards has been rejuvenated. An area of 1.37 lakh hectare has been put under organic farming. Integrated nutrient management (INM) and integrated pest management (IPM) has been adopted in an area of 7.48 lakh hectare apart from setting up of 307 INM/IPM infrastructure (66 disease forecasting units, 78 bio control labs, 95 plant health clinics, 68 leaf/tissue analysis labs). Under post harvest management component, funds have been provided for setting up of 1328 pack houses, 343 cold storage





units, 5 CA storage, 30 refrigerated vans, 346 mobile/primary processing units. To ensure proper handling and marketing of horticulture produce, funds have been provided for setting up of 32 whole sale markets and 298 rural markets.

National Horticulture Board

The NHB was established in 1984 as an autonomous registered society under DAC. Its main objectives are the creation of production hubs for commercial horticulture development, post-harvest infrastructure and cold chain facilities, promotion of new technologies, introduction and promotion of new crops, and promotion of growers' association. During 2009-10, the NHB has sanctioned 4,370 integrated hi-tech commercial horticulture projects. Till now Board has provided assistance for setting



up of 2333 cold storages across the country having storage capacity of 9.8 million MT. Most of these facilities are used for storages of potatoes.

Coconut Development Board (CDB)

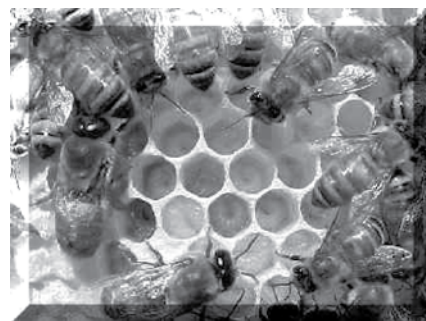
The Coconut Development Board is a statutory body set up by the Government of India for looking after the integrated development of coconut



cultivation and industry in the country. Coconut provides food and Livelihood security to more than 10 million people across 18 states and three UTs in the country. There are five million coconut holdings in the country, and the average size of these holdings is less than one hectare. India accounts for 15.65 per cent of area and 24.14 per cent of production in the world. Some of the thrust areas covered by CDB are: production and distribution of quality planting material, expansion of the area under coconut cultivation, especially in potential and non-traditional areas, improving the productivity of coconut in major coconut producing states, developing technology in post-harvest processing and marketing activities, integrated control of major pests and diseases and product diversification and by-product utilization of coconut for value addition as planned activities.

National Bee Board

In view of the tremendous scope for increasing productivity through pollination and increase in income through apiculture, the National Bee Board (NBB) was formed in 2000 with public-private participation in-



cluding the farmers/beekeepers, processors and other stakeholders. The main objective of the NBB is overall development of scientific beekeeping in India by popularizing state of art technologies relating to nucleus stock production, capacity building and training of bee breeders and beekeepers, processing and quality control of bee products, etc. and to increase the productivity of crops

through pollination and increasing the honey production for enhancing the income of the beekeepers/farmers.

National Bamboo Mission

The National Bamboo Mission was launched in 2006-07 as a centrally sponsored scheme to promote the growth of bamboo sector. The programmes address four major areas of bamboo development namely (i) Research & Development, (ii) Plantation Development, (iii) Handicrafts Development, and (iv) Marketing. An area of 1,36,263 ha (forest area



93,693 ha and non-forest area 42,570 ha) has been brought under bamboo plantations. To supply quality planting material, 1164 bamboo nurseries have been established under public and private sectors. Three bamboo bazaars and 10 bamboo wholesale / retail markets were established for promotion of marketing of bamboo and its products.

National Mission on Micro Irrigation

Micro Irrigation led agriculture, armed with knowledge & technologies; with farmer centric approach is one of the important intervention to attain sustained & enhanced agricultural production & productivity. Adoption enhances water, fertilizer & energy use efficiency through optimum utilization of agri inputs thereby promoting precision farming. The recent drought again brings into sharp focus the need for conserving our resources.

A centrally sponsored scheme on Micro Irrigation was launched in 18 states in 2006 for promoting drip & sprinkler technologies through supply

of equipments. The scheme provided 50% financial assistance to small & marginal farmers for technology adoption & 75% for technology demonstration. The technology provides not only 40-70% enhanced productivity but also 40-60% water saving, optimum use of various inputs & improved quality of produce. An area of 2.77 lakh ha under drip irrigation & 3.2 lakh ha under sprinkler irrigation has been covered in 2009-10. This has increased the gross area coverage at 1.9 and 3.1 million ha, respectively for drip and sprinkler.

To review the status of adoption of MI technology, a National level survey was initiated at the grass root level which highlighted the need for expansion of the scheme across the country. This has led to the launching of National Mission for Micro Irrigation (NMMI) during 2010-11.

Central Institute for Nagaland (CIH)

Recognizing the importance of institutional support for the development of horticulture in the North East region, Government of India has established a Central Institute of Horticulture in Nagaland, during 2005-06.

The thrust areas for the Institute are (i) refinement / demonstration of identified technologies specific for the region, (ii) production and supply of quality seed and planting material of improved/high yielding varieties and (iii) training of state department officials and field functionaries



in selected aspects of horticulture development including post harvest management, processing and value addition.

Precision Farming Development Centre (PFDC)

Recognizing the importance of hi-tech horticulture and precision farming methods for overall development of horticulture sector, the Government of India has set up 22 Precision Farming Development Centres (PFDCs) in various states throughout the country. These PFDCs are working on development of hi-tech applications and precision farming methods, their demonstration and transfer of technologies to farmers' fields. They also provide necessary technical support to scheme implementing agencies in their respective states under NHM, MI, & HMNH.

New Initiatives

New interventions have been included in both the Schemes (NHM and HMNH) such as High Density Plantations (HDP) / Canopy Management, Horticulture Mechanization and certification of Good Agricultural Practices (GAP). Besides, the cost norms of some of the activities like setting up of nurseries, area expansion and protected cultivation have revised to provide better incentives to the farmers for adopting improved technologies and cultivars. The cost norms and pattern of assistance for Post Harvest Management (PHM) have been enhanced to encourage private sector participation in building PHM infrastructure.

**Horticulture Commissioner,
Ministry of Agriculture,
Government of India**

Integrated Pest Management Impact and Challenges

Dr. Ashok Dhawan

During the next two decades, the world will have to feed 2.5 million people with less land and renewable resources. Over half of the world population growth will occur in Asia and one third in African countries. The challenges will be more in under-developed countries, where the population growth is very high compared to the growth in the agriculture sector. Moreover, growing awareness about the quality of food will further throw challenge on increasing production. The green revolution though has increased world food but at the same time has created many ecological, environmental and socio-economic problems. All these practices favoured the buildup of crop pests and many minor pests have taken the status of new pests and several new pest problems has appeared (Table 1). Even today insect pests are one of the limited factors in increasing the crop productivity worldwide. The global losses due to various insect pests vary with crop, geographical location, and pest management options. Immigration of new pest, introduction of new crops/cropping systems, and crop intensification has resulted in significant change in pest populations. The estimated losses in world due to insect pests are 2.8 per cent higher in post green revolution era than in green revolution era. In India the loss is 16.1 % more than in green revolution era (Table2). The loss in different crops varies from 5-30 % in Indian the monetary value is 86388.4 crores (Table 3). It is estimated that by adopting better pest management practices these losses can be reduced by 42.6 %. In case of no insect control, losses can be as high as 69.8 %. Challenges are to reduce the losses due to pests by integrating various management options. Over-reliance on the use of pesticides has resulted in environmental pollution,



ground water contamination, pest resurgence, and poisoning of food material, animals and human beings. In addition, it also affected the agricultural trade where several agricultural commodities were rejected due to the accumulation of pesticide residues. The sustainable pest management practices have to be ecologically-sound, economically-viable, socially-justifiable, and adaptable. Pest management is an ecological approach of

reducing the pest damage to a great extent and determines the management strategy. However, if pest management is faulty it will help the pests to develop and expand their populations or, conversely, make natural enemies ineffective. Therefore, for an effective pest management program, it is essential to consider ecological concepts that can be applied to the design and management of the system to better manage pests and their parasitoids and predators.

"Integrated pest management is a pest management system that in the socio-economic context of farming systems, the associated environment and the population dynamics of the pest species, utilizes all suitable techniques in as compatible manner as possible and maintains the pest population levels below those causing economic injury". Integrated Pest Management is an effective and environmentally-sensitive approach to pest management that relies on a combination of common-sense practices.

Over the centuries, farmers developed a number of mechanical, cultural, physical, and biological control

Table 1. New pest problems due to change in climate and ecosystem

- **American bollworm** - Cotton, chickpea, pigeon pea, tomato, sunflower
- **Whitefly** - Cotton, tobacco, vegetable crops
- **Brown planthopper** - Rice
- **Leaf miner** - Cotton, cucurbits, tomato, vegetables
- **Fruitfly** - Fruits, vegetable crops
- **Mealy bugs** - Various crops
- **Thrips** - Many crops
- **Aphid** - Wheat
- **Pink stem borer** - Rice, Wheat
- **Gall midge** - Rice, fruit crops
- **Hoppers** - Many crops
- **Pyrilla** - Sugarcane

Table 2. Worldwide crop losses due to insect and mite pests during pre- and post-green revolution era

Crop	Losses (%)		
	Pre-green revolution (1965) (1)	Post-green revolution (1988-90) (2)	Changes in loss (2-1)
Barley	3.9	8.8	+ 4.9
Cotton	16.0	15.4	- 0.6
Maize	13.0	14.5	+ 1.5
Potatoes	5.9	16.1	+ 10.2
Rice	27.5	20.7	- 6.8
Soybean	4.4	10.4	+ 6.0
Wheat	5.1	9.3	+ 4.2
Average	10.8	13.6	+ 2.8

measures to minimize the damage caused by phytophagous insects. Synthetic organic insecticides developed during the mid 20th century initially provided spectacular control of these insects and resulted in the abandonment of traditional pest control practices. The increasing insect pests problems encountered with the use of insecticides resulted in the origin of integrated pest management (IPM). IPM does not only include strategy but also to educate and encourage agricultural producers to grow crops using pest management methods that aimed at:

- Reducing, if not replacing, the use of synthetic organic pesticides
- Environment safety
- Posing minimal risk to human health
- Enabling growers to obtain a reasonable return or investment
- Ensuring consumers a supply of high quality, safe and economical foods and other agriculturally related products

IPM IN INDIA

IPM gained a momentum and attained the status of social movement under the ambit of total crop production programme, particularly with the help of externally aided projects sponsored by FAO, ADB and UNDP and also by huge domestic plan allocation. Since 1993, much emphasis is being given to human resource development in IPM technology through rigorous field oriented training of state

extension functionaries and farmers. Training programmes envisage their tier approach comprising of (i) residential training to master trainers through Season Long Training (SLT), (ii) training of agriculture extension officers (AEOs) and farmers through establishment of farmers' field schools (FFSs) and (iii) popularization of IPM practices among the farmers through conduct of IPM demonstrations. Introduction of IPM has brought the following changes in the approach and strategy of scientists, technocrats, farmers, and policy makers with regards to crop protection.

1. Policy change: The government of India has withdrawn all kinds of subsidy and encouragement aimed

for the enhanced use of pesticides. Instead, the government is promoting exploitation of natural biocontrol potential, use of resistant/tolerant varieties and cultural operations so as to minimize pesticide.

2. Awareness towards health of environment and man: Recent upsurge insecticide related social environmental and economic problems forced society at large and farmers and pest managers specifically, to relook and to rethink about their decision to use pesticide. Now, advanced farmers in villages are aware of food chain getting contaminated with pesticides and their impact on human health. As a result, farmers go for pesticide use only when other options are already exhausted.

3. Decline in pesticide use: There is substantial reduction in pesticide consumption, which declined from 75000 MT in 1990-91 to 6300 MT in 1993-94 and to 43860 in 2008-9. In Punjab, Andhra Pradesh and Tamil Nadu, farmers used to apply 10-20 sprays in cotton which has come down to 5-7 sprays due to adoption of IPM strategy.

4. Banning of hazardous pesticides: Contamination of ecosystem with pesticides and associated hazards to human health, environment and deleterious effects on natural bio-control agents inspired the government to ban already registered but

Table 3. Losses due to different insect pests in different crops in India

		%	Total (million tones)	
Cotton	44.03	30	18.9	339660
Rice	96.7	25	32.2	240138
Maize	19	20	4.8	29450
Sugarcane	348.2	20	87.1	70667
Rapeseed mustard	5.8	20	1.5	26100
Groundnut	9.2	15	1.6	25165
Other Oilseeds	14.7	15	2.6	35851
Pulses	14.8	15	2.6	43551
coarse cereals	17.9	10	2.0	11933
Wheat	78.6	5	4.1	41368
Total				863884

*Production and minimum support price (MSP) fixed by Government of India for 2007-08.

most hazardous pesticides. Consequently 27 pesticides have already been banned, 18 pesticides have been refused registration, 25 are under review and 11 are allowed for restricted use only.

5. Promotion of biopesticides: Microbial pesticides and pesticides of plant origin are compatible with IPM, and are being popularized by the government and NGOs amongst farmers.

IPM IMPLEMENTATION

Numerous attempts have been made during the last two decades to implement IPM in different regions of the world. But maximum efforts have been directed towards cotton, a crop which receives a disproportionately high amount of pesticides around the globe. There are many successful examples of IPM implementation on cotton in South and North America and Australia. In Asia success of IPM in rice provides one of the best examples of its implementation in the tropical developing countries. Both these crops provide excellent examples for understanding the progress and problems in IPM implementation.

IPM technology in rice

The IPM technology on basmati rice was disseminated in the districts of Amritsar, Taran Tarn and Gurdaspur. The cost of sprays in IPM villages ranged from Rs 2344 to 2358 with the average of Rs 2350 per hectare, however it was Rs 4596 to 4608 in non-IPM villages with the average of Rs 4603 per hectare. The average cost of cultivation was Rs 18739 per hectare in IPM villages; however it was Rs 21020 per hectare in non-IPM villages. Basmati rice yield of IPM farmers ranged from 4281 to 4327 Kg per hectare, however in non IPM villages it was 3731 to 3913 Kg per hectare. The average net return of the IPM farmer was Rs 88869 (range Rs 88251 to 88929) per hectare which was Rs 14389 per hectare more than that of non-IPM villages. In the nut shell IPM farmers gain more profit by increasing the yield and decreasing the cost of cultivation as compared to non-IPM farmers.

IPM technology in maize

The IPM technology on maize was disseminated in the districts of Hoshiarpur and Nawanshr. The cost of sprays in IPM villages ranged from Rs 767 to 833 with the average of Rs 800 per hectare, however it was Rs 1228 to 1247 in non-IPM villages with the average of Rs 1238 per hectare. The average cost of cultivation was Rs 10477 per hectare in IPM villages; however it was Rs 12631 per hectare in non-IPM villages. The cost of cultivation includes cost of land preparation, cost of sowing, cost of hoeing and thinning, cost of weeding, cost of irrigation application, cost of fertilizer application, cost of spraying and cost of harvesting and threshing. Maize yield of IPM farmers ranged from 5335 to 5386 Kg per hectare, however in non IPM villages it was 5078 to 5085 Kg per hectare. The average net return of the IPM farmer was Rs 27047 (range Rs 26646 to 27447) per hectare which was Rs 4107 per hectare more than that of non-IPM villages. In the nut shell IPM farmers gain more profit by increasing the yield and decreasing the cost of cultivation as compared to non-IPM farmers.

NEW CHALLENGES AND FUTURE PROSPECTS

During the last two decades IPM has moved from a peripheral position to the central stage of agricultural production programmes. The desirability of controlling pests by the use of integrated pest management is no longer questioned. A variety of techniques have been developed and refined for controlling different insect pests. Farmer-centered methods have resulted in successful implementation of IPM in rice in parts of South-east Asia. South American countries showed the way to cotton IPM. Greater challenges, however, lie ahead. The value of pesticides in protection of crops can be questioned when it is noted that estimated percentage losses in food production attributed to pests are as great today as they were 50 years ago when organic pesticides began to be widely used. The pesticides debate will continue and pesticides will contribute to pest control for some time. The future prospect and

challenges of IPM are:

1. Good pesticide management practices are essential to reduce the losses and to minimize the negative effect of these toxic chemicals on health, environment and socio-economic status of the farmers. Emphasis should be placed on the development of pesticides that are active at lower doses, more specific for the target organisms, less toxic to the user, consumer, wildlife, biocontrol agents, and less persistent in the environment. Continued improvements are needed in pesticide application technology and in methods to manage or prevent pesticide resistance in pests.
2. Research must continue on genetic approaches to pest resistance in plants.
3. Biological control is an emerging technology to control pests, diseases and weeds. Genetic engineering will play a vital role in production of transgenic biocontrol agents having biocontrol potential and ecological acceptability.
4. In implementing classical IPM or comprehensive IPM, improved methods for integrating information will be required. Pesticides must be integrated with other pest control technologies-including genetic resistance in plants, cultural practices, biological control, and biotechnology.
5. IPM and other forms of pest management were built on the pre-existing research basis. The challenge before us is to develop new science, new technology, new management skills and new concepts of integration in order to control plant pests, protect our environment and provide a continuous supply of safe and nutritious food in abundance for a rapidly expanding world population. Hopefully, all the stakeholders including scientist, industry, government and farming community will work hand-in-hand to develop and implement innovative IPM strategies targeted towards a sustainable crop protection technology in the coming years and will share the responsibility to protect public health and environment.

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Relevance of Bt-Crops

Introduction

Insect pest management in agriculture is important to safeguard crop yields and productivity. Chemical insecticides that effectively control insect pests have been proven to be harmful to human health and environment. There is a need to reduce the dependence on pesticides by using safer alternatives to manage insect pests. Many insecticidal proteins and molecules are available in nature, which are effective against agriculturally important pests but innocuous to mammals, beneficial insects and other organisms.

Insecticidal proteins present in the soil borne bacterium, *Bacillus thuringiensis* (Bt), which has demonstrated its efficacy as a spray formulation in agriculture over the past five decades, have been expressed in many crop species with positive results.

Three such transgenic crop species (cotton, corn and potato) have been commercialized with substantial benefits

to the farmers. Bt crops occupy an area of 42 million hectares out of the global transgenic area of 134 million hectares in 2009. In India, Bt cotton was cultivated in more than 8.0 million hectares.

Bacillus thuringiensis

Bt is a gram-positive, aerobic, endospore-forming bacterium belonging to morphological group I along with *Bacillus cereus*, *Bacillus anthracis* and *Bacillus laterosporus*. All these bacteria have endospores. Bt, however, is recognized by its parasporal body (known as the crystal) that is proteinaceous in nature

and which possesses insecticidal properties. The parasporal body comprises of crystals varying in size, shape and morphology. The crystals are tightly packed with proteins called protoxins or δ -endotoxins. The first record on Bt goes back to 1901, when a Japanese microbiologist Ishiwata discovered a bacterium from diseased silkworm larvae, which he named *Bacillus sotto*. Between 1909 and 1912, Berliner, working at a research station for grain processing in Germany, investigated an infectious disease of the Mediterranean flour moth and described a spore-forming



bacterium as the causative agent and designated it as *B. thuringiensis*.

There are many subspecies and serotypes of Bt with a range of well-characterized insecticidal proteins or Bt toxins (δ -endotoxins). At present it has been estimated that over 60,000 isolates of Bt are being maintained in culture collections worldwide. Known Bt toxins kill subsets of insects among the Lepidoptera, Coleoptera, Diptera and nematodes. The host range of Bt has expanded considerably in recent years due to extensive screening programs. Currently more than 150 different genes encoding



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Bt toxins have been cloned. Recent information about Bt toxins/genes can be obtained from http://www.biols.susx.ac.uk/Home/Neil_Crickmore/Bt/.

Mode of action

The Bt toxins exert their toxicity by forming pores in the larval midgut epithelial membranes. Initially the protoxins are activated in the midgut by trypsin-like proteases to toxins. The active toxins bind to specific receptors located on the apical brush border membrane of the

columnar cells. Binding is followed by the insertion of the toxin into the apical membrane leading to pore formation. The formation of toxin-induced pores in the columnar cell apical membrane allows rapid fluxes of ions. Different studies revealed that the pores are K^+ selective, permeable to cations, anions or permeable to small solutes like sucrose, irrespective of the charge. It appears that the toxin forms or activates a relatively large aqueous channel in the membrane. The disruption of gut integrity results in the death of the insect from

starvation or septicemia.

Applications of Bt

The first practical application of Bt dates back to 1938 when it was sold as 'Sporeine' in France for the control of European corn borer. The growing realization that organic insecticides are deleterious to the environment and human health spurred a renewed interest in Bt in the 1960s, which led to the introduction of viable Bt biopesticides like Thuricide and Dipel. Bt is the most popular biological control agent with worldwide sales of about \$100 million. Bt spray formulations comprise 5% of total global pesticide market. The use of conventional Bt biopesticides, however, was found to have limitations like narrow specificity, short shelf life, low potency, lack of systemic activity, and the presence of viable spores.

An elegant and the most effective delivery system for Bt toxins is the transgenic plant. The major benefits of this system are economic, environmental, and qualitative. In addition to the reduced input costs to the farmer, the transgenic plants provide season-long protection independent of weather conditions, effective control of burrowing insects difficult to reach with sprays and control at all of the stages of insect development. The important feature of such a system is that only insects eating the crop are exposed to the toxin. Genetic transformation of almost all the major crop species is now feasible with the development of an array of techniques ranging from the *Agrobacterium* approach to electric discharge-mediated particle acceleration procedure (Pattanayak et al., 2000).

The initial attempts to introduce and express native Bt genes encoding protoxins or truncated toxins in plants were not very successful because the levels of toxin expression were very low. In 1990, researchers at Monsanto made a significant advancement in the expression of Bt genes in plants. They noticed that Bt genes were excessively AT rich in comparison with normal plant genes. This bias

in nucleotide composition of the DNA could have a number of deleterious consequences to gene expression because AT-rich regions in plants are often found in introns or have a regulatory role in determining polyadenylation. Introduction and expression of codon-modified genes in crop plants conferred significant protection against target pests. The first transgenic Bt-crops viz., cotton, corn and potato were commercialized in USA in 1995 and 1996. Currently more than a dozen countries cultivate Bt-crops. In 2009, China's Ministry of Agriculture released biosafety certificates for Bt rice Huahui No. 1 and Bt Shanyou 63 with possible planting in 2012. Bt-cotton was permitted for commercial cultivation in India in 2002, which has brought about a revolution in cotton production.

Benefits of Bt-crops

In the past fifteen years, all the countries that have introduced Bt cotton and maize have derived significant and multiple benefits. These include increases in yield, decreased production costs, a reduction of at least 50% in insecticide applications, resulting in substantial environmental and health benefits to small producers, and significant economic and social benefits.

Bt maize: Globally, the farm level benefit of using Bt maize cumulatively since 1996 has been \$6.34 billions. In terms of the total value of maize production from the countries growing Bt maize in 2008, the additional farm income generated by the technology is equal to a value added equivalent of 2.2%.

Bt cotton: Globally, the farm level



benefit of using Bt cotton cumulatively since 1996 has been \$15.61 billions. In terms of the total value of cotton production from the countries growing Bt in 2008, the additional farm income generated by the technology is equal to a value added equivalent of 19.3%. The economic benefits of Bt cotton in India have been enormous and well documented (<http://www.apcoab.org/publications.html>) Millions of farmers benefited from Bt cotton in developing countries such as China, South Africa too where Bt cotton contributed to the reduction in poverty by increasing incomes of small farmers.

The environmental benefits of cultivating Bt crops are:

1. Reduction in use of pesticides: The cumulative reduction of pesticide applications due to Bt crops from 1996-2008 is estimated to be 356 million kilograms of active ingredient.
2. Less insecticides in aquifers and the environment: The substantial decrease in insecticides associated with the cultivation of Bt cotton has led to significant decrease in insecticide run off into watersheds, aquifers, soils and generally into the environment. More widespread global cultivation of Bt-cotton will further improve the water quality.
3. Reduced farmer exposure to insecticides and improvement of human health: Chemical insecticides used in cotton have high toxicity to humans

and animals. Substitution of the chemical insecticides with Bt cotton has clearly reduced the risks to farm workers and to others in the farm community who may be exposed. These effects are particularly important in developing countries where modern application techniques are neither always adopted nor available for use.

4. Increased populations of beneficial insects: The global use of broad spectrum insecticides on cotton has adversely affected and decreased the populations of non-target species including the arthropod natural enemies that can provide effective control of non-lepidopteran pests. Various studies confirmed that the arthropod natural enemy populations in Bt cotton are greater than in non-Bt cotton. In addition to reducing the number of sprays for the bollworm/budworm complex, Bt cotton has also reduced the number of sprays for other insects such as thrips and aphids. This effect has been attributed to higher populations of beneficial predators and parasitic insects that are eliminated by insecticide sprays.
5. Reduced risk for wildlife: Reduction in the use of insecticides, many of which are highly toxic to wildlife will reduce the risks to mammals, birds, bees, fish and other organisms. Many birds are dependent on insects for food and their elimination through the use of insecticides deprives birds of their food source.
6. Reduced fuel and raw material consumption and decreased pollution: Lowering the demand for insecticides, through the use of Bt cotton reduces tractor fuel usage as a result of reduction in number of sprays, which in turn reduces air pollution.

Biosafety

Safety of Bt toxins in terms of toxicity and allergenicity towards mammals and other non-target organisms is well

documented. Lack of receptors that bind to Bt toxins and instant degradation of Bt toxins in human digestive system makes them innocuous to human beings. Community exposure to Bt toxins/spray formulations over a period of six decades has not resulted in any adverse effects. Human volunteers consumed Bt toxins at very high concentration without any undesirable effects. Lack of homology to any allergenic protein/epitope sequences makes Bt toxins non-allergenic. Extensive testing of Bt cotton and Bt maize has proven that the crops and the products derived thereof are totally safe. In India, Bt brinjal expressing Cry1Ac has been shown to be safe in various tests.

Insect resistance management

One of the important considerations of introduction of insect resistant transgenic plants into environment is to prevent the development of resistance in insects towards Bt toxins. Instances where resistance has developed in laboratory and field populations of Diamondback moth and Indian meal moth point towards great caution to be applied in the implementation of this technology. Various resistance management strategies have been suggested to prevent or delay the development of resistance to Bt. Proposed strategies include the use of multiple toxins (stacking or pyramiding), crop rotation, high or ultra-high dosages, and spatial or temporal refugia. Gene stacked Bt cotton is currently available which will ensure the longevity of the technology. The most promising and currently practical strategy is that of using refugia. This strategy calls for



reducing the possibility of long-term impact by preventing the creation of a resistant population. This is achieved by ensuring that there are always plenty of susceptible insects nearby for the few resistant ones to mate with.

Future perspectives:

Introduction of various Bt crops is extremely important towards achieving the goals of eco-friendly and sustainable pest management in agriculture. Deployment of Bt vegetables will go a long way to protect human health by reducing the pesticide use in vegetable crops, which are often consumed raw. There is an urgent need to develop pod borer-resistant pulses, which would usher in a revolution in pulse production in India. Caution is needed, however, while introducing a particular Bt gene in multiple crops. Large-scale bioprospecting of Bt strains will provide us novel Bt genes, which can widen the spectrum of insecticidal activity as well as ensure resistance management.

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Rainfed Agriculture Challenges of Climate Change

Dr. B. Venkateswarlu¹ and Dr. C.A. Rama Rao²

Agriculture in about 58 per cent of 141 m ha of net cultivated area in India is rainfed without access to any source of irrigation. Rainfed agriculture is mostly practiced in arid, semi-arid and sub-humid regions where the rainfall is low in quantity, erratic in distribution and is also characterized by high inter-year variability. The annual rainfall is less than 500 mm in about 15 m ha, 500 – 750 mm in 15 m ha and 750 – 1150 mm in about 42 m ha. Together with poor and degraded soils, this limits the length of growing season as well as the choice of crops that can be grown sustainably. Coarse cereals, pulses, oilseeds and cotton dominate the cropping pattern in the regions where rainfed agriculture is concentrated. Further, geography of rainfed agriculture and poverty largely overlap. In other words, regions where rainfed agriculture is predominant are poorer and underdeveloped making them more vulnerable to any external or environmental shocks like climate change and market risks.

There is now adequate evidence about the impending climate change and the consequences thereof. The fourth assessment report of IPCC observed that 'warming of climate system is now unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global sea level' (IPCC, 2007). Though climate change is global in its occurrence and consequences, it is the developing countries like India that face more adverse consequences. Globally, climate change is seen as a failure of market mechanisms wherein the polluters did not have to pay for the negative externalities (Stern, 2007).

Climate change projections made upto 2100 for India indicate an overall increase in temperature by 2-40C with no substantial change in precipitation quantity (Kavikumar, 2010). However, different regions are expected to ex-

perience differential change in the amount of rainfall that is likely to be received in the coming decades. The Western Ghats, the Central Indian and North Eastern parts of the country are projected to receive higher amount of rainfall. Another significant aspect of climate change is the increase in the frequency of occurrence of extreme events such as droughts, floods and cyclones. All of these expected changes are will have adverse impacts on climate sensitive sectors such as agri-



Dr. B. Venkateswarlu



Table 1. Projected changes in climate in India: 2070-2099

	January - March	April - June	July - September	October – December
Change in temperature (°C)				
Northeast	4.95	4.11	2.88	4.05
Northwest	4.53	4.25	2.96	4.16
Southeast	4.16	3.21	2.53	3.29
Southwest	3.74	3.07	2.52	3.04
Change in precipitation (%)				
Northeast	-9.3	20.3	21.0	7.5
Northwest	7.2	7.1	27.2	57.0
Southeast	-32.9	29.7	10.9	0.7
Southwest	22.3	32.3	8.8	8.5

culture, forest and coastal ecosystems and also on availability of water for different uses and on human health.

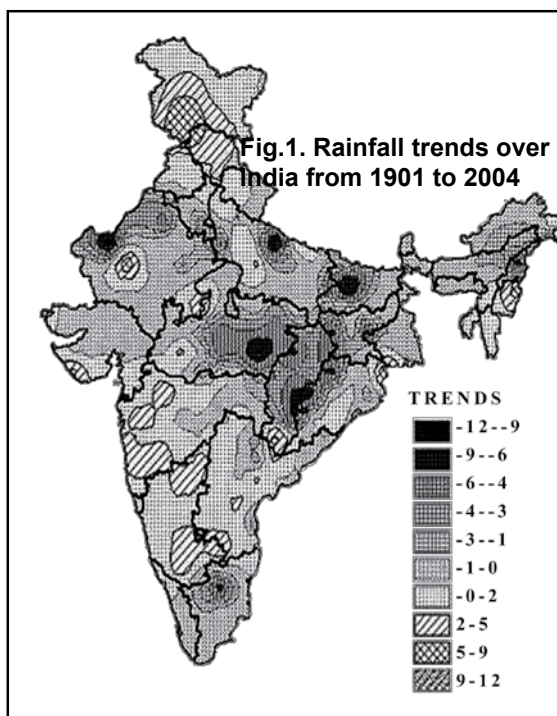
Within agriculture, it is the rainfed agriculture that will be most impacted for two reasons. First, rainfed agriculture is practised in fragile, degraded and sloppy lands which are thirsty as well as hungry and prone to erosion. Second, the people dependent on rainfed agriculture are also less endowed in terms of financial, physical, human and social capital limiting their capacity to adapt to the changing climate.

The following are some of the challenges that the changing climate will pose to rainfed agriculture:

Temperature is an important weather parameter that will affect productivity of rainfed crops. Last three decades saw a sharp rise in all India mean annual temperature. Though most rainfed crops tolerate high temperatures, rainfed crops grown during rabi are vulnerable to changes in minimum temperatures. Analysis of data for the period 1901-2005 by IMD suggests that annual mean temperature for the country as a whole has risen to 0.51oC over the period. It may be mentioned that annual mean temperature has been consistently above normal (normal based on period, 1961-1990) since 1993. This warming is primarily due to rise in maximum temperature across the country, over a larger part of the data set. However, since 1990, minimum temperature is steadily ris-

ing and rate of rise is slightly more than that of maximum temperature. Apart from direct impacts, higher temperatures also increase the water requirements of crops putting more pressure on the availability of water (Table 2).

According to Indian Meteorological Department (IMD), no significant trend is observed in the summer monsoon rainfall over the country on all India basis. However, significant changes were noted at the sub-divisional level. Three sub divisions, viz., Jharkhand, Chhattisgarh and Kerala show significant decreasing trend and eight sub-divisions viz. Gangetic West Bengal, West Uttar Pradesh, Jammu & Kashmir, Konkan & Goa, Madhya Maharashtra, Rayalaseema, Coastal Andhra Pradesh and North Interior Karnataka show significant increasing trends. A study carried out by CRIDA based on rainfall trends from 1901-2004 indicated that significant increase in rainfall is likely in West Bengal, Central India, Coastal regions, south Western Andhra Pradesh and Central Tamilnadu. Significant decreasing trend was observed in



central part of Jammu and Kashmir, northern MP, central and western part of UP, northern and central part of Chhattisgarh. In some areas, both the rainfall and number of rainy days are decreasing which is a cause of concern. It is to be noted here that the negative deviations in the monsoons are accompanied by a fall in foodgrain production in India.

The extent to which rainfall and temperature patterns and the intensity of extreme weather events will be altered by climate change remains uncertain, although there is growing evidence that future climate change is likely to increase the temporal and spatial variability of temperature and precipitation in many regions (IPCC, 2007). More than seasonal rainfall, the distribution is more important for dryland crops grown during kharif. Long dry spells have significant negative impact on fodder and grain production indirectly affecting the livestock production. Extreme events such as cold waves, heat waves, floods and high intensity single day rainfall events are on increasing trend during the last decade. For example, the 2002 drought across the country during kharif, the heat wave of May 2003 in AP, extreme cold winter in North during 2002-03, prolonged dry spell during July in 2004, abnormal temperatures during March, 2004 and

Table 2. Projected changes in water requirement and duration of different crops in Andhra Pradesh due to climate change by 2020

Zone	Location	Crop	Change in water requirement (mm)	Change in duration (weeks)
North coastal	Anakapalli	Maize	51.7	1
		Groundnut	61.3	1
Scare rainfall	Anantapur	Groundnut	70.1	1
		Pigeonpea	174.3	1
North Telangana	Jagityala	Cotton	60.5	2
		Maize	49	1
South Telangana	Rajendranagar	Pigeonpea	114.5	2
		Groundnut	73	1
South	Tirupathi	Groundnut	73	1

Source: Central Research Institute for Dryland Agriculture (2008)

January, 2005 in North, floods during 2005, cold wave during 2005-06, unusual floods in Rajasthan desert and drought in North-East 2006 and abnormal temperatures during January-February, 2007 in North and country wide drought during 2009 and floods in Andhra Pradesh and Karnataka are some extreme weather events which had significantly impacted agriculture. To sum up, expansion of rainfed agriculture as more and more regions become arid and semi-arid, increased risk of crop failures and climate-related disasters and decreased yields are the important challenges that the changing climate will lead to. These will result in further deepening of poverty and food insecurity and loss of livelihoods in the rainfed regions.

What to be done?

The international negotiations on climate change have now rightly recognized that adaptation is as important as mitigation in dealing with climate change as the world is already committed to certain extent of climate change and even the fullest possible mitigation efforts will not prevent the projected rise in temperature till 2100. Therefore, adaptation measures to climate variability and change need greater attention in terms of research, policy and institutional support.

Conservation of natural resources, especially soil and water, need to be given high priority, as it is these two factors that predispose a given region to a climate related disaster like an agricultural drought. Though there are a number of programmes such as DPAP, DDP, NWDPRA, NREGA initiated by the government from time to time, they need to be better coordinated and technically backstopped. Government policies should encourage cropping patterns and practices that conserve natural resources. Since conservation is as much a management issue as it is a technical one, appropriate and innovative institutional arrangements are to be nurtured and promoted.

The main adaptation strategies in agriculture include growing crops and varieties that fit into changed rainfall and seasons, development of varieties with changed duration that can over winter the transient effects of change, development of varieties for heat stress,

drought and submergence tolerance; evolving varieties which respond positively in terms of growth and yield under high CO₂. In addition, varieties with high fertilizer and radiation use efficiency and also novel crops and varieties that can tolerate coastal salinity and sea water inundation are needed. Intercropping is a time tested practice to cope with climate variability and climate change if one crop fails due to floods or droughts second crop gives some minimum assured returns for livelihood security. Germplasm of wild relatives and local land races could prove valuable source of climate ready traits. We need to revisit the germplasm collected so far which has tolerance to heat and cold stresses but not made use in the past due to low yield potential.

Putting in place an effective weather monitoring and early warning system is essential for minimizing the impacts of weather aberrations. Improvement of forecasting capabilities is an important first step in achieving a better preparedness for an imminent abnormal weather event. For this to happen, investments are to be made in generation of hydrological and meteorological data in a much more synchronized and coordinated manner. As the data collection responsibilities at present are now divided between ministries and departments, the utility of the data availability is also limited. The scientific capacity to predict the weather/climate should also be strengthened. Equally important is to communicate the predictions to all the stakeholders – farmers, government departments, finance and insurance institutions, etc. – in a form that is more relevant, understandable and actionable.

Making strategic investments for enhancing preparedness for the disasters in terms of keeping enough food stocks by quickly adjusting the policies related to procurement and trade of food grains. In addition, it is also required to be prepared for the health and medicare requirements that accompany disasters like floods. The climate linked disasters like droughts affect the economic decisions of the farmers not just when they happen but also during when they do not: the prospect of a drought will inhibit farmers in making investments for im-

proving productivity and similarly, the credit institutions will be discouraged to lend farmers in the drought prone areas fearing loss of capital advances. It is therefore required to popularize appropriate insurance policies for risk transfer. For example, carefully designed weather insurance policies will be helpful to farmers as well as to the government agencies. If the government agencies partly support the insurance premiums, they can be more certain about the availability of monetary resources that they require in the event of a disaster which can help speed up the relief operations. In fact the delay in taking up relief operations which is often attributed to lack of or slow release of funds causes the affected people to liquidate their assets for immediate survival. If this can be prevented, it will be highly useful for them to come back to their livelihood activities soon after the disaster.

Encouraging soil conservation and rain harvesting measures go a long way in drought proofing. Water harvesting and recycling through farm ponds and location specific land configurations like ridge and furrow method of planting help cope with dry periods as well as floods. Similarly, it is equally important that the natural stream courses are not disturbed by urbanization and industrialization as it will increase the probability of floods. There has to be a fine coordination between different departments concerned in this regard. Water harvesting both in rural and urban areas has to be taken up in a mission mode. Investments can be mobilized even by imposing a cess on luxurious consumption of water for non-essential sectors.

Timely dissemination of knowledge to the stakeholders is of utmost importance. The State Governments should develop contingency agricultural plans for each district and blocks and provide the necessary institutional support, so that farmers can be helped at a short notice in case of natural calamities induced by climate change. Promoting good agricultural practices – the INM, IPM, soil and water conservation practices, will protect the crops though the impacts are not dramatic in the short term.

Director, CRIDA, ICAR, Hyderabad

Nanobiotechnology

A cutting edge science

Challenges of this century are many. To name a few : energy crisis, shrinking water resource, fatigued green revolution, concern for soil health and biodiversity, GMO dilemma, rapid growing nanobio-food, nanobio monopoly – its uses and abuses etc. In this context, it is urgently required to concentrate towards the cost effective devices of non-conventional energy options, control the salinization and pollution of water, the soil health and biodiversity, eco-friendly repellent technology in place of Bt controversy, formulating policy, regulation and legacy for judicious and safer use of cutting edge science like nanobiotechnology. Nanoscience is the nexus of the sciences. It discusses phenomena of the 1– 100nm scale. At this scale, traditional boundaries between biology, chemistry and physics are not very distinguishable. Yet, nanotechnology plays important roles in all of these disciplines at macroscopic scale. The dominant forces in the nano-world are different from those in the macro world. The gravitational force loses its significance at nano scale but its surface area per unit volume matter much. Thus the scale of matter influences its nature and properties. For example, gold particle at 1 nm is blue in colour and at 3 nm scale it is of reddish colour.

“We shape our tools and forever after, they shape us.”

Nanobiotechnology is the intersection of biology and nanotechnology. Molecular biologist help nanotechnologists to understand and access the nanostructures and nanomachines designed by 4 billion years of natural en-

gineering and evolution- cell machinery and biological molecules.

Global Scenario

The world needs about 2 million nanotechnology literate workers to supply an anticipated global market of 1 trillion USD over the next one decade. Scientists, researchers, business managers, investors, funding agencies and governments worldwide all acknowledge the huge social and economic potential of nanobiotechnology, that is why public funding has increased from \$500 million in 1999 to almost \$4 billion in 2004. Scientific publications in nanotechnology have increased by a factor of six over the past ten years, and the number of nanobiotechnology patents has also increased substantially. However, the rate of growth has varied across the globe, and also between different areas of nanosciences.

Planned spending

- Japan : \$200,000million in total by 2010



Dr. N. C. Patel

- US : \$2027 million each year (until 2008)
- Germany : \$201 million in 2005
- China : \$100 million each year
- UK : \$45million each year (2003-2009)

Indian Scenario

Indian nanotechnology is estimated to be \$100million and is estimated to grow at over 35 per cent per year. The Government of India is planning for large investment in R & D through several initiatives and the private

companies will exploit the technology for commercial benefits.

Since October 2001, when the nano science and technology initiative was launched, India has invested Rs. 200 crore (about US \$44.5 million). and 2006-07, Rs. 180 crores. Recently, DST declared funding of Rs. 1000 crore for nanotechnology.

Nanobiotechnology

Working at the level of individual atoms and molecules allows researchers to develop innovations that will dramatically improve our lives. The new realm of



nanobiotechnology holds the promise of improving our health, our industry, and our society in ways that exceed even those of computers and biotechnology

Nanobiotechnology envisages nanobio machine, bio-nano interface, DNA / RNA transfection, tissue engineering, nano surveillance, bio-molecules sensing etc. Biology provide plethora of basic materials and methods for nano machinery. These will be important as we move further ahead from bio inspired nano-machines and begin to create nano worlds of our own.

Nano-Bio-information Fusion

Although the nanobiotech industry is in a nascent stage, rapid advancement and a streamlined road map of progress ensure that the future is quite promising. The realization of this industry's potential will have revolutionary and compelling impacts upon mankind. For example, the rapid DNA screening and diagnosis modalities will open the gateway genetic makeup. An achievement of this magnitude would serve dual roles. First, nanobiotechnology would be cemented as the visionary industry for the next millennium. Second, the true benefits for mankind enabled by the maturation of this technology will be realized

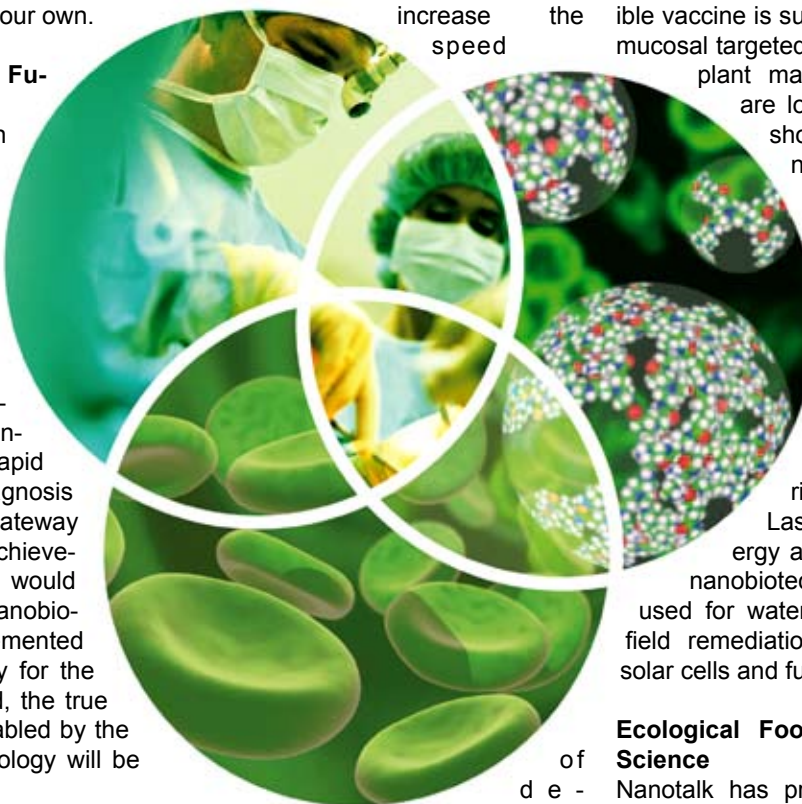
Nanobiotechnology in Agriculture

The nanobiotechnology has various applications in Agricultural and Animal sciences like crop improvement, animal health, precision farming, fisheries, disease detection, post harvest technology, green houses, solar energy utilization, water purification, nano-biosensors based stress detection, etc.

The nanobiotechnology has also various application in monitoring quality of agricultural products like increasing solubility in water, sensors could be integrated into packaging materials to monitor the freshness of the food, spoiling of the food could be indicated

by a colour change of the sensor and minute amount of chemicals and even presence of bacteria and viruses can be detected with ease on bio-selective surfaces.

The crop improvement is possible in nanobiotechnology through modifying the genetic constitution and mutations – both natural and induced. The nanobiotechnology has various applications in plant disease diagnostics like the detecting of the exact stage of virus, application of some therapeutics to stop the disease, increase the speed



of detection and increase the power of the detection, etc.

The nanobiotechnology has various applications in protein micro arrays which includes the discovery of protein biomarkers that indicate disease stages, assess potential efficacy and toxicity of pesticides (natural and synthetics) and measure differential protein production across cell types and developmental stages, in both healthy and diseased plants, study the relationship between protein structure and function and evaluate binding interactions between proteins and other molecules.

The nanobiotechnology has vari-

ous applications in animal health like nano vaccines for prevention of disease in advance by developing antibody against the particular pathogen, for genetic manipulation, and nano-apoptosis which kills the cancer cells and tumor and measurement of changes in the level of estradiol in the blood, etc.

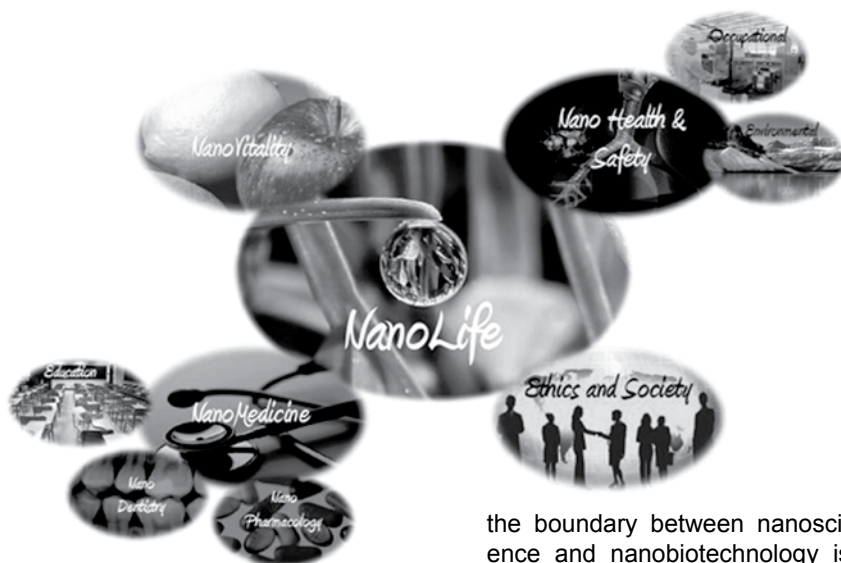
The nanobiotechnology can also be used for the production of plant made vaccines or edible vaccine like for biopharmaceuticals. It is called the next generation of vaccines. This edible vaccine is sub- unit vaccines and mucosal targeted. The advantages of plant made edible vaccines

are low cost, needle free shot, easily scale up, no refrigeration requirements, no risk of provoking infection, elicit mucosal as well as systemic immunity, effective distribution in developing countries, easy consumption by children and no purification required.

Lastly in the field of energy and environment, the nanobiotechnology can also be used for water purification, brown field remediation, catalysts, filters, solar cells and fuel cells, etc.

Ecological Footprint of Nanobio Science

Nanotalk has provoked expectation just as high as fears: On the one hand Nanobio Science is expected to solve problems in almost every area of our daily lives; on the other hand the serious objections are being raised against the promises of a "brave new world". Nanoretrospects and prospects, the fictitious and factitious, the seemingly rational and irrational in the debate coalesce with peculiar sharpness in the "environmental argument". Here, in turn, the ambiguous concept of sustainability is important. The variety of meanings of this concept, its pluralistic use and at the same time problematic and attractive characters should be addressed with respect to nanodiscourse. The concept of the



ecological footprint will show the inconsistencies in the nanodebate. The concept of sustainability may at least be conceived to serve as a sort of information campaign or boundary concept that allows the debate of issues like growth and environment in the nanodiscourse. As such it could eventually help to place the whole debate in a more political and less ethical or economical context and to prevent the “nanotechnification” of nature and society.

Nano-Ethics

Nanobiotechnology will bring surprises, both beneficial and harmful, and so will create ethical issues for its practitioners and for society. If we are to have some understanding of what lies in store, we need to distinguish between ethical issues internal to practice and thus of particular concern to its practitioners, and ethical issues external to a practice. We also need to understand how artifacts can produce harms and how rapidly developing technologies produce harms by provoking errors, wholly unintentionally, among those who use its artifacts.

Ethical questions of many kinds arise in the general area of research, manufacturing, and application of nanobiotechnologies. For example:

- Who is responsible for preventing and dealing with possible harm to health or the environment?
- How can intellectual property right be defend and deafened when

the boundary between nanoscience and nanobiotechnology is so ambiguous?

- How the public can’s right to know about the nanotechnology that may affect their lives balanced against an innovator’s right to protect trade secret and against the cost of collecting and disseminating correct information?
- What priority should be placed on developing new products and techniques that will be highly beneficial for some people, versus defending the interests of individuals ?
- We should examine the nature of nanoethics and motivate why it is a proper concern and possibly an emerging new field. There are several specific ways in which nanotechnology is likely to raise ethical issues. Some of these issue will almost certainly confront us in the not too distant future and others, through not imminent, may well become serious issues some years from now.

Risks and Nanobiotechnology

There is no scientific evidence to support the notion that nanoparticles and nanotubes-basic components of nano-based products- pose risk to human health and the environment. Yet, there already have been considerable discussion in the mass media For now though the lack of genuine scientific data on the potential hazards of nanotechnology on human health and the environment has misled the discussion: debate about the risks of nanotechnology today truly amounts to the

perceived risks of nanobiotechnology – since the technical, scientifically estimated risks remain at bay. Gravity and size barriers are negligible at nano-scale. Their thermal motion is significant and water environment is excellent for bio-nano particles. Thus bio-nano particles can expand, travel and penetrate extensively up to red blood cell of human and most of the cell of living organisms. Thus, nanobio molecules are potential danger to all the facets of environment provided we work wisely and respect the life on this planet.

Deciding the future: Endless frontiers

What potential problems do emerging nanobiotechnologies present? Who should decide how, where, and by whom new nanobiotechnologies should be pursued and regulated? The concerns should be raised to draw attention to issues that must be addressed if societies are to maintain control over the design and production of new technologies, including nanobiotechnologies. Specifically, the focus should be on issues of technological determinism, technology- society relations, and building a base for broad public participation in the creation, acceptance, and use of new technologies.

Role of universities

Nano-bioscience is a multi-institutional sciences and we are negotiating the novelties. Universities have great role to play in education, development and transfer of technology in the benefit of all sections of the society. We are committed to remain globally competitive in the newly emerging technologies. Educational initiatives are urgently required for future generations to develop and adopt new technologies beyond nanotechnology i.e. nanobiotechnology.

In the above context, it is high time that the central and the state governments take up the matter on top priority and provide all the required supports to the universities in our country so as to address the issues immediately.

The author is the Vice Chancellor of Junagadh Agricultural University, Junagadh, Gujarat



Major Focus



- ☞ Treat seeds before sowing.
- ☞ Take care to maintain soil health.
- ☞ Apply fertilizers based on soil test recommendation.
- ☞ Adopt improved variety.
- ☞ Harvest rain water and develop a modern system for its storage and recycling.
- ☞ Timely control of weeds, insect pest and diseases.
- ☞ Judicious and timely use of Pesticides.
- ☞ Use appropriate spray technology.
- ☞ Timely harvest and safe storage.
- ☞ Buy pesticides from credible sources and use judiciously.
- ☞ Make all pesticide purchases against Bill.

SOME FACTS ABOUT INDIA'S FOOD SUSTAINABILITY AND SECURITY

THINK AND ACT

- Our population is expected to reach 1389 million by 2025AD. Feeding this growing population and reducing hunger will only be possible if agricultural yields can be increased significantly - and sustainably. The challenge is to double food production by 2025, and triple it by 2050 from a fast shrinking per capita available crop land.
- We are first producer of total pulses; and second largest producer of wheat, rice, sugarcane; however, in terms of per hectare productivity, the rice, wheat and maize yields in China were 1.9, 1.7 and 2.1 times respectively higher to that of India.
- India's pesticides consumption is 570 grams while in Japan it is 11 Kg, Taiwan 17 Kg and in other developed countries it is more than 2.5 KGs. We produce 16% food of the world and use only 2.3% pesticides used in the world.
- A huge loss in food grains production is caused by insect pests, diseases and weeds etc. Pesticides are the cost effective means to control pests and are an essential input for the much needed food security & sustainability. Pesticides are used in very small quantities and measured in ppm (parts per million), which is the same in proportion as 1 second in 11 days: hence harmless if used as per recommendation. Pesticide molecules are NOT like bacteria or germs that if they are found in blood, urine, food or water they will cause a disease like Cancer. As long as the pesticides residue remains within the approved limits, these are not a cause of concern, as it will have no impact on human health.
- The 'grain saved is grain produced'. By judicious use of pesticides, we can save Rs. 2.5 lakh crore worth food grains per annum.

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Khet ka Pani Khet Mein



Gaon ka Pani Gaon Mein



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- ◆ Mahyco Monsanto Biotech Ltd
- ◆ Sudarshan Chemical Industries
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*Research, Training,
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NUTRIENT MANAGEMENT THROUGH SOIL TEST CROP RESPONSE CORRELATION RESEARCH

Dr. P. Murugesu Boopathi

Introduction

About forty per cent of the food grain production in India can be attributed to fertilizer use and the fertilizer consumption in India has increased significantly in the last 40 years from 9.4 kg ha⁻¹ in 1967-68 to 117 kg ha⁻¹ in 2007-08. Though the increased use of fertilizers has resulted in higher productivity of food grains and commercial crops until last decade, now there are signs of fatigueness in agricultural productivity, particularly on food grains, decline in response ratio and wide diversity in fertilizer use in different parts of our country. Owing to these reasons, ensuring higher fertilizer use efficiency by farmers at large is still to be realized. Further the recent escalation in fertilizer prices has severed a setback to the concept of balanced fertilization. Economic rationality, therefore, dictates a more comprehensive approach to fertilizer utilization incorporating soil tests, field research and economic evaluation of results. In spite of the complexity of soil test-crop response studies arises due to the heterogeneity of soils, climate, crop and management practices, many attempts have been made by the scientists in establishing relationships between yield function and soil test values and making use of soil testing as a predictive tool for fertilizer recommendation to achieve higher agricultural productivity.

Methods

Genesis and Growth of Soil Test

Crop Response Correlation Research in India

Since Liebig's time around 1840, many methods and approaches have been tried to get a precise or workable basis for predicting the fertilizer requirement of crops. For soil test interpretation under Indian conditions, soil testing research is required extensively and on continuous basis. At this juncture some important land-

on the results of the Model Agronomic Experiments on Government farms and Simple Fertilizer Trials on Cultivator's field, blanket or general fertilizer recommendations were arrived at. Since the fertility variations were not accounted for, uniform adoption of this kind of recommendations did not ensure economy and efficiency of fertilizer use.

Therefore, making use of the services of soil testing laboratories at Indian Agricultural Research Institute, New Delhi and the results of Adhoc Research Projects, tentative soil testing procedures were identified and soil test values were empirically grouped into categories like low, medium and high (Muhr *et al.*, 1965). The general or blanket recommendation is equated to medium fertility status of soil available NPK. For soils testing low or high category, the fertilizer recommendations are increased or decreased by 30 per cent of the general recommendations. In Tamil Nadu (Southern India),

the general or blanket recommendation is equated to low, low and medium fertility status of soil available NPK respectively. For soils testing low or high, fertilizer dose is correspondingly increased or decreased respectively by 25 per cent of general recommendation. Though it is an improvement over the general recommendation, grouping of soils into different categories is quite arbitrary. To overcome the difficulties encountered above, the Soil Testing Laboratories of Tamil Nadu prescribes site



marks in Soil Test Crop Response Correlation (STCR) research have been made in India. The first systematic attempt in the whole of the country to relate the knowledge of soils to the judicious use of fertilizers was the fertilizer use project initiated in 1953 following a study made by Stewart (1947). Subsequently, the soil testing laboratories were initiated in 1955-56 and the project on Model Agronomic Experiments on Experimental Farms and Simple Fertilizer Trials on cultivator's field was started in 1957. Based

and situation specific recommendations using Mitscherlich-Bray model and fertilizer recommendations are given for 87.5, 94.0 and 94.0 per cent sufficiency levels for NPK nutrients respectively. However, the neglect of nutrient interaction and lack of standard procedures for assessing the maximum yield, limits the scope of its applicability. Concurrently, the deductive approach developed by Colwell (1968) in Australia which involves conduct of multi locational trials was also attempted and however, it has not met with much success in deriving soil test based fertilizer calibrations in India.

At this juncture, the Inductive approach research in soil test calibration was called for to provide a strong base and sound service to farmers, promoting fertilizer use efficiency, balanced fertilization and soil fertility maintenance. With the above background and necessity, Indian Council of Agricultural Research (ICAR) has initiated the All India Coordinated Research Project for the Investigations on Soil Test Crop Response Correlation during 1967-68 to develop soil test calibrations for Indian soil and climatic conditions.

Results

Inductive cum Targeted yield ap-

Table 1. Soil test based fertilizer prescription for 4 t ha⁻¹ yield target of hill wheat

Initial soil test values (kg ha ⁻¹)			Fertilizer doses (kg ha ⁻¹) (NPK + FYM @ 12.5 t ha ⁻¹)		
KMnO ₄ -N	Bray-P	NH ₄ OAC-K	FN	FP ₂ O ₅	FK ₂ O
160	40	160	161	120	53
200	50	190	139	118	39
240	60	220	117	115	26
280	70	250	95	112	15

proach

Experimental technique

A unique field experimental approach (Inductive methodology) for soil test crop response correlation was evolved through creating a macrocosm of soil fertility variability within a microcosm of an experimental field (Ramamoorthy *et al.*, 1967). This provides a scientific basis for balanced fertilization not only between fertilizer nutrients but also with the soil available nutrients. The principle methodology is to develop a quantitative relationship between measured levels of anyone component (eg. fertilizer N) of a crop production system and the yield obtained from it. Since more than one factor influences the yield (fertilizer N, P₂O₅ and K₂O) and there are interactions among the different variables, the fractional fac-

torial design is adopted to describe the desired relationships. The objective of the field experiment is to have data covering the appropriate range of values for each controlled variable (eg. fertilizer dose) at different levels of uncontrolled variable (eg. soil fertility). Since different levels of uncontrolled variable (eg. soil fertility) cannot be expected to occur at one place, normally different sites are selected to represent the different levels of soil fertility. However, in the present approach, all the needed variation in soil fertility level is obtained not by selecting soils at different locations as in the earlier studies, but by deliberately creating it in one and the same field experiment in order to reduce the heterogeneity in the soil population studied, management practices adopted and climatic conditions prevailing.



Soil Test Crop Response Calibrations

i) Soil test based fertiliser recommendation for targeted yield of crops

Ramamoorthy *et al.* (1967) established the critical basis and experimental proof for the fact that Liebig's law of minimum operates equally well for N, P and K. This forms the basis for fertilizer application for targeted yields, first advocated by Truog (1960). This procedure takes into account the nutrient requirement (NR) of a crop for production of unit quantity of economic produce, the per cent contribution of nutrients from soil (Cs) by a given soil test and the per cent contribution of nutrients from the added fertilizer (Cf). These



$FP2O5 = 3.59 T - 0.26 SP - 0.54 OP$
 $FK2O = 3.88 T - 0.45 SK - 0.51 OK$
 where, FN, FP2O5 and FK2O are fertilizer N, P2O5 and K2O in kg ha⁻¹, respectively; T is the yield target in q ha⁻¹; SN, SP and SK respectively are alkaline KMnO₄-N, Olsen-P and NH₄OAc-K in kg ha⁻¹ and ON, OP and OK are the quantities of N, P and K supplied through FYM in kg ha⁻¹.

The Fertiliser Prescription equations (FPEs) are valid only under the following situations

1) They should be used for the same type of soil for which they are developed or for related soil series for which the FPEs have been tested for their validity, 2) The targets should not be high or low and should be within the range of experimental yields obtained, 3) The maximum target should not exceed 75-80 per cent of the highest yield achieved for that crop in the area, 4) FPEs must be used within the experimental range of soil test values and cannot be extrapolated, 5) Good and recommended agronomic practices need to be followed while raising crops and 6) Other micro and secondary nutrients should not be yield limiting.

Test Verification trials

The soil test based fertiliser prescriptions developed for various crops were verified at farmers' holding on similar and allied soil series. The results of the test verification trials proved the validity of the equations

three parameters are used to relate yield target (T) with soil nutrients (S) and fertilizer nutrients (F) as below:
 Fertilizer Dose = $\{(NR \times 100 T) / Cf\} - \{(Cs \times S) / Cf\}$

ii) Soil test based fertiliser recommendation for targeted yield of crops under Integrated Plant Nutrition System (STCR-IPNS)

Under Integrated Plant Nutrition System, the fourth parameter viz., the per cent contribution of nutrients from the added organic manure (Co) is also used to relate the yield target (T) with soil nutrients (S), fertilizer nutrients (F) and organic nutrients (O) and then the equation takes the form as indicated below:

Fertilizer Dose = $\{(NR \times 100 T) / Cf$

$\} - \{(Cs \times S) / Cf\} - \{(Co \times O) / Cf\}$

By substituting the required parameters in the fertilizer prescription equations, fertilizer doses are arrived at for desired yield target of crops for a range of soil test values (nomograms). An example of such nomograms is furnished for hill wheat in Table 1. After evaluation in the test verification trials, these fertilizer prescription equations are used to prescribe the fertilizer recommendations for the corresponding crops. In Tamil Nadu, fertilizer prescription equations were developed for major cereals, millets, pulses, oilseeds, cotton, sugarcane, vegetables, spices and medicinal plants.

Fertilizer prescription equations

FN = $7.60 T - 0.55 SN - 0.92 ON$

Table 2. Results of the verification trials with hill wheat (Range and mean values of six locations)

(Initial soil test values: 182-212 : 20.7-91.0 : 110-285 kg available NPK ha⁻¹ respectively)

Sl. No.	Treatments	Nutrients added (kg ha ⁻¹)			Mean Grain yield (kg ha ⁻¹)	Mean Achievement (%)	Mean RR
		N	P2O5	K2O			
1.	Control	0	0	0	1934	-	-
2.	Blanket	100	60	30	2760	-	4.3
3.	STCR 35 q ha ⁻¹	149-166	102-120	15-86	3548	101.4	5.3
4.	STCR 40 q ha ⁻¹	187-204	120-138	27-106	4065	101.7	5.6
5.	STCR -IPNS* 35 q ha ⁻¹	98-114	91-108	15-64	3624	103.6	6.0
6.	STCR -IPNS* 40 q ha ⁻¹	136-152	109-126	15-84	4163	104.2	6.3

*IPNS: FYM @ 12.5 t ha⁻¹

Table 2. Fertilizer recommendation for desired yield target of rice in a rice-rice-pulse cropping sequence
(Initial soil test values: 280:22:250 kg available NPK ha⁻¹ respectively)

Yield target (tha ⁻¹)	First crop (kharif)						Yield target (tha ⁻¹)	Second crop (Rabi)		
	Fertilizer doses (kg ha ⁻¹)			Post harvest soil test val- ues (kg ha ⁻¹)				Fertilizer doses (kg ha ⁻¹)		
	N	P2O5	K2O	N	P	K		N	P2O5	K2O
6.0	148	107	141	268	23	381	6.0	77	60	25*

*maintenance dose

by recording + / - 90 per cent of the yield targets aimed at. The results of verification trials conducted with hill wheat in hilly western zone of Tamil Nadu are furnished in Table 2.

Front Line Demonstrations

After validation, front line demonstrations were conducted with various crops and soils in different agroclimatic zones of Tamil Nadu with a view to popularize the STCR-IPNS technology. The results of the dem-

tial soil test values

Under intensive cropping sequence, the soils of the farmer's field cannot be tested for every season in time. Under such circumstances, the basis developed by Ramamoorthy et al. (1975) is found to be very valuable. Using this basis, the post-harvest soil test values of the experimental field can be predicted from the initial soil test values, the fertilizer doses added and yield/uptake obtained. The equation takes the mathematical form

and Selvakumari, 1998). An example for the rice-rice-pulse cropping sequence on Manakkarai soil series (Typic Ustropept) of Southern Tamil Nadu is furnished in Table 2.

iv) DSSIFER

A computer software DSSIFER (Decision Support System for Integrated Fertilizer Recommendation) was developed to generate crop, site and situation specific balanced fertilizer prescriptions in Tamil Nadu. This software utilizes the crop and location specific fertilizer prescription equations based on targeted yield model developed by the AICRP-STCR scheme, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University and Mitscherlich and Bray percentage sufficiency recommendation equations developed by soil testing wing of the Department of Agriculture, Tamil Nadu.

Conclusion

Soil test calibration for fertiliser prescription through inductive cum targeted yield model revealed that this model is unique in developing fertilizer prescriptions under IPNS for Indian conditions which will enable to achieve the targeted food production of our country. Further this approach has the advantage of deciding the desired yield target by the farmer with his resource availability and constraints besides ensuring balanced fertilization with sustenance of soil fertility.



onstrations have brought forth the possibility of increasing the productivity and profitability of crops and efficiency of added nutrients (Santhi et al., 2002) and created awareness among the farmers about the STCR-IPNS technology.

iii) Fertilizer recommendations for a cropping sequence based on ini-

YPHS = $a + b_1F + b_2ISTV + b_3$ yield / nutrient uptake
where, YPHS = post harvest soil test value; F = fertilizer nutrient (kg ha⁻¹); ISTV = Initial soil test value (kg ha⁻¹); b₁ to b₃ = regression co-efficients. Studies on this aspect were carried out by many workers for various cropping sequence and soil types (Murugesu Boopathi, 1995; Santhi

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Success Stories of Agribusiness/ Agri-clinics

A Tool of Agri Entrepreneurship

Avinaash Diraviyam

1. Introduction

Agricultural development over years has been the result of continuous agri skill generation and its popularization. The earliest agriculture was animal domestication over thousands of years ahead, man domesticated wild fowl, dog, goat and smaller animals, which he could overpower easily and subjugate to his sub-ordination. Agriculture thus since beginning has been the results of trails, experiments and experiences over years, learned first though behavioral changes, psychic reoccurrences, memories passed through parents to children and later on through doing and learning and now through sharing experiences and writing them as an Entrepreneurship concern.

2. Entrepreneurship concept

The Entrepreneurship adds economic profits and cost-benefit ratios to Agricultural Output. Entrepreneurship is dominated by four factors like:

- Social systemic changes
 - Support system availability and use
 - Resource base and its utilization
 - Self confidence, exploration work capacity and intellectual potency.
- An entrepreneur has to have a thinking of his own, a capacity building interest in acquiring needed technique. An explorative and analytic faculty to judge the way of procuring cheap raw material. He must be equipped with "knowledge" and mindset to use and benefit out of it.

3. Farm Business

A potential entrepreneurship must strive from getting maximum output. Decades back agricultural development and industrial setups was a public sponsored and heavily subsidized but over time "knowledge" explosion in India Agriculture, have brought us on threshold of a system, where wide distances exist between industry and farm business. Where huge subsidies are benefiting Agro-Industrialists. The Farmers who use fertilizers or agro-chemical are crushed under eco-

ing and bringing change. It demands more educated and trained farmers. Our education system has produced more literates but not educationally trained youth to earn their own bread. They after attaining graduation in agriculture and allied sectors, beg for job. The system has to be corrected to make these graduates as employers and not employees. I wrote a treatise as back as 1992, emphasizing a system. Germans are smart to have Farmers school, Farmer business training institutes, practical agri-farmers training centres and like, where way farmer or animal husbandry man is essentially a trained fellow. The banking system is so organized that they are on the door of convocation hall to sell their agribusiness and agri-clinics to graduates, without any personal investments. Banks are so smart, that they have surveyed the villages who need vets or agri-graduates or have attained land and all facilitation, so that agricultural or veterinary or even other medico-biological graduates are used as bank investment. This is what is envisaged in India under agriclinic, Agribusiness venture. We have trainings not in the hands of banks but universities.

4. Success of Agribusiness:

A systematic liaison and support system between Govt. banking and University culture has made this otherwise an remunerative and lucrative programmes into a failure inspite of its personal monitoring of PMO. The success of Agri-business and Agri-clinics success rates are shown



conomic pressures. The gaps between technology generated and technology use at farmers door is increasing day after day. The farm technology adoption rates are not more than 20-30% by any higher prospective. The use of information and communication technology (I&CT) for reducing the gaps and increasing productivity is the need of the hour (Wani, 2005). The modern technology and knowledge flow is fast expand-



in table 1. The universities involve and their success stories are shown in table 2. Both these details are distressing inspite of huge moral, financial support from Govt. This is inspite of subsidiary support table 3. Various ventures are listed in table 4 – 7. Agricultural professionals are getting converted into Agribusiness and agri-clinical experts. More than 14,000 applicants and 615 agriclincs came to existence in Indian 12 states. The agri clinic trained persons in J&K many number in hundreds. Among them 34 have registered agri clinics earning a handsome profit annually. We visited Bandipora district and un-registered Agriclincs were earning a handsome salary, more than the Rahbar-e-zerat or Agriculture Asstt. A visit documentary is enclosed and shall be shown. It consisted of Agri-business viz sale of pesticides, cattle feed, poultry feed and agri-extension services. At a small village in Pappan, one agri graduate Mr. Iqbal Shah earns Rs. 10,000/- per month by selling the services and input. At a distance of few kms. In same district one Mr. Khyatlani owns a big poultry farm and earns around Rs. 20,000/- per month. Both these entrepreneurs employ 2-3 persons at present. Similarly, the success shown by one Mr. Shah at Malangam in Agri products and pesticide sale and one Mr. Bhat in Dairy production and milk product sale earn a handsome income besides generating employment for poor.

5. Farmer as Entrepreneur

Indian Farming and farmer has to change if proper WTO recommendation and GATT agreements are to be

followed.

The present day poultry scenario has emerging high profile agri-business prospects in India.

The conversion of poultry farmer's into poultry entrepreneurs shall make the present day 6% contribution of poultry products to 25% share of Global market from India and China. This when translated into action shall increase employment generation by manifolds. The introduction of rural based Vanraja, Gramapriya, Giriraja, Cari Gold and vast other locally grown varieties of poultry have adopted well to our agri-rural base. The market acceptability is higher than exotic poultry concerns. Research to farmers doors in generating free-rang-poultry is like BT cotton hybrid spreading through villages of India and assuring high returns and exports (wani, 2007).

6. Poultry as Agri-business

Dr. Gordon Butland, president of Global poultry strategies presents "Backyard poultry production" as a tool of alleviating poverty and malnutrition. We have tried to distribute "birds" under free-rang system in all our KVK's our results were excellent and income generation was totally in favour of the Agri-business and agri-clinics as will be shown in case histories and success stories.

A grand show of using poultry, rabbit meat processing introduction at SKUAST-K have innovated white meat usage. Our own preparation could be seen in Figs 1-3.

This all will need the involvement of Agri-Veterinary and food processing technocrats to develop rural-based establishments so as to faster export

and fast returns.

7. Holistic Vision for Livestock Enterprise.

Improving income, employment and self-reliance are among educated graduates and un-employed youth especially women needs fostering community development, women empowerment, environmental protection. Rural-based backyard poultry subscribes to all these norms and could be a rich resource for developing agri-entrepreneurship. Govt. of India is liberally financing such agri-business ventures and a proposed infrastructure cost set-up can be seen in table 8. A vast and finance assured schemes are available for agri-graduates for establishing poultry ventures (table 9). An initial allocation of 107 crores for initiating nucleus breeding farms. Further more provision of hatcheries to provide chicks to more than 2 lac farmers and farm women will need many agri-business centres for providing basic germplasm, medicine and above all training.

Some of the success stories in animal husbandry section can be reproduced as follows:

a. Backyard poultry and incubation

Though the Vanraja are the most suitable for back yard poultry, they do not have habit of broodiness. There is a problem among the farmer to get a broody hen in all season. KVK solve this problem of hatching by installing small unit of hatchery. Every month 15-20 farmers are benefitted by purchasing chicks for backyard poultry. There 200 back yard poultry units of Vanraja. Each farmer is rearing 10 to

25 in the backyard. There is a good demand and response for the chicks and eggs of Vanraja. KVKs are now planning to expand this unit.

b. Semi-stall-fed Goat Rearing

KVK's made an intervention to improve this enterprise by conducting short durational training programmes for rural youth. Similarly exposure visit were organized on goat feed, breed and health management. More emphasis was given on Osmanabadi goat and up-gradation in selected non-descript goat breed by osmanabadi pure buck and given the knowledge about semi stallfed goat rearing concept.

c. Broiler Production

KVK has conducted many durational training programmes for 165 trainees. Due to training and demonstrations awareness was increased about contract farming in broiler production with private sector which provide chicks, feed and medicine and after 40 days purchases Rs. 3 to 3.50 per kg on live weight and FCR basis

and changed their attitude. They acquired skills through learning by doing at KVK demonstration unit.

The technology has been adopted by 10 percent of youths now in the radius of 20 km there are 27 poultry units having capacity of 5000-10000 poultry birds on contract farming basis. These self employed rural youth earning Rs 10000-15000 per lot.

Recently a seminar-cum-farmer's meet was arranged at SKUAST-K on 26-27th of Oct.2007. The knowledge –sharing and use for making agricultural graduate and scientists was emphasized by our worthy Chancellor. A vision of poverty alleviation through backyard poultry intervention was the theme of the seminar. Many belts in Gurez, Tangdar, Telail and Zanskar are rearing native livestock species. Who are better suited and need improvement and identification. The cooking methods will need more expansion and scientific intervention for export. More emphasis has to be made on:

- Safe feed and food.

- Organic fodder and food.
- Operational excellence and modern mechanization to improve quality of indigenous enterprises.
- Local family management to farm business management and seller-buyer model adoption.

8. High Value Agri-business

Rapid growth rate in high value commodities in Indian agriculture promises 40% total output. The sectors assuming importance for export earnings are Fruits, milk vegetable and poultry. Thus Agrilclinic training centres should focus on these commodity oriented training. The sector may need more than 1 lac young entrepreneurs to achieve national goals and not the more 14000 applicants.

What is needed:

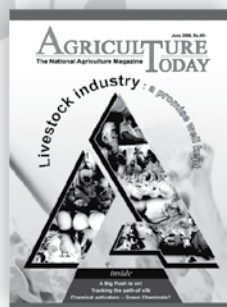
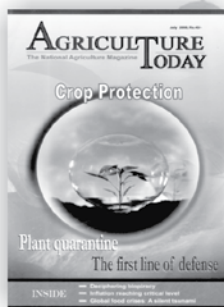
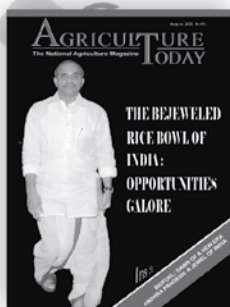
- Openness and transparency.
- Simple banking.
- Credit facility.
- Mission and Training.

Academic Head, IABM, Noida

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Post Harvest Management and Technologies for Food Security in India

The strategic approach pursued in India for achieving food security during post independence era was centered around 'grow more food' backed by improved seeds and evolution of location specific technologies, policy interventions, support through institutional network for technologies, input delivery, output marketing and associated activities. Resultantly, food grain production has impressively increase from 50.8 million tones 1950-51 to 234 million tones in 2008-09. The production of oilseed during this period has increased from 5.2 to 28.2 million tones. The fruit production has exceeded 73 million tones and that of vegetables has exceeded 136 million tones during 2009-10. Today India is the largest producer of pulses, jute and milk and second largest in wheat, rice groundnut, vegetables, fruits, sugarcane, tea, etc. Bestowed with varied agro-climatic conditions, India is favorable for growing a large number of cereals, pulses, oilseeds, commercial crops, fruits, vegetables, root, tuber, aromatic and medicinal plants, spices and plantation crops. Presently, horticultural crops occupy around 13 per cent of India's gross cropped area, producing 226.87 million metric tones of produce during 2009-10. India is the largest producer of mango, banana, sapota and acid lime in the world. About 39.5 per cent of the world's mangoes and 11 per cent bananas are produced in India. Similarly the country occupies prime position in the production of vegetables like cauliflower, onion and cabbage in the world and emerging to occupy respectable position in the field of floriculture. It has become the largest producer, consumer and exporter of spices and spice producer.

Agriculture, the engine of growth, engages almost 58.4 per cent work force in pre and post harvest agricul-

tural operations with addition of about 5 million new workers every year for their livelihood. The livelihood system of rural population consisting of 72 per cent of total population has direct dependence on agriculture. By and large, food security in terms of physical access for 118 crores people of the country depends on the prospects of agricultural sector. While the per capita income of the people has gone up remarkably, the share of agricultural GDP has dropped to 17 per cent without shifting the workforce from agriculture. The decline in share of agricultural GDP has created distortions in income and widened the inequalities in the social system. Optimum level of agricultural production and minimum gap between production and effective consumption by minimizing post production losses are the viable options to meet food security of the people.

For sustainable food security, both physical access as well as economic access is needed equally well. Hence, more employment opportunities are required for improving economic access in rural areas. Further scope for employment in primary agricultural production activities has already diminished. Therefore, agro processing, value addition, agri-business and export promotion are the possible avenues for more income and employment in agricultural sector. And for it, both pre and post harvest operations are important for ensuing food security in terms of physical and economic access.

Post Harvest Operations

- The post harvest operations broadly include.
- Preparation which is a preliminary separation of edible part from non-edible part.
- Preservation which is the prevention of loss and spoilage of food



Prof. S.S. Chahal

- Processing which is the conversion of edible part into another readily consumable form
- Storage which is holding of food for future use and
- Transportation which involves movement of produce from production to consumption.

It helps to fetch more values for agricultural produce, thereby improving the purchasing power of the rural producers.

Post Harvest Losses

Efforts for increased agricultural production in our country were more centered on pre-harvest strategies for a good harvest during and after green-revolution period.

Unless the gap between quantity actually harvested and quantity effectively consumed is minimized, the benefit of a good harvest can not be fully utilized. The post-harvest losses are more in developing countries like India compared to developed countries. Developed countries use advanced technologies for the post-harvest and handling operations. Rather post harvest technologies and management are equally or even more important that the pre-harvest technologies and management to take full advantage of agricultural growth and development Horticulture crops, specially fruits, vegetable, flowers, tuber crops are quite different from cereals, pulses and oilseeds in terms of mois-

ture content, respiration rate, texture and natural shelf life. As a result the losses of cereals and oilseeds vary from 10 to 20 per cent while that of horticultural crops vary from 15 to 50 per cent in developing countries.

The post harvest losses occur during harvesting, transportation, drying, threshing, processing and storage. Harvested grains undergo series of transportation from field to threshing floor to household storage to market channels. Before reaching the ultimate consumer there are chances of spoilage and physical loss during the transport.

There is need to prioritize research efforts to mitigate post harvest losses which are due to biological factors such as rodent, birds, monkeys, and other large animals, microbiological factors such as fungi and bacteria and chemical factors resulting in loss of colour, flavour, texture and nutrient value and secondary factors such as inadequate harvesting, packaging and handling skills, lack of adequate containers for transport and handling of perishable goods, inadequate storage facilities to protect the food, inadequate transportation to make the food to market before it spoils, inadequate refrigerated storage, inadequate dry equipment, traditional processing and marketing system, and many others. The losses can also be due to bio-chemical reactions and mechanical factors like bruising and cutting excess pooling or trimming of horticultural production and physical factors such as excessive or insufficient heat or cold which spoil the food which too need adequate attention.

Storage and Storage Losses

Storage is an interim and critical phase during transit of agricultural produce from producer to processor and its products from processor to consumer. Besides, agricultural products need to be stored from one harvest to next, thus demanding additional carry over as safeguard against uncertainties of the following crop like low yield or poor quality, against speculation in price and market demand or against shortage and famines.

Storage of grain and control of quality occur in three points i.e. on the farm, at collection points and at terminal points where grain is processed or moved forward in still larger bulks. It involves additional costs for loading and unloading at each type of storage, for transportation between storages and for storage itself and conditioning of grains, mainly cleaning and drying and maintaining the quality. People in rural areas store grains in structures like Mora, Bukhari, Kothar, Mud Kothi, Muda, Kanaj Kuthla etc. popular in different parts of the country. It needs improvement and technical support which is the need of the time. Some of the improved low cost and small capacity storage structures are Pusabin Brick/cement bin, bunker storage, CAP Storage etc. The modern storage structures for storing grains in bulk include silo system like vertical and square silos. The location of storage for central and state warehouses needs to be decided based on possible natural calamities for safe storage of grains. Safe storage of agricultural produce is essential to avoid losses due to rats, insects, diseases, moisture etc. so as to maintain quality for a long period. About 10 per cent of the grain that reaches the farmers after their hard labour and use of scarce capital resources is lost due to faulty and unhygienic storage conditions. The farmers either store in bags which is costly and not rodent proof, or in rooms in open heaps or under ground stores. Some farmers store

the grains in storage structures like metal bins, wooden bins and cement bins. However, they store without giving due importance to air tightness of the structure and other sanitation aspects. The farmers store their produce for own consumption, for sale at some later date or for seed purposes. There is need to make transfer of technology more quick and efficient to educate and train farmers for skilful storage to avoid quantitative and qualitative losses during storage.

India is experiencing colossal loss of food grain in storage. In 2010, till July end, loss of 11,700 tonnes of food grain was reported to have been occurred in government godowns. In a surplus producing state like Punjab only, out of procurement during 2008-09 and 2009-10, loss of 48,000 tonnes wheat has been reported to rot. Because of inadequate storage every year the country losses huge food grain. It calls for planned, short and long term storage and accordingly creating required infrastructure and scientific storage facilities. Construction of silos, through costly reduces many other expenditures. Even if one per cent loss of grain is set aside through silo storage, it can save more than 2.5 million tones of food grain which can be substantial contribution towards food security of the country.

Agro-Processing

Regarded as sun rise sector, agricultural processing is needed to maintain or improve the quality or to



change the form or characteristics of an agricultural product and to incorporate value addition and minimize qualitative and quantitative deterioration of the agricultural produce after harvest. Processing operations generally performed on cereals, pulses and oilseeds like cleaning, grading, sorting, drying, cooling, storage, milling, size reduction, expelling, mixing, blending, packaging, waste utilization, seed treatment require precision and skillful handling.

Food is the single largest component of household consumption expenditure. The current food consumption in India is estimated at Rs. 900 thousand crore. Processed food account for Rs. 460 thousand crore and share of primary processed food (includes packed fruits and vegetables, packed milk etc.) is at Rs. 280 thousand crore. Changing age profile of people, increase in income, social changes like increasing number of working women, life style factors, organized retail outlets, etc. are all factors favouring the growth of the food processing sector. Food processing sector has great potential to generate significant employment. The multiplier effect of investment in food processing industry on employment generation is 2.5 times more than in other industrial sectors which are higher than any other sector. Probably the reason being that processing consists of a series of labour intensive 'unit operation' such as:

- Cleaning, grading and sorting
- Drying and dehydration
- Storage
- Milling
- Handling, packaging and transportation and
- Agricultural wastes and by-products utilization

Some of the unit operations are performed in more than one processing job like cleaning, drying and material handling.

Though India has a strong raw material base, it has been unable to tap the potential for processing and value addition in perishables like fruits and vegetables. Only about 2 per cent of the fruits and vegetables in India are processed, which is much

lower when compared to countries like USA (65%), Philippines (78%) and China (23%). Even, within the country, share of fruits and vegetables processed is much less when compared to other agricultural products such as milk (35%) and marine products (26%). More importantly the lack of processing and storage of fruits and vegetables results in huge wastages estimated at about 35%, the value of which is approximately Rs. 33 thousand crore annually.

Constraints in Food Processing

Some of the key constraints identified by the food processing industry include poor infrastructure in terms of cold storage, warehousing, inadequate quality control and testing infrastructures, inefficient supply chain and involvement of middlemen, high transportation and inventory carrying cost, affordability, cultural and regional preference for fresh food, high taxation and high packaging cost.

Status of Indian Cold Chain Industry

The estimated size of the Indian cold chain industry at present is projected to be somewhere between Rs. 80-100 billion. It forms part of the overall logistics and supply chain industry in India that is approximately Rs. 600 billion contributing to 13 per cent of India's GDP. This industry is likely to grow at an annual rate of 7 per cent during the next five years. The share of the organized sector in logistics and supply chain forms only 20-30 per cent of the sector. As per the Confederation of Indian Industry reports-India's cold chain infrastructure will require at least Rs. 180-200 billion of investment over the next five years to meet the overall requirements. It is estimated that India's Cold Chain Industry will grow to Rs. 400 billion by the year 2015. According to one estimate, the country accounts for nearly 10 and 13 per cent of the world production of fruits and vegetables, respectively, but experiences 25-40 per cent of its production wasted due to various factors. Despite being a major producer of fruits and vegetables, the industry experiences severe and

significant wastage due to the lack of proper cold chain storage, handling, and logistics.

Need for Post Harvest Management and Technologies

The post harvest losses in grains are estimated to be 9-10 per cent of the total production. It amounts to 21-22 million tones of food grains per annum at present level of the production in our country. In value terms it comes to 33-35 thousand crore rupees for food grain alone. The 10 per cent loss of oilseeds on similar line amount to 3 million tones which in monetary terms amount to 6 thousand crore rupees.

India losses about 35-40 per cent of the produce due to improper post harvest management of fruits and vegetable. The loss is estimated at Rs. 40 thousand crores per year. India wastes fruits and vegetables every year equivalent to the annual consumption of the UK. The total loss in post harvest operations is more than Rs. 80 thousand crores in India which is sufficient for free meals to all BPL population in our country.

Effective post harvest technologies and management will surely lead to minimization of physical and quality loss, value addition, creation of additional employment and generation of extra income in agricultural sector. Finding gainful employment for workforce in agriculture related activities warrants the need for developing post harvest activities as a potential area for employment. Therefore systematic post harvest management and technologies seek more investment, policy interventions and support in our country. Horticulture Mission can play a pivotal role to act as promoter to fully exploit potential of food processing in India. Similar to the institutional support for increased agricultural production, institutional networking for post harvest management and technology is required to be developed in India to make food security for all a reality.

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Development and Status of Microirrigation

Dr. T.B.S. Rajput and Neelam Patel

India shares 16% of the global population with only 2.4% of land and 4% of water resources. Efficient utilization of land and water resources is therefore very important for any sustainable development in the country. During post independence era the development of irrigation potential in the country has been without any parallel in the world. Though, India has created one of the largest irrigation networks in the world, a large cultivated area still remains without irrigation facility. Even in so called irrigated areas the water productivity is very poor. Increasing food grain requirements owing to ever increasing population in the country requires that available irrigation water is put to most optimal use. Highest water use efficiency may be achieved through adoption of micro irrigation. Government of India has initiated several schemes including financial assistance to promote the adoption of micro irrigation in the country. This paper presents a comprehensive view of different initiatives and their impact on agricultural production, in general and productivity of

irrigation water in horticultural crops, in particular.

INTRODUCTION

Globally, 3240 m km³ fresh water is being utilized, out of this 69% is being used in agriculture sector, 8% in domestic, 23% in industrial and other sectors (Fig. 1 & 2). In India around 88% water is being used in agriculture sector, which covers around 80 m ha area under irrigation (Fig. 1 & 2). Due to the liberalisation of industrial policies and other developmental activities, the demand for water in industrial and domestic sectors is increasing day by day, which forces to reduce the percentage area under irrigation. Expected annual water demand by various sectors in the year 2025 is given in Fig.1. The current irrigated area of around 38% of total cultivated area. The growing demand from the population calls for more efforts to enhance agricultural production activity covering cereal, millets, oilseeds and horticultural crops.

Sustainable development of land and water resources is very important for

a country like India which shares 16% of the global population with only 2.4% of land and 4% of water resources. Efforts were therefore made to develop irrigation potential during the Plan periods. However, simultaneously efforts were not made to utilise irrigation water more efficiently. The conventional system of irrigation employing different methods like flooding, furrow, border irrigation revolved around the concept of replenishing the moisture level to full Field Capacity (FC) only after depletion by 50% to 60% of FC. The system did not permit the restricting of irrigation only to meet the requirement of the root zone, thus leading to excessive percolation and other losses. It, therefore, resulted in problems like water logging, soil salinity and even drought like conditions in tail ends of the system. These conditions have created the low productivity levels of 2-3 tonnes/ha in irrigated agriculture against 4-6 tonnes/ha at research levels. Also, the overall efficiency of the system ranged between 25%-40%. Thus, judicious use of irrigation water is needs more attention to enhance total production and area under irri-

Figure 1. Expected annual water demand by the year 2025 in India

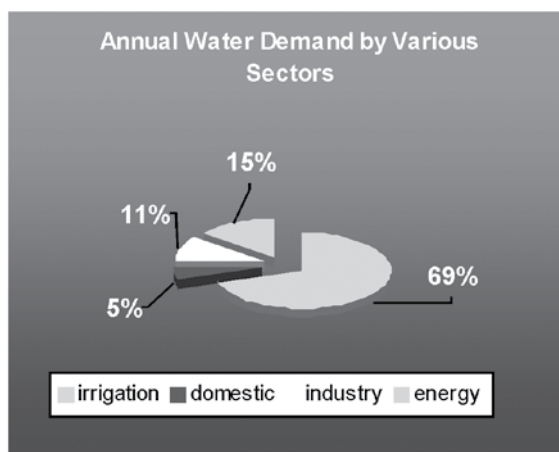
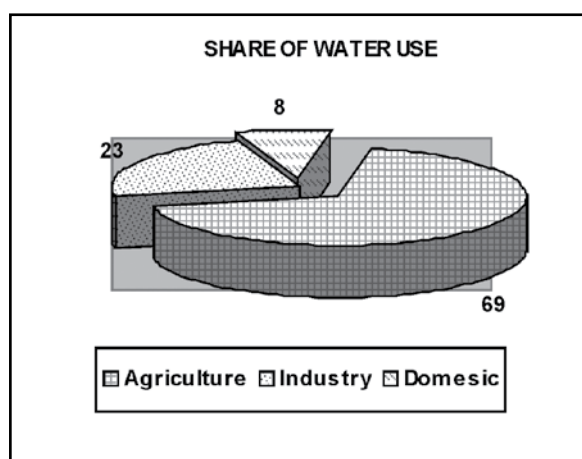


Figure 2. Share of water use



Source: Central Water Commission, Min. of Water Resources, 2010, GoI

gated agriculture. It can be achieved by introducing advance method of irrigation like micro-irrigation coupled with other improved water management practices.

United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, Agenda 21 says: "Sustainability of food production increasingly depends on sound and efficient water use and conservation practices consisting primarily of irrigation development and management with respect agriculture, livestock water supply, inland fisheries and agro forestry. Achieving food security is a high priority in many countries including India, and agriculture must not only provide food for rising population, but also save water for other uses. The challenge is to develop and supply water saving technology and management methods and, through capacity building enable farming communities to adopt new approaches in

irrigated agriculture".

Micro-irrigation system is irrigation system with high frequency application of water in and around the root zone of plant system. The micro-irrigation system consists of a network of pipes along with a suitable emitting device.

Micro irrigation is based on the fundamental concept of irrigating only the root zone of the crop rather than the entire land surface, as done during surface irrigation. Micro irrigation system is known to be able to achieve high water use efficiency, and also results in improved crop yield. In



traditional type of surface irrigation, huge amount of water is lost through seepage and conveyance of water from the source to field. This loss can be avoided to a greater extent by adopting micro irrigation. In conventional irrigation methods, the plants are stressed for a good part of irriga-

Table 1 Conventional irrigation methods v/s micro irrigation methods

Performance indicator	Conventional irrigation Methods	Micro irrigation method
Water saving	Wasteful of water, losses occur due to percolation, runoff and evaporation	40-100% of water can be saved over flood method. Runoff and deep percolation losses are nil or negligible
Water use efficiency	30-50% because losses are very high	90-95%
Saving in labour	Labour engaged per irrigation is higher than Micro	Labour required only to start or stop the system
Reduced weeds problem	Weeds infestation is very high	Less wetting of soil, weeds infestation is very less or almost nil
Use of saline water	Concentration of salts increases and adversely affects the plant growth. Saline water can not be used for irrigation	Frequent irrigation keeps the salt concentration within root zone soil below harmful level
Diseases and pest problems	High	Relatively less because of less atmospheric humidity
Suitability under physical soil constraints	Deep percolation is more in light soil and with limited soil depths. Runoff loss is more in heavy soil.	Suitable under various soil physical constraints as flow rate can be controlled.
Water control	Inadequate	Very precise, high and easy
Efficiency of fertilizer use	Efficiency is low because of heavy losses due to leaching and runoff	Very high due to reduced loss of nutrients through leaching and runoff water
Soil erosion	Soil erosion is high because of large stream sizes used for irrigation.	Partial and control the wetting of soil surface eliminates any possibility of soil erosion
Increase in crop yield	Non-uniformity of available moisture reduced the crop yield	Frequent watering eliminates moisture stress and yield can be increased up to 20-100% as compared to flood

Table 2: Relative performance of crops with drip irrigation in comparison with that of traditional Irrigation methods

Crop	Location	Yield (q ha-1)		Irrigation water		WUE (q ha-1cm-1)		Advantages of drip irrigation	
		Surface	Drip	Surface	Drip	Surface	Drip	Saving of water (%)	Increase in yield (%)
Ash gourd	Jodhpur	108	120	84	74	1.3	1.6	12	10
Beet	Coimbatore	5.7	8.9	86	18	0.07	0.5	79.1	36
Bottle gourd	Jodhpur	380	558	84	74	4.5	7.5	12	31.9
Bitter gourd	Chalakudy	32	43	76	33	0.42	1.3	56.6	25.6
Brinjal	Akola	91	148.0	168.0	64.0	0.55	2.3	62.0	38.5
	Delhi	280	33.8	45.0	35.0	6.2	9.7	22.2	17.2
	NCPA	280	320.0	90.0	42.0	3.11	7.6	53.3	12.5
	Pune	225	245.0	78.0	51.0	2.9	4.8	34.6	8.2
	Rahuri	280	280.0	90.0	42.0	3.11	6.7	53.3	0.0
Cauliflower	Akola	83	116.0	39.0	26.0	2.1.0	4.5	33.3	28.4
Chilly	Pantnagar	171	274.0	27.0	18.0	6.3.0	15.2	33.3	37.6
Cucumber	NCPA	42.3	60.9	109.0	41.7	0.30	1.5	61.7	30.5
Ladyfinger	Pune	155	225.0	54.0	24.0	2.9	9.4	55.6	31.1
	Coimbatore	100	113.1	53.5	8.6	1.87	13.2	84.0	11.6
	Delhi	360	480.0	42.0	26.0	8.6	18.5	38.1	25.0
	Rahuri	189	203.0	219.0	113.0	0.86	1.8	48.4	7.0
Onion	Delhi	284	342.0	52.0	26.0	5.5	13.2	50.0	17.0
	Hisar	93	112.0	50.0	45.0	1.6	2.5	25.0	17.0
Radish	Coimbatore	10.5	11.9	46.0	11.0	0.23	1.1	76.1	11.8
Sugarbeet	Hisar	418	489	50.0	37.0	8.4	13.2	26.0	14.5
Sweet potato	Coimbatore	42.4	58.9	63.0	23.0	0.67	2.4	60.3	28.0
Tomato	Akola	45	58.0	102.0	77.0	0.44	0.75	24.5	22.4
	Coimbatore	6108	88.7	49.8	10.7	1.24	8.28	78.5	30.3
	Delhi	257	396.0	47.0	25.0	5.5	15.8	46.8	35.1
	Pantnagar	104.0	137.0	22.0	14.0	4.7	9.8	36.4	24.1
	Parbhani	320/0	480.0	32.4	22.2	9.9	21.6	31.5	33.3
	Rahuri	16.4	17.2	29.7	20.8	0.6	0.82	30.0	4.7
	Udaipur	144.0	175.0	41.0	28.0	3.5	6.3	31.7	17.7
Banana	Hawanisagar	277.0	329.0	186.0	172.0	1.5	1.9	7.5	15.8
	Kharagpur	290.0	400.0	106.0	106.0	2.74	3.8	0.0	27.5
Ber	Belvatgi	13.7	18.0	15.4	12.5	0.9	1.4	18.8	23.9
Grapes	Dharwad	101.0	101.0	53.0	28.0	1.91	3.6	47.2	0.0
Guava	Allahabad	0.16/ plant	0.22/ plant	6.4	5.21	0.03	0.04	18.6	27.3
Kinnow	Delhi	68.0	98.0	22.1	17.3	3.1	5.7	21.7	30.6
Lemon	Delhi	15.0	27.0	23.0	17.5	0.65	1.54	23.9	44.4
Pomegranate	Belvatgi	7.4	14.4	10.7	8.7	0.7	1.7	18.7	48.6
	Hyderabad	15.0	37.0	183.0	178.0	0.08	0.21	2.7	59.5
Watermelon	Jodhpur	294.6	882.0	80.0	80.0	3.7	11.0	0.0	66.6
	Pune	82.1	504.0	72.0	25.0	5.9	20.2	65.3	16.3

tion interval from the desirable water regime of field capacity of root zone. On the other hand, micro irrigation system allows frequent application of small quantities of water, which ultimately provides a nearly constant low-tension soil water condition in the major portion of the root zone. Table 1 presents a comparison of conventional irrigation methods and micro irrigation method.

Many trials have been conducted in the country on the water saving and yield enhancements of different horticultural crops by adopting micro irrigation technologies. Table 2 presents relative performance of different crops with drip irrigation in comparison with that of traditional irrigation methods (Sivanappan, 2009)

Fertigation

Irrigation and fertilization (= Fertigation) are the most important management factors through which farmers control crop development, yield and quality. The introduction of fertigation opened up new possibilities for controlling water and nutrient supplies to crops and maintaining the desired concentration and distribution of ions and water in the soil. Farmers are gradually getting convinced of the added benefits of using fertigation along with water application by micro irrigation system. Adoption of fertigation by farmers in several crops registered significant fertilizer savings (15 to 40%) in different crops. New fertilizers for fertigation include slow and controlled release fertilizers which ensure continuous plant nutrition over months besides matching nutrient release rate with plant needs, labour saving and reduced leaching. High efficiency of fertigation require ensuring the irrigation system supplies water with a high distribution uniformity (DU); using proper injection devices and safety hardware; recognizing how do plants respond to the pH of the fertigation solution and the effect of cation/anion ratio on the pH of the soil solution; fertilizer compatibility and solubility & corrosivity.

Chemigation

Drip irrigation system, which is highly efficient for water & fertilizer application, is also ideally suited and is prac-

tical to apply chemicals. The application by chemigation plant protectants such as herbicides, fungicides, insecticides, Nematicides, growth regulators, fumigants, bio-control agents and chlorine, acids and other chemicals to control clogging has rapidly expanded during the last two decades. The terms herbigation, insectigation, fungigation, nemagation, entomopathogation, and mycoherbigation have been coined to describe various types of chemigation now in use to apply plant protectants. While a great deal of success has been experienced with chemigation of plant protectants, all available chemicals or chemical formulations have not yet been evaluated for this application technique. Likewise, some chemical formulations that have been evaluated have not produced effective or consistent results. In general the application of most soil active chemicals via chemigation has given effective and consistent results. Soil active protectants include pre-emergence herbicides, some insecticides and fungicides, and most nematicides materials.

Use of saline water for irrigation

Improvements in salinity control generally come hand-in-hand with improvements in irrigation efficiency.

The key to the effective use of saline irrigation waters and salinity control is to provide the proper amount of water to the plant at the proper time. Because soluble salts reduce the availability of water in almost direct proportion to their total concentration in the soil solution, irrigation frequency should be increased so that the moisture content and salinity of irrigated soils are maintained as high and low, respectively. The most practical way to accomplish this is through use of drip irrigation. In general drip irrigation will reduce the sensitivity of most crops to saline waters, due to its ability to maintain low water tension in the root zone. The frequent application of water with drip irrigation reduces the concentration of salts in the root zone by moving the salts away from the root zone to the edges of the wetted perimeter. This process called micro leaching, prevents the harmful combination of high soil salinity and low soil moisture tension from occurring. Thus, crops under drip irrigation are more tolerant to saline soil and water conditions.

Use of waste water for irrigation

As competition for good quality water increases, there will be increased interest in using water of lower quality,

Fig. 1. Location of Plasticulture Development Centres, NCPAH

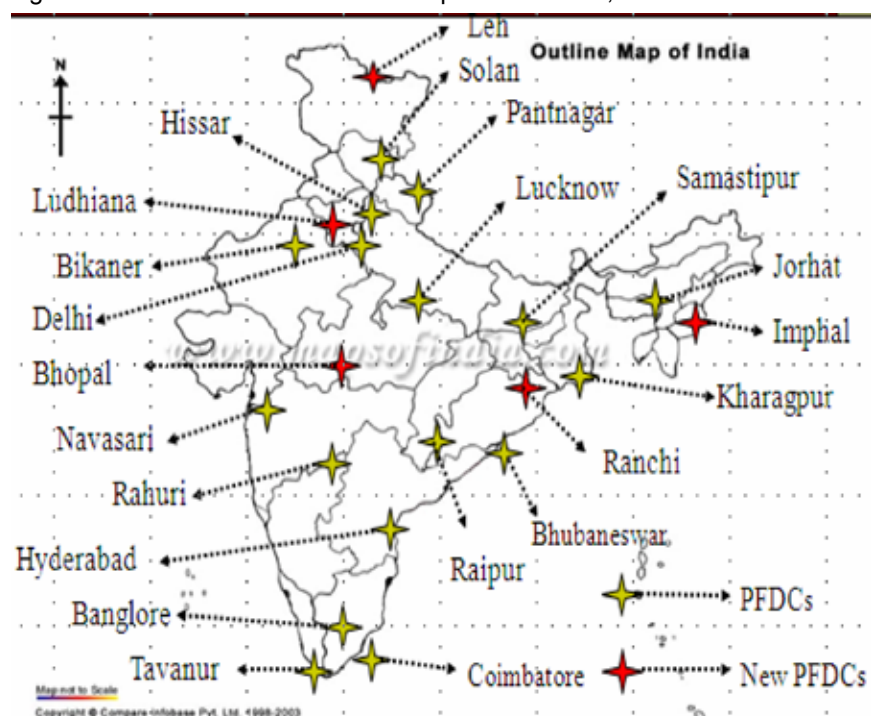


Table 3. Theoretical potential of micro irrigation in India

Crop	Area (Million Ha)		
	Drip	Sprinkler	Total
Cereals	-	27.6	27.6
Pulses	-	7.6	7.6
Oil seeds	3.8	1.1	4.9
Cotton	7.0	1.8	8.8
Vegetables	3.6	2.4	6.0
Spices and condiments	1.4	1.0	2.4
Flowers, Medicinal, aromatic plants	-	1.0	1.0
Sugarcane	4.3	-	4.3
Fruits	3.9	-	3.9
Coconut, Oil Palm & Plantation Crops,	3.0	-	3.0
Total	27.0	42.5	69.5

e.g. recycled domestic waste and animal waste waters. Use of wastewater for irrigation of industrial crops, fruits, managed landscapes, golf & race courses has been actively practiced in other countries for many years, especially in Israel & USA. However, wastewaters often contain microbial and chemical contaminants that may affect public health and environmental integrity. Wastewater pretreatment strategies and advanced irrigation systems may limit contaminant exposure to crops and humans. Subsurface drip irrigation (SDI) shows promise for safely delivering reclaimed wastewater. The closed system of SDI subsurface pipes and emitters minimizes the exposure of soil surfaces, above ground plant parts, and groundwater to reclaimed wastewater. Experiments in several countries revealed that subsurface drip irrigation prevented the virus movement onto crop leaf surfaces. However, beneficial and safe use of reclaimed wastewater for subsurface drip irrigation will depend on management strategies that focus on irrigation pretreatment, virus monitoring & inactivation strategies, field and crop selection, appropriate drip design & component (emitter type & discharge rate; filter type) selection, assessment of water quality, monitoring and periodic leaching of salts. Before wastewater can be used for irrigation of food crops, even with SDI where water does not directly contact edible portions of the crop, regulations in most countries will have to be

modified.

Automation

There is an increasing trend to shift from manual to automatic operations. Irrigation can be almost totally automated by using micro irrigation systems. This requires linking the irrigation water lines to a remote control mechanism that uses small computers. Israel first introduced these computerized controls into its farm management systems in the early 1970s. At that time, the principal reason for the program was protection for farmers who were in danger from land mines and snipers when they went to the fields to maintain irrigation controls. Later, automated irrigation was developed into a water efficient technology and a means of increasing crop yields. In either small or large micro irrigation systems and greenhouses, the computer can control water flow, detect leaks, shut off faulty lines, adjust water application for wind speed, air temperature, and soil moisture content; filter backwash;

apply fertilizer on schedule; monitor plant growth & water relations. An added advantage of the computerized systems is their ability to locate malfunctions and alert the operators to make necessary repairs before the faulty element causes too much damage or water loss.

Potential for Micro irrigation in India

Cost economics of Micro Irrigation for various horticultural as well as agricultural crops has been well proven. Because of several benefits in terms of water saving, low water utilization, usage in undulating areas, the drip technology has peculiar benefits in following areas which may result into fetching higher productivity.

1. All horticultural crops, row crops, flowers, plantation crops, cash crops, cereals
2. Well irrigated areas constituting about 35% of irrigated area in the country
3. Hilly areas
4. Arid & semi Acid zones
5. Waste lands
6. Saline lands
7. Land with saline water
8. Coastal belts
9. Water scarce areas

Task Force on Micro irrigation

Recognizing the urgent need for increasing Water Use Efficiency (WUE), Government of India had constituted a National Task Force on Micro Irrigation under the Chairmanship of the then Chief Minister of Andhra Pradesh, Shri. N. Chandrababu Naidu with the following terms and references.

1. To suggest strategies to expand coverage of area under micro irrigation in the country.
2. To suggest institutional mecha-

Table 4: Area covered under drip/ sprinkler irrigation under Centrally Sponsored Micro irrigation Scheme

Financial Year	Drip Irrigation (ha)	Sprinkler Irrigation (ha)	Total (ha)
2006-07	155000	144000	299000
2007-08	209000	241000	450000
2008-09	250000	324000	574000
2009-10	1897280	3044940	4942220
Total	2511280	3753940	6265220

S.N.	State	Drip, ha	Sprinkler, ha	Total
1.	Andhra Pradesh	505205	256911	762116
2.	Arunachal Pradesh	613	0	613
3.	Assam	116	129	245
4.	Bihar	301	435	737
5.	Chattishgarh	6360	95740	102100
6.	Goa	793	582	1375
7.	Gujarat	226773	180572	407345
8.	Haryana	11351	533740	545090
9.	HP	116	581	697
10.	Jharkhand	208	742	950
11.	Karnataka	209471	385579	595050
12.	Kerala	15885	3540	19425
13.	Madhya Pradesh	51712	143233	194946
14.	Maharashtra	604440	295382	899822
15.	Manipur	30	0	30
16.	Mizoram	72	106	178
17.	Nagaland	0	3962	3962
18.	Orissa	11046	33015	44061
19.	Punjab	17925	11414	29339
20.	Rajasthan	30047	866592	896639
21.	Sikkim	23460	11339	34799
22.	Tamil Nadu	153437	27834	181271
23.	UP	12636	13310	25945
24.	Uttanchal	38	6	44
25.	West Bengal	247	150196	150443
26.	Others	15000	30000	45000
Grand Total		1897280	3044940	4942220

nism needed for promoting micro irrigation including quality assurance, quality assurance, regionally differentiated technologies and interventions. 3. To suggest technological support for regions & crop specific interventions on micro irrigation. 4. To suggest measures so that the intended benefits reach the target groups.

Major Recommendations of Task Force

1. Micro irrigation is to be promoted in a holistic manner involving appropriate cultivars, agronomic practices, post harvest handling, processing and marketing. The assistance for micro irrigation should be viewed as an investment for infrastructure support. 2. 50% financial assistance should

be provided to farmers for adoption of micro/ sprinkler irrigation with the Central Govt. share @ 40% of cost and State Govt's share @ 10% of cost. The balance 50% share will have to be borne by the beneficiaries for which they may seek institutional financing.

3. Micro irrigation should be made compulsory in command areas of new irrigation projects.

4. That the system is more affordable to farmers, the task force has recommended that no such taxes as sales tax, trade tax, purchase tax and local taxes like octroi, entry tax, etc should be levied on the micro irrigation system.

5. Adequate post-installation maintenance and extension services need

be provided to the farmers

6. Task force recommends a sound institutional mechanism in operationalising the scheme on plasticulture. The network of 22 Precision Farming Development Centers (Fig 1) to be strengthened and converted into centers of excellence. These should be equipped to function as quality testing centers for micro irrigation.

7. The potential for coverage under drip and sprinkler irrigation is estimated to be about 27 and 42.5 million ha respectively (Table 3).

Centrally Sponsored Scheme on Micro Irrigation:

Based on the recommendations of the Task Force, Government of India had initiated a Centrally sponsored micro irrigation scheme in the country with 50% financial support to farmers from Central as well as State Government budgets in the ratio of 4:1. National Committee on Plasticulture Applications in Horticulture was made its coordinating agency. The results of the efforts of the scheme may be seen from Table 4 (Anonymous, 2010).

Different States have encouraged farmers through additional financial support too to adopt micro irrigation with a view to realize enhanced water savings and yield increases. Table 5 presents the area covered under micro irrigation in different States of India.

CONCLUSIONS

Government of India is making sincere efforts in enhancing water productivity in agriculture. To give water saving techniques further water needs to be treated as a national resource to develop and monitor and implement national schemes avoiding States interferences. Large irrigation schemes need to be combined with micro irrigation techniques to achieve higher water productivity at farmers fields. Besides attempts to reduce capital cost requirements of micro irrigation systems efforts need to be made to convince the Government of India to treat expenditure on micro irrigation as an investment to provide farmers the requisite tax benefits.

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Status of Food Processing In India

Introduction

The food processing sector is highly fragmented industry in India. It comprises of the sub-segments like fruits and vegetables, milk and milk products, beer and alcoholic beverages, meat and poultry, marine products, grain processing, packaged or convenience food and packaged drinks. A huge number of entrepreneurs in this industry are small in terms of their production and operations, and are largely concentrated in the unorganized segment. This segment accounts for more than 70% of the output in terms of volume and 50% in terms of value. Though the organized sector seems comparatively small, it is growing at a much faster pace. The organized sector is mostly controlled by multi national or big business houses and hence they have sourced the technologies from the countries from where they import the machines. The unorganized sector has cottage and tiny industries spread over length and breadth of the country. Due to large population and easy availability of locally grown raw material they have thriving business and hence not much concerned with the quality and food safety. Though little intervention and efforts they can get higher value addition benefits.

However to get premium price for better quality products was not possible earlier however due to growing middle class with higher disposable income now it is possible. Even then change is very slow. The innovative approach in using the modern technologies for our own commodities was not followed earlier. Using our own crop commodities and making ready to eat/cook convenient products using modern techniques like baking, extrusion, osmo dehydration etc. offer great scope for its acceptance in domestic urban as well export market.

The country has not been able to make big strides in food processing sector mainly due to poor infrastructure in terms of cold storage, warehousing, etc. The produce which is grown is highly heterogeneous due to fragmented land holding and hence not suitable for large capacity processing plants. Present day market relies on standards and certification, and we have inadequate quality control and testing infrastructure to meet the growing demand of processed foods. The supply chain is inefficient and value chain is controlled by large number of middlemen. This results in high transportation and inventory



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carrying cost and makes whole process uneconomical and unattractive. Due to ability to grow almost all perishable crops through out the year in one portion or other in the country, they are affordable in fresh form. The cultural and regional preference also supports use of fresh food. The production catchment processing seems only alternative to increase food processing activity. However non availability of adequate and efficient equipment and machinery to be used in catchment and restrictions on purchase, movement and storage of food commodities by private entities are some other reasons for slow growth of this sector.

Present status

The food processing industry can be classified into three categories: organized (25 %), small scale (33 %) and unorganized (42 %) (Source: FAIDA/Ministry of Food Processing Industries). The share of food processing in total manufacturing is only 9 % in India.

Fruits & Vegetables

The installed capacity of fruits and vegetables processing industry has doubled from 1.1 mn tonnes in Janu-



ary 1993 to 2.1 mn tonnes in 2006. Presently, the processing of fruits and vegetables is estimated to be around 2.2% of the total production in the country. The major processed items in this segment are fruit pulps and juices, fruit based ready-to-serve beverages, canned fruits and vegetables, jams, squashes, pickles, chutneys and dehydrated vegetables. The new arrivals in this segment are vegetable curries in retortable pouches, canned mushroom and mushroom products, dried fruits and vegetables and fruit juice concentrates. The fruits and vegetable processing industry is also fragmented. A large number of units are in household and small-scale sector, having low capacities of up to 250 tonnes per annum. From the year 2000 onwards the industry has seen a significant growth in ready-to-serve beverages, pulps and fruit juices, dehydrated and frozen fruits and vegetable products, pickles, processed mushrooms and curried vegetables, and units engaged in these segments are export oriented.

Milk and Milk Products

India with highest livestock populations in the world, accounts 50% of the buffaloes and 20% of the world's cattle population, most of which are milch cows and milch buffaloes. India's dairy industry is considered to be one of the most successful development industry in the post-Independence era. In 2005-06 total milk productions in the country was over 90 million tonnes with a per capita availability of 229 gms per day. During 1993-2005, the dairy industry recorded an annual growth of 4%,

which is almost 3 times the average growth rate of the dairy industry in the world. The total milk processing in India is around 35%, of which the organized dairy industry accounts for 13% while remaining is either consumed at farm level, or sold as fresh, non-pasteurized milk through unorganized channels. In an organized dairy industry, dairy cooperatives account for the major share of processed liquid milk marketed in India. Milk is processed and marketed by 170 Milk Producers' Cooperative Unions, which federate into 15 State Cooperative Milk Marketing Federations. Over the years, several brands have been created by cooperatives like Amul (GCMMF), Vijaya (AP), Verka (Punjab), Saras (Rajasthan). Nandini (Karnataka), Milma (Kerala) and Gokul (Kolhapur). The milk surplus states in India are Uttar Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. The manufacturing of milk products is very much concentrated in these states due to the availability of milk in huge quantity. According to the Ministry of Food Processing Industries, exports of dairy products have been growing at the rate of 25% per annum in terms of quantity and 28% in terms of value since 2001. Significant investment opportunities exist for the manufacturing of value-added milk products like milk powder, packaged milk, butter, ghee, cheese and ready-to-drink milk products.

Meat & Poultry

Since 1995, production of meat and its products has been significantly growing at a rate of 4% per annum. Presently the processing level of buffalo meat is estimated at 21%, poultry is estimated at 6%



while marine products are estimated at 8%. But only about 1% of the total meat is converted into value added products like sausages, ham, bacon, kababs, meatballs, etc. Processing of meat is licensed under the Meat Food Products Order, 1973. Presently the country has 3,600 slaughterhouses, 9 modern abattoirs and 171 meat-processing units licensed under the meat products order. Poultry industry is also among the faster growing sectors rising at a rate of 8 % per year. It is observed that the vertical integration of poultry production and marketing has lowered costs of production, consumer prices of poultry meat and marketing margins. There are eight integrated poultry processing units in the country, which of course hold a significant share in the industry. Meat export is largely driven by poultry, buffalo, sheep and goat meat, which is growing at close to 30% per annum in terms of quantity. It is considered that the growing number of fast food outlets in the country has and will have a notable impact on the meat processing industry.

Marine Products

India is the largest fish producing country in the world, it is the third largest fish producer in the world while ranks second in inland fish production. Categorically India's potential for fishes, from both inland and marine resources, is supplemented by the 8,000 km coastline, 3 mn hectares of reservoirs, 50,600 sq km of continental shelf area, 1.4 mn hectares of brackish water and 2.2 mn sq km of exclusive economic zone.



Processing of marine produce into canned and frozen forms is carried out fully for the export market. With regards to infrastructure facilities for processing of marine products there are 372 freezing units with a daily processing capacity of 10,320 tonnes and 504 frozen storage facilities for safe storage with a capacity of 138,229.10 tonnes, besides there are 11 surimi units, 473 pre-processing centres and 236 other storages. Processed fish products for export include conventional block frozen products, individual quick frozen products (IQF), minced fish products like fish sausage, cakes, cutlets, pastes, surimi, texturised products and dry fish etc. Exports of marine products have been inconsistent and on a declining trend which can be owed to the adverse market conditions prevailing in the European and American markets. The anti-dumping procedure initiated by the US Government has affected India's shrimp exports to the US.

Grain Processing

Processing of grain includes milling of wheat, rice and pulses. In 1999-00, there were more than 91,000 rice hullers and 2,60,000 small flourmills which were engaged in primary milling. There are 43,000 modernized rice mills and huller-cum-shellers. Around 820 large flourmills in the country convert about 10.5 mn tonnes of wheat into wheat products. Also there are 10,000 pulse mills milling about 75% of pulse production of 14 mn tonnes in the country. Primary milling of grains is the considered to be the important activity in the grain-processing segment of the industry. However, primary milling adds little to shelf life, wastage control and value addition. Around 65 % of rice production is milled in modern rice mills. However, the sheller-cum-huller mills operating give low recovery. Wheat is processed for flour, refined wheat flour, semolina and grits. Apart from the 820 large flourmills, there are over 3 lakh small units operating in this segment in the unorganised sector. Dal milling is the third largest in the grain processing industry, and has about 11,000 mechanised mills

in the organised segment. Oilseed processing is another major segment, an activity largely concentrated in the cottage industry. According to estimates, there are approximately 2.5 lakh ghanis and kolus which are animal operated oil expellers, 50,000 mechanical oil expellers, 15,500 oil mills, 725 solvent extraction plants, 300 oil refineries and over 175 hydrogenated vegetable oil plants. Indian Basmati rice has gained international recognition, and is a premium export product. Branded grains as well as grain processing is now gaining popularity due to hygienic packaging.

Beer & Alcoholic Beverages

When discussed on alcoholic beverages, India is considered to be the third largest market for alcoholic beverages in the world. The domestic beer and alcoholic beverage market is largely dominated by United Breweries, Mohan Meakins and Radico Khaitan. The demand for beer and spirits is estimated to be around 373 million cases per year. There are 12 joint venture companies having a licensed capacity of 33,919 kilo-litres per annum for production of grain based alcoholic beverages. Around 56 units are manufacturing beer under license from the Government of India. Country liquor and Indian Made Foreign Liquor are the two segments in liquor; both cater to different sections of society. The former is very much consumed in rural areas and by low-income groups, while the middle and high-income groups consume the latter. The wine industry in India has come into prominence lately and has been receiving support from the Government as well, to promote the industry. The market for this industry has been estimated to be growing at around 25 % annually. Maharashtra has emerged as an important state for the manufacture of wines.

Packaged /Bottled/ Convenience Foods

Consumer food industry mainly consists of ready-to-eat and ready-to-cook products, salted snacks, chips, pasta products, cocoa based products, bakery products, biscuits, soft drinks, etc. There are around 60,000 bakeries, several pasta food units and 20,000 traditional food units in India. The bakery industry is among



the few processed food segments whose production has been increasing consistently in the country in the last few years. Products of bakery include bread, biscuits, pastries, cakes, buns, rusk etc. This activity is mostly concentrated in the unorganised sector. Bread and biscuits constitute the largest segment of consumer foods with an annual production of around 4.00 million tonnes. Bread manufacturing is reserved for the small-scale sector. Out of the total production of bread, 40 % is produced in the organized sector and remaining 60 % in the unorganised sector, in the production of biscuits the share of unorganized sector is about 80 %. Cocoa products like chocolates, drinking chocolate, cocoa butter substitutes, cocoa based malted milk foods are highly in demand these days, 20 production units are engaged in their manufacture with an annual production of about 34,000 tonnes. After packed tea and packed biscuits the soft drink segment is considered to be the 3rd largest in the packaged foods industry. Over 100 plants are engaged in aerated soft drinks indus-

try and provide huge employment. It has obviously attracted one of the highest FDI in the country. Strong forward and backward linkages with glass, plastic, refrigeration, sugar and the transportation industry further strengthen the position of the industry. Soft drink segment has a huge potential in the Indian market, as a vast portion of the market is still to cover.

Post Harvest Losses

However there are huge post harvest losses especially in perishable products. This mainly due to long supply chain, because every change of hand the loss in quality and quantity is bound to take place. The essential primary processing operations of washing of fruits and vegetables to remove field heat and also removal of contaminants coming from field at farm level as well as cleaning, grading of grain is not at all followed that leads to losses during short as well as long term storage. Another reason is lack of infrastructure to properly store the grain as well as perishables. The grains are stored in open where they are exposed to sun and rain and fruits and vegetables are stored at high temperature low humidity conditions that causes physiological damage. The total capacity for storage of food grains is around 25 million metric tonnes. The total capacity of the cold stores is around 24 million metric tonnes. The manpower engaged in agriculture is also not scientifically

trained. The farmers are mostly concentrating on production and are not sensitive to post harvest operations though it is possible to do at rural level and the benefits are highly visible looking to the gap between the prices of raw and processed foods. Lack of proper transport is another reason, for examples grains are transported in the gunny bags which are reused, in reusing they become weak and also more porous to atmospheric moisture. The spoilage during handling due to insertion of hooks is also substantial to the tune of Rs. 15000 crores. The food material is very badly handled hence mechanical injury, bruising, breaking takes place which spoils the food during storage. Another food safety concerns are use of inappropriate use of agricultural chemicals, use of untreated or partially treated wastewater, excreta or manure supplies for crop irrigation, absence of proper food inspection, lack of potable water for processing and poor personal hygiene.

Therefore training and sensitization of the manpower, development of post harvest handling, transportation and storage protocols for different commodities, development, testing and popularization of physical and chemical post harvest treatments, establishment of infrastructure for processing (primary/secondary/tertiary) in production catchments are some of the interventions for reduction in post harvest losses.

Contributions of CIPHET in Post Harvest Sector

The CIPHET has contributed significantly by developing appropriate technologies in the field of post harvest management and value additions which are namely Development of protocols for pre-harvest treatments especially for horticulture crops, like irrigation scheduling, application of

chemicals, growth hormones etc., Determination of maturity indices for harvesting of food grains and horticulture crops, Development of appropriate tools and gadgets for safe and efficient harvesting, Development of efficient machinery for pre-cooling, pre-cleaning, grading, sorting of commodities at production catchments, Determination of safe storage moisture content and drying techniques for adoption at farmers and traders level, Standardization of design for modern storage structures, rural godowns for food grains and evaporatively cooled storage structures for fruits and vegetables, Process protocols for minimal and intermediate processing for fruits and vegetables such as puree and powder making, controlled ripening, and waxing and CFB packaging, Developing the novel processing techniques for value added products suitable for small scale operations in production catchments. In addition to this CIPHET conducts EDPs on value addition, provides consultancy on setting up of processing units and licensing of successful & proven technologies. The specific technologies developed by CIPHET are Pomegranate Aril Extracting machine and hand tool, CIPHET evaporatively cold storage structures, banana comb hand cutter, rotary maize cob sheller, porous bricks, castor decorticator, basket centrifuge, lac scrapper cum grader, groundnut pod grader, groundnut pod decorticator, mobile agro-processing unit, mustard sauce, vegetable blended meat products, process and equipment for groundnut milk curd and paneer, green chilli powder and paste, garlic/ginger and onion powder, minimal processing of vegetables, sorghum soy blended biscuits, extruded snacks, de-hulling of guar gum, aonla beverage, guava bar, pomegranate products, makhana kheer mix, ready to eat mustard saag, shrink packaging of fruits and vegetables, MAP of fruits and vegetables.

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Low Cost Wheat Cultivation Technology for Warmer Areas of India

S. V. Sai Prasad and H. N. Pandey

India has achieved the distinction of becoming the second largest producer of wheat in the world, with an annual production of around 70 million tones. However, for feeding the burgeoning population, India would require an estimated 105 million tones of wheat by 2020. Hence, a concerted effort is needed to enhance the genetic potential of newer genotypes and also to bridge the gap between realized and realizable productivity. To make the wheat cultivation more productive and profitable, it is essential to cut down the cost of production for competing more effectively in global market. With decreasing per capita land availability, it is essential to increase cropping intensity to improve vertical production for ensuring **"Food Security"** to exploding population of the country. Warmer areas like Peninsular and Central India along with the north east hold the potential to bridge the gap in productivity (Table 1). The main environmental advantages of warmer areas for higher yield are low atmospheric humidity during grain filling, hence least yellow berry in the

grain, produce has high hectoliter weight and high protein content due to nutritionally rich vertisols, absence of seed borne diseases, excessive vegetative growth is cut off, hence high plant population can be maintained to obtain high grain yield.

While, the realized productivity of the region is very low because of various reasons, of which inadequate availability of irrigation water and warmer temperatures during crop growing seasons, susceptibility to stem and leaf rusts, frosting are the major limitations. So, all the technologies / strategies to be adopted to improve the productivity of this region, must aim at improving **"water use efficiency"** and breed for wheat genotypes having high tolerance to drought and heat, particularly to the early October-November heat to enable them to yield even under limited water availability.

Combining high yield along with early maturity will reduce the water requirement of the genotypes, protecting it from terminal drought and heat. For ex., evolution of wheat varieties, HI 8498, HI

1479 and HI 1500. Such genotypes with high tolerance to drought will need limited irrigation to produce high yield, thereby saving irrigation water for other useful crops or to meet drinking water supply. Because of high degrees of tolerance to drought and high temperatures, du-

Table 2 : Irrigation requirement of durum and aestivum wheats

Varieties	Av. Yield (q/ha)	Irrigation needed
Durums	51	3
Aestivums	49	5 - 6

rum wheats need less irrigation; and hence, in warmer areas, their cultivation essentially needs to be promoted on priority to save irrigation water. Durum need 3 to 4 irrigations to yield 50 q/ha while, aestivums need 5 to 6 irrigation to give similar yield.

To make use of September – October precipitation, and of unstable water sources of the Central and Penninsular warmer areas, early wheat sowing will be essential. Such genotypes need to have high tolerance to early October-November heat to maintain their normal vegetative growth. Similarly at maturity, in absence of adequate moisture availability, these genotypes need to have late heat tolerance as well as for proper and

Table 1: States / Area covered under warmer areas of Tropical India.

States Covered	Wheat Area (Million hectares)
Madhya Pradesh	5.0
Chhattisgarh	1.0
Gujarat	0.5
Southern Rajasthan	0.5
Bundelkhand (UP)	0.5
Maharashtra	0.8
Karnataka	0.3
Total	8.6
India	25.5 (average)

Equal Area under North East as in Central and Penninsular India



Table 3 : Appropriate water use efficient varieties for Central India

Class of wheat	Varieties	
Bread wheat	HW 2004 (Amar)	HI 1500 (Amrita)
	HI 1531 (Harshita)	HI 1418 (Naveen Chandousi)
	HI 1479 (Swarna)	DL 788-2 (Vidisha)
	HI 1544 (Purna)	
Durum wheat	HD 4672 (Malav Ratna)	HI 8381 (Malavshree)
	HI 8498 (Malavshakti)	HI 8627 (Malav Kirti)
	HI 8663 (Poshan)	HI 8638 (Malav Kranti)

plump grain filling. Under multiple crop rotation, December-January sown genotypes will essentially need stronger tolerance to late heat for proper grain filling at maturity.

In these warmer areas, wheat cultivation can be made more profitable by following limited tillage after kharif crop and dry sowing, growing water use efficient appropriate drought and heat tolerant varieties (Table 3 for Central India), requiring limited irrigation for improving productivity, and thereby saving irrigation water and energy.

Compared to talls, semidwarfs show better water use efficiency even under limited water supply. Semi-dwarf and medium early maturing HD 4672 and HI 8627 (durum wheats) and HD 2781 (aestivum wheat) are better yielders than their respective tall and medium late check varieties, which proved that dwarfness and early maturity can be combined along with drought tolerance. These semi-dwarf genotypes are more desirable under low input conditions because of their better water use efficiency. Similarly, HI 1500 (Table 4) being nearly 10 days early in heading and maturity

to “Sujata” and “HW 2004”, had outyielded both the check varieties in production and productivity, proving that early maturity and drought tolerance can be easily combined. Such genotypes will escape terminal drought at maturity and hence, will yield better because of their good grain filling. So, these varieties must be popularised in the areas of Tropical India, where limited irrigation facilities are available to improve the productivity and profitability of the wheat crop.

Dry shallow sowing followed by irrigation instead of giving paleva (pre-sowing irrigation) ensures good germination, uniform crop stand and saves one irrigation, energy of repeated ploughing and 10 to 15 days of time. Use of balanced fertilizers (N:P:K in 4:2:1 ratio) by drilling three inches deep in the soil before sowing in wheat ensures fertilizer use efficiency. Applying 5- 10 tons /ha FYM or 2.5 tons /ha poultry manure or green manuring and Zinc Sulphate application at least once in every three years along with recommended doses helps in maintaining soil health and sustain productivity

in wheat based crop rotation. In warmer areas, where two irrigations are available, use 1st as post-sowing to ensure good germination and 2nd after 40 to 45 days of 1st irrigation. Irrigating fields by making beds and channels, rather than long strips increases water use efficiency. Studies conducted at IARI – Indore indicated that by providing adequate nutrition to wheat crop, a good harvest of both wheat and soybean crops can be ensured without giving any additional nutrition to soybean crop, which will reduce the input cost in wheat-soybean system, improving profitability of both the crops. Dry sowing and clean cultivation methods will eliminate the use of weedicides too.

Studies indicated that durums have high resistance to leaf rusts while aestivums to stem rusts for ex., pathotype 77-5 of leaf rust, being most virulent on aestivum, is the weakest pathotype on durum and similarly, pathotype 117-6 of stem rust, being most virulent on durums, is the weakest pathotype on aestivum. So, aestivum and durum varieties complement the weaknesses of each other for the control of stem and leaf rusts. Hence, equal emphasis must be given on the popularization of both durum and aestivum varieties in tropical area to minimize the chances of leaf and stem rusts epidemics in the country.

Thus, popularization of durum wheat and early maturing high yielding varieties requiring less irrigation will improve “**water use efficiency**” and “**per day productivity**”. In addition, growing drought and heat tolerant varieties, eliminating pesticide use, following integrated cultivation methods in any wheat based cropping system and practicing appropriate low-cost water use efficient cultivation methods will help in improving wheat productivity and profitability in these tropical areas of the country.

Acknowledgements : The authors are grateful to all the scientific staff of IARI, Indore for their suggestions.

Table 4 : Yield potential of HI 1500 under rainfed conditions

Varieties	Maturity	Average yield (q/ha)	Per day productivity (Kg / ha)
HI 1500	ME	16.0	12.9
Checks			
Sujata	ML	14.3	11.0
HW 2004	ML	15.2	11.9

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– 452 001

Changing scenario of Pulses in India

A critical analysis

Dr. N. Nadarajan* and Dr. P.S. Basu**

Importance of pulses

Pulses are one of the important segment of Indian Agriculture after cereals and oilseeds. These pulses constitute chickpea, pigeonpea, lentil, mungbean, urdbean and fieldpea. The split grains of these pulses called ***dal*** are excellent source of high quality protein, essential amino and fatty acids, fibers, minerals and vitamins. These crops improve soil health by enriching nitrogen status, long-term fertility and sustainability of the cropping systems. It meets up to 80% of its nitrogen requirement from symbiotic nitrogen fixation from air and leaves behind substantial amount of residual nitrogen and organic matter for subsequent crops. The water requirement of pulses is about one-fifth of the requirement of cereals thus effectively save available precious irrigation water.

Present status

About 90% of the global pigeonpea, 75% of chickpea and 37% of lentil area falls in India, (FAOSTAT 2009). Due to stagnant production, the net availability of pulses has come down from 60 gm/day/person in 1951 to 31 gm/day/ in 2008. India is the largest producer and consumer of pulses in the world contributing around 25-28% of the total global production. The country grows a variety of pulse crops such as chickpea, pigeonpea, greengram (mung beans), blackgram (urdbean), dry peas and lentils under a wide range of agro-climate conditions. The production of total pulses in India is presently about 15 million tons covering an area of about 24 million hectare majority of which falling under rainfed, resource poor and harsh environments frequently prone to drought and other abiotic stresses. condition Fig 1. Pulses are least pre-

ferred by farmers because of high risk and less remunerative than cereals, consequently, the production of the pulses is sufficiently low. To meet the demand of pulses, India is at present importing about 3 million tons. Chickpea continues to be the largest consumed in this complex comprising of 45-50% of the total pluses production of India Table 1.

Production of pulses by various states

The major producers of pulses in the country are Madhya Pradesh (24%), Uttar Pradesh (18%), Maharashtra (15%), Rajasthan (10%), Andhra Pradesh (9%) followed by Karnataka (6%) which together share about 78% of total pulse production while remaining 22% is contributed by Gujarat, Chhattisgarh, Bihar, Orissa and Jharkhand (Fig. 2).

During the period of 4 decades (1971-2010), there is a marginal increase of approximately 10% in the area under pulse cultivation with a nominal gain of total production, however the yield of pulses has remained virtually stagnant for the last 20 years (580 kg/ha in 1990's to nearly 607 kg/ha during 2010) Fig 3. In terms of area, produc-



Dr. N. Nadarajan

Table 1 : Percent share of major pulses in total production of India

Commodity	Percent share
Chickpea	40-50%
Pigeonpea	15-16%
Blackgram	10-12%
Lentil	9-10%

tion and yield, chickpea contributes maximum among all major pulse crops Table 2.

Fig 1: Trend in production of total pulses in India

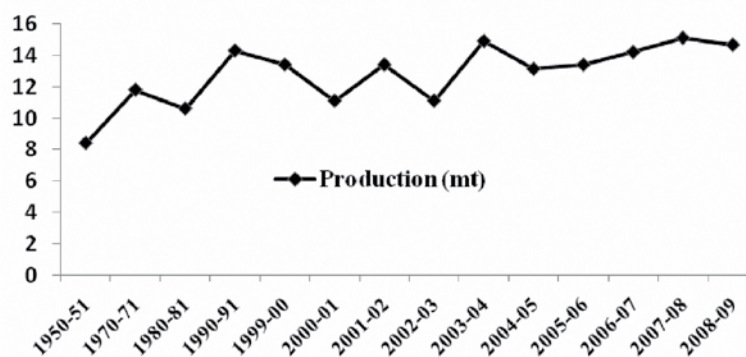
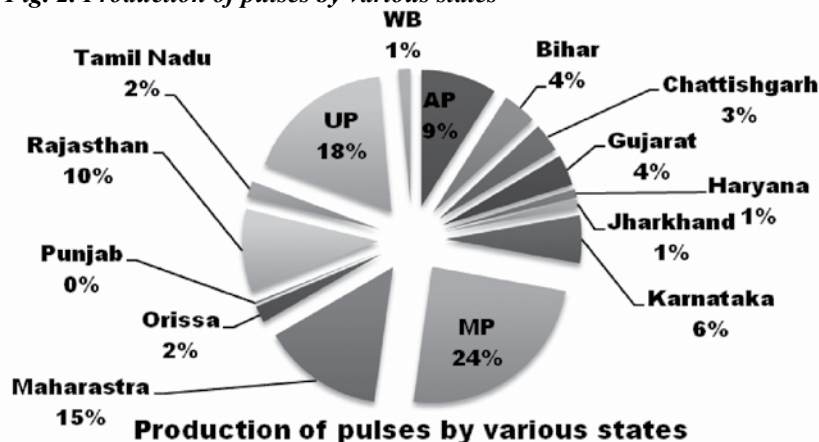


Fig. 2. Production of pulses by various states



ares) from northern India (cooler, long season environment) to southern India (warmer, short season environment) during the past four decades (Fig 5). The short-duration varieties developed through ICRISAT along with NARS partnership have played a key role in expanding area and productivity of chickpeas in central and southern India. Among all major pulses of northern India, chickpea suffered maximum losing 63% area from 4.98 million hectare to 1.85 million hectare. It is a serious concern for sustainability of agroecosystem of northern India.

Changing scenario of pulse growing states

The Indogangetic plains of northern India, once had been the pulse basket of India is showing a declining trend in area which are quite heavily replaced by wheat, rice and maize due to better irrigation facilities (Fig 4). Andhra Pradesh leads in the total pulse productivity with an average increase in the yield of two major pulses particularly in chickpea and pigeonpea to the tune of about 81-100% during two decades (1991 to 2010) (Table 3). This remarkable increase surpassed the national average increase in the total productivity ranging between 0-20%.

There has been major shift in chickpeas area (about 3.0 million hect-

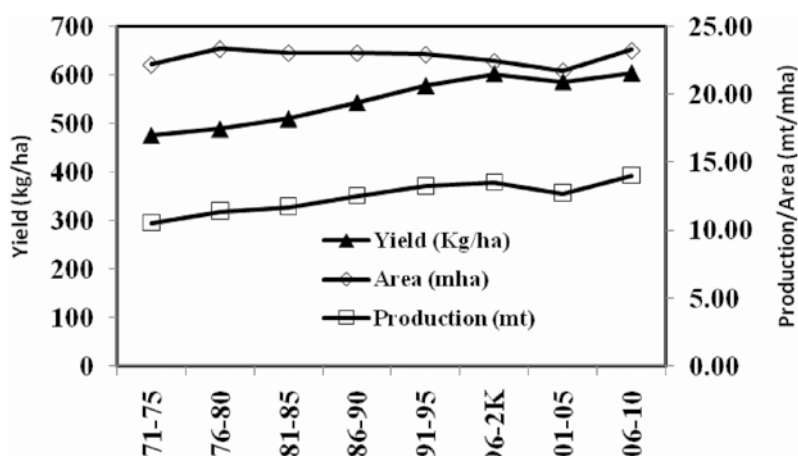


Fig 3: Trend in production, area and yield of total pulses in India (1971-2010)

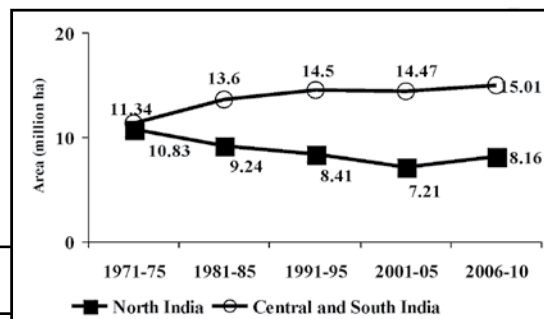


Fig 4: Geographical shift in pulses in India

In north India, rice-wheat crop rotation is predominant, and there is little scope for replacing wheat with rabi pulse crops, while in south India, there are vast patches of rice fallows, which can be utilised for sowing rabi pulse crops, as there is no strong competitive crop in the rabi season. The expansion of irrigated agriculture in northern India has led to displacement of chickpea with wheat in large area. The present trend revealed that

Table 2: Crop-wise national scenario

Crop	Area (mha)	Production (mt)	Yield (Kg/ha)	Major states
Chickpea	7.37	5.89	800	MP,UP,AP,Rajasthan,Karnataka, Haryana, Maharashtra
Pigeonpea	3.63	2.76	762	Maharashtra, UP, MP,Karnataka, AP, Gujarat
Lentil	1.50	0.95	629	UP, MP,Bihar, West Bengal
Dry peas	0.77	0.71	915	Uttar Pradesh, Madhya Pradesh
Urdbean	3.10	1.40	451	Maharashtra, AP, UP, MP, Tamilnadu, Karnataka, Orissa
Mungbean	3.44	1.20	351	Rajasthan, Maharashtra, AP, Bihar, Karnataka, Gujarat
Total pulses	23.26	14.12	607	Maharashtra, MP,UP,AP, Rajasthan,Karnataka, Gujarat

Table 3: Changes in the productivity of pulses (percent increase) during 1991 to 2010

	Pulses	Chickpea	Pigeonpea	Lentil	Greengram	Blackgram	Fieldpea
Andhra Pradesh	41-60	81-100	81-100		0-20	-	
Bihar	-	-	-	-	-	21-40	0-20
Gujarat	0-20	21-40	21-40		0-20		
Karnataka	21-40	41-60	81-100		-	-	
Madhya Pradesh	0-20	0-20	-	0-20	0-20	21-40	0-20
Maharashtra	21-40	21-40	21-40				21-40
Rajasthan	-	0-20	41-60	0-20	21-40	21-40	21-40
Uttar Pradesh	0-20	0-20	-	0-20	0-20	-	
West Bengal	0-20	21-40			-	0-20	
Orissa	-		-		-	-	
India	0-20	0-20	0-20	0-20	-	-	

area under pulses declined from 10.12 million hectare to 8.16 million hectare (about 20%) in north India (Fig 4). On the other hand, area of pulses increased from 11.34 to 15.01 in central and south India during the same three decades. Among pulses chickpea area decreased more than 50% from north India during 2006-10 considering the base year 1971-75 (Fig. 5). On the contrary, Andhra Pradesh set an example for remarkable increase in the production, area and yield in chickpea (Fig 6)

While area, production and yield of lentil, another cool-season legume in Uttar Pradesh remained stable over a long period but increased significantly in Madhya Pradesh (Fig 7). Productivity of pigeonpea (Arhar) productivity in north India remained stable inspite of about 25% decrease in area within four decades. While Andhra Pradesh and Karnataka (Fig 8) showed a increasing trend in production of pigeonpea. Contrary to this, area of cultivation of mungbean and urdbean has increased almost double in north India along with significant increase in the productivity of these two summer crops (Fig 9 and 10). The major reasons for

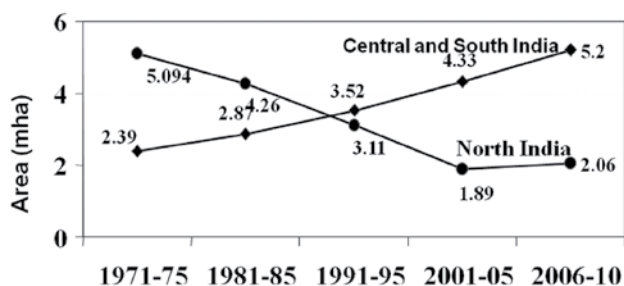


Fig 5 : Geographical shift in chickpea

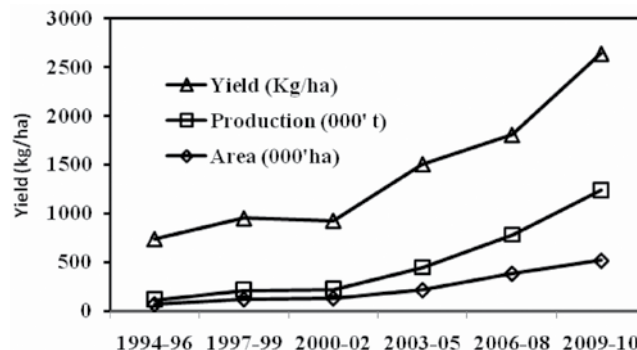


Fig 6 : Area, production and yield of chickpea in Andhra Pradesh

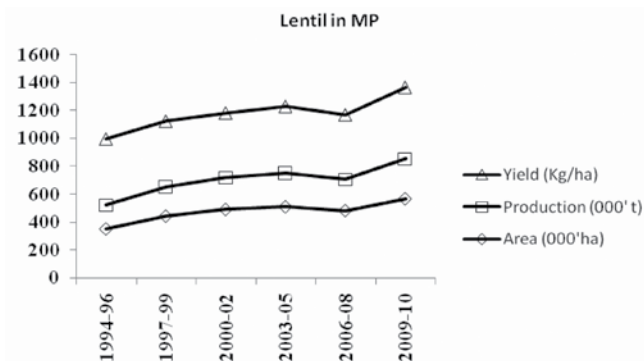


Fig 7 : Area, production and yield of lentil in Madhya Pradesh

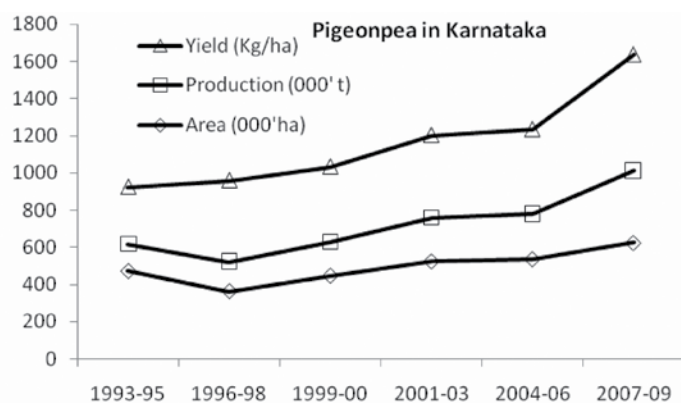


Fig 8 : Area, production and yield of pigeonpea in karnataka

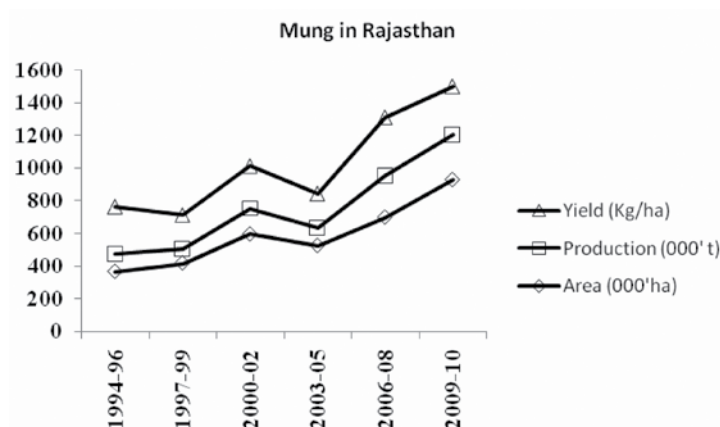


Fig 9: Area, production and yield of mungbean in Rajasthan

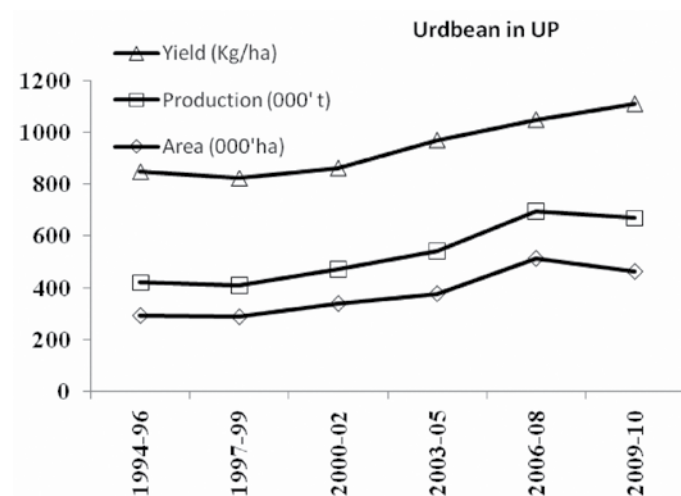


Fig 10: Area, production and yield of urdbean in UP

increasing both area and productivity in these two summer/kharif crops could be due to incorporation of many short duration varieties with synchronous maturity grown as catch crops in various cropping systems under irrigated condition.

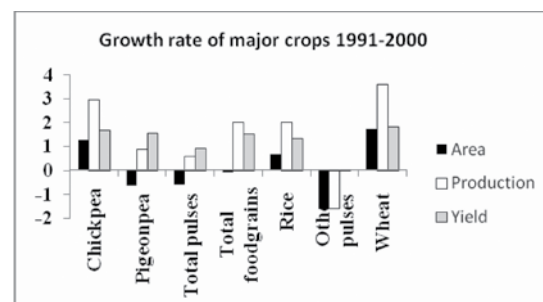
Factors determining reduction in pulses area in North India

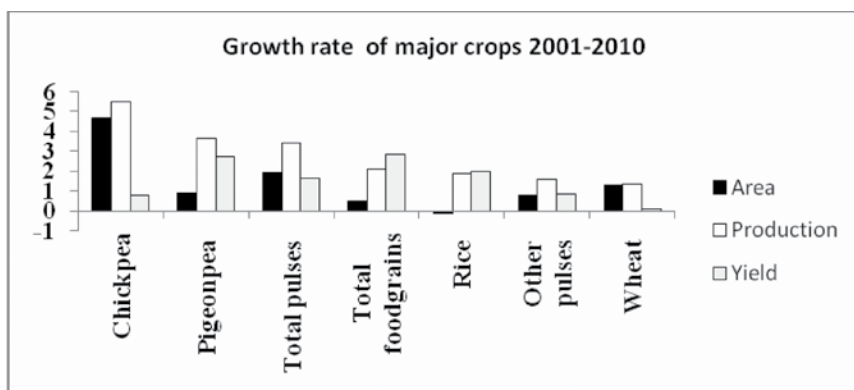
Critical analysis of the north Indian environments revealed that agroecosystem of this regions is becoming fragile and posing a potential threat for pulses cultivation. Some of the major underlying reasons for deteriorating conditions are as follows.

- Extensive rice-wheat cropping system replacing pulses.
- Farmers choice towards more remunerative crops
- Over-use of groundwater enhancing salinity
- Increased incidence of ascochyta blight aggravated with low temperature.
- Excessive fertilizers, pesticides and irrigation deteriorated soil quality
- Fast depletion of micronutrients (Zinc , Sulphur and boron)
- Cereal based cropping system has little scope to break the disease cycle.
- Inadequate or deficient rainfall amount during monsoon season
- Asymmetric pattern of temperature increase i.e. night minimums is increasing more rapidly than day time maximums.
- High yielding long duration pulses varieties bred for northern conditions are no longer suitable under changing scenario of climate change.

Growth rate of major crops

The growth rate in the total pulses area in the 1990s was negative. Both production and yield increased along with increase in area during 2001-10. Growth in yield of pigeonpea has been significantly higher during 2001-10, due to wider adoption of long duration varieties. While rapid growth in the production of chickpea has mainly been through higher growth of area in south India with the expansion of area under rice fallows, the growth rate in yield and area in case of other





pulse crops is still quite low.

Climate change influencing pulse production

India is most vulnerable to climate change. Intergovernmental Panel on climate change (IPCC) projected rise of temperature by 3-4 degrees over current levels. The predicted changes in temperature and their associated impacts on water availability, pests, disease, and extreme weather events are all likely to affect substantially the potential of pulse production.

Abiotic and biotic Constraints

There has been a high degree of risk in pulses production. More than 87% of the area under pulses is presently rainfed with annual rainfall of about 1,000 mm. Terminal drought and heat stress result in forced maturity and may reduce seed yields by 50% in the tropics. Another major problem is salinity and alkalinity of soils which is high both in semi-arid tropics and in the Indo-Gangetic plains in irrigated areas. Grain yield is also influenced by temperature extremes both low and high temperatures. Poor drainage/water stagnation during the rainy season causes heavy losses to pigeonpea on account of low plant stand and increased incidence of phytophthora blight disease, particularly in the states of UP, Bihar, West Bengal, Chhattisgarh, MP and Jharkhand. Ridge planting has been found very effective in ensuring optimal plant stand and consequently higher yield. Among biotic factors, weeds and a large number of insect pests attacking pulses, pod borer (*helioverma armigera*) causes the most harm, followed by pod fly and

fungal pathogens wilt, root rot and nematodes.

Possible initiative to revive pulse production in north India

Strategies to be made for breeding and popularization of region specific short duration pulses with combined tolerance to ascochyta blight and cold., development of extra large seeded *kabuli* chickpea varieties, short duration pigeonpea varieties for sequential cropping with wheat, breeding for wilt resistant, root rot complex combined with reproductive stage tolerance to high temperature, soil reclamation to prevent degradation and restore fertility and long term monitoring of hydrological cycle, soil nutrient status, climatic change through Geographical information system (GIS), remote sensing and meteorological database for these high risk zone.

Integrated Pest Management

A variety of chemical, biological and cultural methods together called IPM have been found to reduce pest and disease damage. Massive screening against diseases and pests led to the development of many resistant varieties now available for different agro-climatic zones. Besides these, many biocontrol agents cultural practices are shown to be effectively manage the diseases in pulses.

Physiological Limitations

Pulses have a high rate of flowers drop. In pigeonpea, over 80% of the flowers are shed; by decreasing flower drop, yield can be increased considerably. This can be done by breeding lines which retain a large

proportion of flowers producing pods or through spray of hormones which reduce flower drop.

Biofertilisers and Irrigation

Integrated nutrient and water management involve timely application of chemical fertilizers, sulphur and zinc, light irrigation at a critical stage, residue incorporation or rotation of legumes with short duration moong-bean, cluster bean, cowpea and horse gram may increase the yield of pulses and subsequent crops. Seed inoculation with biofertiliser (*rhizobium*) combined *Vesicular-arbuscular mycorrhizae* (VAM) can increase pulses productivity by 10-15%. In view of good response for supplemental irrigation to pulse crops, government should encourage policies to provide supplemental irrigation.

Genetic improvement for enhancing productivity

There is further scope for enhancing genetic improvement through heterosis breeding, biotechnology, Mutation breeding and development of ideal plant types in all pulses. ICPH-8, a hybrid pigeonpea was found to be superior to controls, UPAS-120 and Manak by 30.5% and 34.2% respectively, in productivity. Mutation breeding has contributed about 10% of the total improved varieties of pulses and is supplementing the conventional breeding programme. The mutant variety, Pant Moong-2, with resistance to YMV disease is very popular in north India

Post-Harvest Technology

Post-harvest losses involving storage (bruchid infestation), processing, threshing and transport together account for 9.5% of total pulses production. Increase in the processing efficiency in dal mills and appropriate storage structures (metal storage bins) need to be popularised for reducing post-harvest losses and encouraging rural employment.

Indo-Gangetic Plains and Rice Fallows for expansion of pulse area

The rice fallows have tremendous potential for future expansion of area, where there is no other crop

to compete. Policy options have to be evolved to incorporate at least one pulse crop in cropping systems to enhance returns from irrigated farming systems. In Indo-Gangetic plains, short duration pigeonpeas UPAS-120, Manak etc. have been introduced in the irrigated areas of Punjab, Haryana, Delhi and western UP under pigeonpea-wheat based cropping system. Similarly, short duration with synchronised maturity and YMV resistant varieties of mungbean PDM-11, PDM-54 offer good scope for their introduction as catch crop in rice-wheat system. There is vast area of fallow land in MP (78% of kharif rice area, which accounts for 4.4 million ha), Bihar (2.2million ha) and in West Bengal (1.7 million ha), which are most suitable for pulses cultivation.

About 7 lakh hectare of land from Punjab, Haryana, Delhi, Western UP can be expanded for pulses through diversification of rice-wheat and maize-wheat cropping system by substituting wheat by chickpea/fieldpea/lentil (1 lakh ha), popularization of mungbean as catch crop after wheat (5 lakh ha). Similarly another 7 lakh hectare of land from UP, Bihar, Jharkhand, Orissa, West Bengal and Assam can be brought under pulses through diversification of rice-wheat and rice-rice cropping system by catch cropping of mungbean (2 lakh hectare), substituting wheat with lentil (3 lakh hectare), expansion of chickpea and lentil in Diara land and Tal area of UP, Bihar in rice fallows (1 lakh hectare), Intercropping of urdbean and mungbean with spring sugarcane (1 lakh hectare)

Other Issues in Increasing Production

Lack of Seed Availability, Marketing and Gaps in Technology

The wide gap between requirement of certified/quality seeds and its distribution is a matter of great concern. The seed replacement ratio is very low (2-5%), while required seed replacement ratio is 10%. Markets for legumes are thin and fragmented due to scattered production and consumption across states. Farmers do

not benefit from the higher market prices of pulses. Farmers' need to be sensitized for optimum application of fertilisers, pesticides, number of irrigations and improved varieties through farmer participatory research (FPR) .

National Food Security Mission (NFSM)

Under Accelerated Pulse Production Programme launched in 2010, about 60,000 villages are being covered only for pulses where 100 per cent fertilizer, 250 Kg Gypsum and other inputs will be made available for farmers for promoting pulse cultivation. In 2007 during 11th Five year Plan, National Food Security Mission (NFSM) was commissioned by National Development Council under Chairmanship of Prime Minister Dr Manmohan Singh with a commitment to produce 2 million ton additional pulse production. Under this programme, 14 states covering 168 districts were identified with declaration of providing Minikits to the pulse growing farmers of the country.

Imports and Exports

India continues to be the world's largest importer and accounts for 30-40% of total world import of pulses due to the explosive population growth. The India meets its domestic needs primarily through imports from USA, Australia, Myanmar, Turkey Tanzania and Canada. India's net imports of pulses have ranged from 1 mt to 3 mt, while exports are one-tenth of the volume of imports. Imports of pulses increased from 0.58 mt to 3.1 mt between 1994-96 and 2007-09 and are projected to increase to 4 mt by 2012. The share of peas, chickpeas, pigeonpea and moong was higher in total imports. Peas, chickpeas, beans and pigeonpea showed increase in imports during 1994-96 to 2007-09. India also has a comparative advantage in the export of lentils, as it has

Table 4: Changes in the import of pulses in India

Commodity	Import (qty in Tonnes)		
	1994-96	2007-09	% Change
Peas	1,72,180	9,28,101	439
Chickpea	87,390	4,35,681	399
pigeonpea	96,200	3,59,094	273
Mungbean	33,570	2,20,080	556
Other beans	23,220	1,38,987	499
Lentils	30,040	87,488	191
Urd bean	35,140	33,111	-6
Total pulses	5,79,120	23,05,377	298

Source: FAOSTAT (2009).

been the largest export item among pulses during the last 10 years. Pulses shortfall may increase to 6.8 mt by 2020-21 and the anticipated increase in per capita consumption of pulses is from 9 kg per year in 2007-08 to 10.9 kg by 2020-21. Overall, the India needs to increase domestic production of peas, chickpeas, beans and pigeonpea as substitutes for surging imports, and lentils for export promotion.

Conclusions

In order to enhance area and production of pulses, the major thrust areas which need to be addressed are as follows :

- Diversifying cereal crops in the prevailing rice-wheat cropping systems with high yield varieties of pulses.
 - Diversifying pulses in new niches like rice-fallows
 - Inclusion of short duration varieties of pulses as catch crop.
 - Development of short duration, high yielding, multiple disease and pest resistant varieties.
 - Development of more resilient pulse varieties matching with the changing climate
 - Reducing storage losses and improving market information and infrastructure.
- Linking MSP to market prices can bridge the gap between demand and supply.
- Coordination of research, extension and farmers to encourage farmer's participatory research.

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Visioning a paradigm shift to liberalise Indian sugar sector

Dr R.L. Yadav

Abstract:

Sugar Industry, contributing 5 % to the Agriculture Gross Domestic Product (GDP) of India is the second largest agro-based industry in the country. The industry is highly regulated and controlled through various Central and State Governments acts like 'The Sugarcane Act, 1934,' 'Essential Commodities Acts, 1955', 'The Sugarcane (Control) Order, 1966', 'The Sugar (price control) Order 1979' which have been amended from time to time. In spite of the Government controls, a high degree of discontentment always remained among farmers and the millers. This discontentment sometimes brewed into an agitation by the farmers for the remunerative cane price. This often resulted in delayed crushing of cane in mills, inordinate delay in payment of cane dues to farmers and reduction in the supply of sugar in the market with concomitant rise in sugar price. This discontentment always had a tailing effect on sugarcane cultivation and immediately reflected as shrinkage of cane acreage and eventual reduction in sugar industry. Being an agricultural produce, the price of sugarcane is fixed by CACP, whereas the price of sugar, the actual commercial product of commerce goes out of the ambit of CACP, as it is treated as an industrial produce. It is known that there is no direct relationship between the price of sugarcane and the price of sugar. Under such situation both producer of cane and the consumer of sugar suffer a lot. Through this communication, we are analyzing the complexity of sugarcane cultivation and Indian sugar sector and suggesting remedial measures for liberalizing the sector to make it more vibrant.

Introduction

It appears that a 'boom and bust cycle' has become a characteristics feature of Indian sugar industry, primarily because of the variation in sugarcane production, which in turn is governed by the area under cane cultivation. In a democratic setup like India, farmers are free to grow any crop of their choice. Thus area under sugarcane cultivation is largely depended on the price of sugarcane fixed by the Central and state governments and the timely payment of the cane dues to farmers by the sugar mills. It will be pertinent to mention here that sugar is a highly regulated and controlled commodity in India and the regulation starts with the production of sugarcane itself, and it continues until sugar reaches the consumer. The State Government regulate sugarcane area, production & supply while Central Government controls the licensing of the new sugar mills, expansion of old mills, fixation cane & sugar prices, release and distribution of sugar in the open market and exercises control on by-products like molasses, press-mud,



co-generation of electricity and procurement of levy sugar etc. A look at the production trends of sugarcane and sugar reveals that India has steadily progressed in these fronts (Fig.2&3). From around 40t/ha productivity in 1950-51, average productivity has risen to 67t/ha during the last 10 years. Likewise, area under sugarcane has risen from 1.71 million hectare in 1950-51, to 4.4 million hectare in 2008-09 (Fig.1.). This jour-

ney however, was not a smooth one; there were several ups and downs in the production of both sugarcane and sugar often leading to a messy situation. (Fig.2&3).

In India the first sugar factory was established in 1784 by the British rulers in Bengal. Subsequently, due to lack of suitable sugarcane varieties for milling purposes, there was very little growth of sugar mills in India in the next 150 years. The development

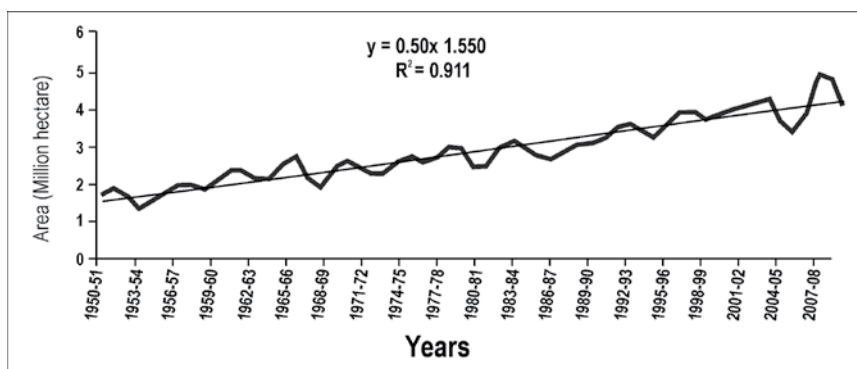


Fig. 1. Area under sugarcane in India

and release of new hybrid sugarcane varieties from sugarcane Breeding Institute, Coimbatore starting with Co 205 in 1918 has revolutionized the sugarcane farming with considerable increase in productivity and sugar recovery and thus, the operation of sugar mills became more remunerative. At the same time sugar industry got a fillip in 1931 with the Tariff protection by the Govt. of India and the number of sugar mills increased from 29 in 1931 to 111 in 1934.

During this period, keeping in view of the phenomenal growth of sugar industry Govt. of India introduced

an Act '**The Sugarcane Act, 1934**' to regulate the price of sugarcane intended for use in sugar factories. Thereafter, different states followed suit and promulgated their own Acts like The Bihar Sugar Factories Control Act, 1937; The U.P. Sugarcane (Regulation of supply and purchase) Act, 1953, etc. The next major order was issued in 1966 in exercise of the powers conferred by the **Section 3 of the Essential Commodities Act, 1955**. "**The Sugarcane (Control) order, 1966**" and "**The Sugar (Control) order, 1966**" and "**The Sugar (Price control) order, 1979**"

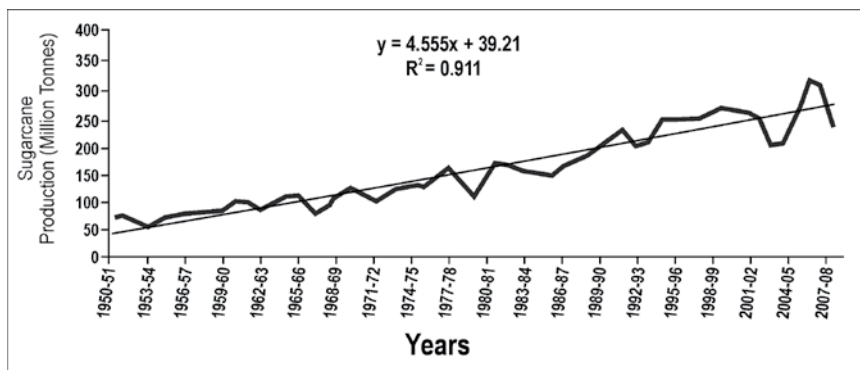


Fig. 2. Sugarcane production in India

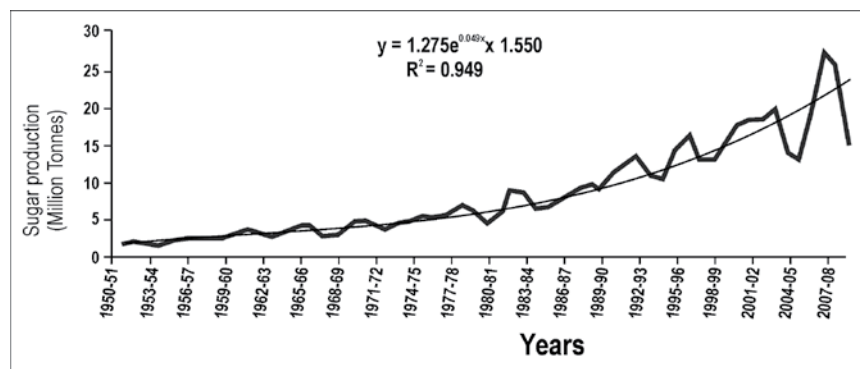


Fig. 3. Sugar production in India

were put in place. The main objective of these orders was to promote the sugar industry, to eliminate unnecessary impediments in the production of sugar and also to ensure a fair deal to the growers of sugarcane and provide sugar to common man at a reasonable price. Adequate provision were also made to maintain a harmony between the growers of sugarcane and the producers of sugar and to enable both of them to share profits reasonably.

Due to imposition of all above acts and orders, the production of sugarcane and manufacture of sugar and their marketing have become highly regulated leading to a certain amount of discontentment among the mill owners and the cane growers. This sometimes brewed into an agitation by the farmers leading to the delayed crushing by the millers and non-payment of cane dues. Over the years it has been perceived that it has become a cyclic feature in the Indian Union. The situation has been further aggravated due to ulterior motives of different political establishments and unions fish in troubled water to snatch political advantage using sugarcane and sugar turmoil as the base plank. Moreover, the state machineries are sometimes putting sugar mills in a piquant situation to please their political masters, indirectly hitting the entire chain of sugarcane from 'Beej to Bazar' and as a result, consumers are suffering badly.

A cane crop once planted lasts for at least two years as ratoon crop in the fields. Thus, farm land is engaged for three years and after harvest of final ratoon, a suitable crop in rotation is grown. Therefore, any corrective measure initiated in between does not have much effect in this four year period. In general, ratoon crop is poor yielder than its plant crop and productivity of farm diminishes in successive rations. The very nature of plantings and gradual decline in yields in rations, a cyclic nature of production trend is often encountered. For the integrated development of Indian Sugar Sector from 'Beej to Bazar', one has to keep in mind that raw material of sugar Industry is an



Commission of Agricultural Costs and Prices (CACP). However, sugarcane is not directly traded for general consumption like other agricultural commodities. It needs industrial processing before reaching the market for consumption of the common man. Due to involvement of industrial processing the actual pricing of the produce i.e., sugar goes out of the ambit of CACP. It is easily perceived that there is no direct correlation between the price of sugarcane and the market price of sugar. Under such situation both the producer of sugarcane and consumer of sugar suffers a lot. This duality of price fixation is crippling both sugarcane and sugar production in India as well as acerbating sugar consumer woes. Such a situation was witnessed in the last sugarcane crushing season (2009-10). It is utmost necessary that the 'boom and bust cycle' (as shown in Fig.3) must be broken to harmonize sugarcane productivity and utilization at one hand and to minimize farmers' woes on the other due to inadequate remuneration and inordinate payment delays.

Breaking the sugar cycle :

To break the 'boom and bust cycle' which adversely affects the interest of both cane growers and sugar-industries alike, following measures are suggested.

1. Sugarcane price be announced well in advance before the onset of planting season so that farmers are encouraged to have fresh planting and to ensure the availability of quality seed cane.
2. It is suggested that 50 % of the payment of cane price be paid in advance to the farmers at the time of planting to sustain their interest in sugarcane farming. For determining the cane productivity, average productivity of the area may be taken into consideration. Sugar mills should implement the crop insurance scheme to encourage sugarcane cultivation by safeguarding farmers from any eventuality of crop failure.
3. While fixing cane price, the earnings of sugar factories from cane by-products, like molasses, press mud and co-generation may also be taken into account along with matching price of the competitive crops.
4. Remaining cane price may be paid to farmers within a week of cane supply to sugar factories. Any delay in payment should be paid with the interest as stipulated.
5. To ensure the profitability of sugar factories, the Levy system of sugar procurement should be abolished. Government should

fix minimum sale price of sugar as deemed fit and procure sugar from the open market like the procurement of food grains. For PDS, Government should ensure the supply of sugar in subsidized rates like rice/wheat.

6. It is submitted that all the government control on sugar sector be removed. Let sugar float with market forces like other industrial produce. The undue fear of government that sugar prices will soar high is unfounded.

Sustainable development of sugar sector

As outlined above, the important Acts governing sugarcane and sugar came in force much before the WTO regime and the advent of Green revolution of food crops. The Green revolution has indeed transformed Indian agriculture beyond recognition. It has increased the availability of fertilizers, pesticides, irrigation as well as tractorization of farming practices. Farmers are growing non-traditionally remunerative crops, leaving the less remunerative traditional ones in the oblivion.

The WTO regime has opened up the flood gate of World market and now sugar mills have to be competitive to remain in business. It is high time that these acts be relooked at and necessary amendments be made to meet the present day requirements in this changed perspective.

In sugarcane, there is a dual price fixing mechanism i.e. , the Minimum support price (MSP) fixed by the Central Government and the State Advisory price (SAP) fixed by the State Government. These price fixations are inviting wraths from the farmers, as many a times they fail to satisfy farmers' aspirations. Due to the unhappiness over cane price fixations and announcement by the Governments, farmers gheraoed the Parliament during 2009 and stopped supply of cane to sugar mills to urge for a remunerative cane pricing. In this turmoil, common man suffered badly, as sugar prices increased 2 to 3 times in the open market. Sugar mills, on the other hand increased the cane

procurement price and paid as high as Rs.280 per quintal to farmers as against SAP of Rs.160 in the State of Uttar Pradesh. In the hindsight, if this much price was announced by the Government, there was reasonable doubt that sugar factory would have agreed to it. However, it was agreed by the mills that because of high price of sugar in the open market, they were able to pay high cane prices to the farmers during this 2009-10 crushing season. SAP is also inflicting unnecessary discontentment among cane farmers of different States and especially the farmers of Uttar Pradesh. The disparity of cane prices in different states is encouraging poaching of sugarcane by the mills beyond the reserved area and increasing litigations among the affected parties. Moreover, the practices of assigned area is often detrimental in the cane development work and this has become so after reducing the mill to mill distance to 15 Km. To ease out this situation in sugar industry, many a times a consensus agreement was arrived at through out of the court settlement. These warrant a radical change in the policy of sugarcane production and sugar industry regulation as well as sale of sugar.

1. On this, it is suggested that
 - i) Let the Government fix the maximum price of sugar, above which mills should not sale sugar and
 - ii) The minimum support price of cane for effecting purchase of cane from growers.
 - iii) Then, at the given price of sugar, let sugar mills negotiate with farmers for cane price and
 - iv) At this negotiated cane price sugar mills should sign a formal contract with cane growers for next two years (plant+ ratoon) with assurance of support in case of crop failure. At the same time, factory command area also should be changed to allow the mills to take initiative for cane development, so that the benefit of vertical movement be realized.
2. To stabilize sugarcane and sugar production in the country sugar mills should be encouraged to utilize excess cane to produce ethanol directly

from juice during the years of excess cane production so that farmers do not suffer. While in the years of short supply of cane, entire cane crop should be used for sugar production. Growing of alternative sugar crops like sugarbeet may be encouraged to run the sugarmills in the lean sugarcane availability/ period.

3. A mechanism has to be worked out to ensure that sugar mills should meet their cane requirement by enhancing cane yield using modern scientific methods of cane cultivation rather than expanding area under sugar planting. Sugar mills should not discourage the practice of intercropping with sugarcane which helps the sustenance of farmers during long gestation period of sugarcane. Sugar mills should go for mechanization of sugarcane cultivation in a big way for timely operation and reduction in cost of cane cultivation. Further, weather forecasting has to be made more valuable and effective to plan a mid-term correction.

Policy & planning

Further, when one talks about 'Beej to Bazar', there are many issues require adequate attention, be it research, development or policy and planning. Today, policy and planning is clamouring for attention. There is a need to understand the dynamics and nuances of sugarcane crop in relation to other field crops. In most of the respect sugarcane crop differs widely and has different needs. It is urged that sugarcane may be taken out from the category of general field crop for all policy and planning issues.

1. Sugarcane though an agricultural commodity has a unique niche of its own and widely differs from the other field crops in terms of seed, growing condition, processing needs, marketing, etc.
2. It is good to learn that sugarcane has been brought under the Seed Act to ensure trading of quality seed cane. But because of highly perishable and bulky nature, packaging and certification is difficult. The practical difficulty warrants a special treatment.

3. Among the field crop sugarcane has a special niche and warrants a special treatment. It is mostly planted in spring and it is lean period for availability of fertilizers in the market, as the release of fertilizers is mostly geared around sowings of 'Rabi' and 'Kharif' crops. In order of fertilizers consumption, sugarcane ranks third after rice and wheat. It is therefore urged that the ministry of chemicals & Fertilizers should make special provision for sugarcane and release fertilizers to sugar mills for ensuring their availability to farmers at the time of planting.
4. Similarly, sugarcane faces problem with canal irrigation – when it requires irrigation support most during hot summer months, canal water remains available for irrigation during its peak requirement. Policy has to be framed to address this situation. Ministry of water resources may be requested to consider the plight of sugarcane farmers and make necessary amendments in the provision of water supply in the canal for meeting the irrigation requirement of sugarcane during the summer months.
5. Sugarcane is highly perishable like tea and needs immediate processing after harvest. Like tea, it has long harvesting time, in fact, harvesting time is much longer than any other field crops. Thus, sugarcane also needs special attention from the policy makers.
6. Keeping in view of the above mentioned complexity of sugarcane crop and the processes involved from 'Beej to Bazar' in sugar sector, it is proposed that sugarcane may be taken out from the purview of the CACP and be treated independently like the tea and to coordinate all these activities an apex body "The national Sugarcane board" may be formed.

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Cotton

Technology Drives Productivity

M. Rafiq Chaudhry

Cotton is sometimes called a difficult crop, which is not true. Cotton is a technical crop and any farmer, whether educated or illiterate, can grow cotton successfully if he/she understands what happens to the plant in the case of stress (external or internal) and how to manage that stress. The cotton plant is highly responsive to the treatment it receives from nature and from the producer. There are productivity differences among countries because of growing conditions, but differences in yields also reflect the level of technology adopted in a country or region. Inappropriate use of inputs can suppress the genetic ability of a variety, and over use of inputs affects the economic profitability of a grower.

Cotton Supply and Use

Cotton is the most important natural fiber in the world. Though the share of cotton in comparison to manmade fibers has been declining over the last half century, cotton use in absolute terms continues to increase. Cotton accounted for 38% of all fibers consumed at the end use level in the world in 2009. In India, cotton's share to manmade fibers is still 59:41. There is more demand for cotton but cotton must be produced safely at a price that can compete against synthetic fibers. The quality of cotton must be such that the textile industry likes it. There is always demand for cotton, and every kilogram of cotton will be consumed if good quality cotton is produced at lower cost. Competition with synthetic fibers is a great challenge for the cotton industry including researchers. Competition with chemical fibers is only going to grow. While the chemical fiber industry is endeavoring to induct cotton qualities into synthetics, cotton researchers must also stride to transgress good qualities from synthetic fibers into cotton. At the same time, research must also devise technologies where cotton and synthetic fibers can compliment each other in blends.

According to the International Cotton Advisory Committee, an intergovern-



mental organization established in 1939, 25 million tons of cotton will be produced in 2010/11 from about 33 million hectares. In 2009/10, 52% of world cotton area was planted to biotech varieties. Commercialization of insect resistant characteristic in biotech cotton saves a tremendous amount of insecticide sprayings on cotton every year. However, plant protection chemicals worth US\$2.5 billion were still sprayed on cotton in 2009, and the same amount will be used in 2010, which means cotton's share of plant protection chemical use is declining. Significant successes in avoiding/eliminating insecticide use, in India and across countries, across regions and around the world, indicate that there is a possibility to further lower the use of chemicals in cotton production. Biotech cotton is one technology, but insecticide use has gone down significantly in many countries, including countries that have not commercialized biotech cotton.

New Technologies

Cotton breeding is entering a new era of directed breeding. Conventional breeding will co-exist, but the main

thrust of breeding will expand to include molecular marker assisted breeding with specific targets. The ten to twelve years of breeding currently needed to develop a new variety will have to be shortened with new methods that bring certainty in the transfer of desired characters. Undesirable combinations will have to be terminated, and unwanted characters eliminated. One such avenue is the utilization of RNA Interference (RNAi) system. RNA Interference (RNAi) is a system within living cells that helps control which genes are active and how much active they are. RNAi has an important role in defending cells against parasitic genes and in directing development, as well as in gene expression. RNAi, previously known as post-transcriptional gene silencing, among others, can play an important role to induce the suppression of specific genes of interest.

Insecticide use dominated cotton production practices for almost four decades. At one stage, insecticides were considered an integral component of production systems wherever cotton was grown. However, the trend is changing, and commercial production

of biotech cottons has opened new avenues that are more sustainable environmentally and economically. Economic sustainability will be improved with new biotech products. Spinning will prefer biotech cotton over regular cotton because of better fiber quality. Producers favor biotech varieties because of lower production costs and better pest management. Longer and stronger fibers or colored cotton are among many avenues to be utilized by biotechnology. An agronomic trait, fertilizer efficient cotton, is already under going testing. The war against insect pests will shift from over-the-top application of chemicals to technology embedded in the seed.

Role of India in the International Arena

Now, with over three quarters of production and consumption located in Asia, the role of India in the international arena has become very crucial. India improved its production technology and cotton yields nearly doubled in five years from 2002/03 to 2007/08. The rise in Indian cotton yields was a record for a large country. The only example of any other country expanding, as rapidly, is Brazil but Brazil a shift in the cotton area from the north to the central south. India exported 1.5 million tons of cotton in 2007/08, which is more than all the cotton produced in Africa. In 2009/10, India exported 1.4 million tons of cotton to over 20 countries around the world.

India is a pioneer in the development and commercialization of commercial cotton hybrids. Thanks to hybrid technology, India was able to spread biotech varieties on over eight million hectares in 7-8 years. The Technology Missions on cotton and biotech cotton have dramatized India's role in the international cotton industry both as a producer and international supplier of world class quality fiber. Owing to significant increases in yields, India is producing cotton at the lowest cost/kg of lint in the world. In the field of research, India should be proud of its scientists like Dr. Keshav R. Kranthi who won the first 'ICAC Researcher of the Yield Award-2009.'

Currently, India is the largest producer of organic cotton in the world. India can maintain this distinction through increased focus on the organic cotton industry in the country. National

organic cotton standards, local certifying companies and communication among organic cotton producers, processors and merchants need to be improved. All organic cotton produced in India should be promoted under uniform standards for improving credibility among consumers who are mostly located in developed countries.

Rising Cost of Production

The International Cotton Advisory Committee undertakes a survey of the cost of production of cotton every three years. The latest survey based on data for 2009/10 was published in September 2010. The net cost (excluding land rent and seed value) of producing a kilogram of lint in the US Fruitful Rim region is the highest under irrigated conditions, US\$2.38/kg lint, closely followed by Colombia and China. The cost of production per kg of lint is the lowest in India, but that is because of recent increases in yields and the high value for seed after ginning. As in the USA and in some other countries, the total cost of production is higher than the value of seedcotton or the value of lint plus seed. One reason for such an imbalance is family labor employed in farm operations, which is not counted in some countries. This may apply to many developing countries where families take part in operations at home and at the farm. Some countries, developed and developing, have programs to provide financial support to farmers, who otherwise might cease to produce cotton.

The net cost of producing a kilogram of lint increased from US\$1.04 in 2006/07 to US\$1.22 in 2009/10, a 17% increase in three years. One of the reasons for this increase is lower yields in 2009/10 compared to 2006/07, but the costs of inputs and field operations also increased significantly.

A Common Solution to Common Goals in Cotton

Cotton is a crop of developed and developing countries. It is self-evident that many problems that have common origins and similar characteristics will have common solutions. Consequently shared efforts to address such problems will save resources. Accordingly, member governments of the International Cotton Advisory Committee are considering creation of an international center for cotton research. Cotton re-

search has many more common issues today than in the past. For example, more than half of world cotton area is now planted under one feature — insect resistant biotech cotton. Other common issues include resource scarcity such as water, a need to improve soil fertility, and a need to develop cost-effective approaches to insect and weed control without the use of toxic chemicals. All countries have an interest in raising yields and improving cotton quality. These issues can be tackled efficiently through a common approaches. Biotech cotton is just one example of a common issue that could be efficiently tackled with a higher level of research that would benefit many countries at the same time. At various times, ICAC member governments have acknowledged the need for increased cooperation in cotton production research. The process of expanding international cooperation on cotton research must continue, and perhaps the time has come to create an international center for cotton research.

The agricultural research centers of the Consultative Group on International Agricultural Research (CGIAR) have saved millions of lives by developing short stature wheat varieties. This work alone justified decades of expenditures on agricultural research. Likewise, breakthroughs in cotton technology developed within an international research center on cotton could provide benefits to the world many times the costs associated with the establishment of such a center. The real question is not who will pay to establish an international research center on cotton, but the questions should be, is there a need for such a center and what will its mandate be?

The international research center on cotton will not compete with public and private sector research organizations. Rather, an international research center could work on broad issues with multinational implications. Such a center can benefit the cotton industry as a whole by pooling resources through collaboration and by helping to coordinate and ensure coherence in cotton production research.

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Rice

A key for food and nutritional security

Dr. B. C. Viraktamath

Globally rice is cultivated on 160 million hectares with annual production of around 650 million tons and average productivity of 4.18 tons/ha (FAO stat 2007-08). More than 90% of the rice is produced and consumed in Asian countries. The other continents in which rice is grown are Africa (7.78% of the global area), South America (6.4%) and North America (1.4%).

In India during 2008-09, rice was cultivated on an area of 44.0 million hectare with a production of 99.3 million tons of rice, with an average productivity being 2.13 t/ha milled rice. Though, rice production growth trend had kept in pace with population growth rate during last five decades, signs of decreasing growth rate are evident. This has been a cause of concern. The current Indian population of 1.17 billions is expected to reach 1.3 billions by 2020 and 1.4 billions by 2025 AD. It is estimated that by 2020 at least 115-120 million tons of milled rice is to be produced in India to maintain the present level of self sufficiency.

From where this additional rice will come? During the green revolution period the semi-dwarf, fertilizer responsive, high yielding genotypes of rice and wheat were introduced, which led to phenomenal increase in production and productivity of these crops. It is now obvious that the technology introduced during the green revolution have reached the diminishing return phase. Hence it is very pertinent to critically consider whether the rice production can be further increased to keep pace with population growth with the current green revolution technologies. Is there a need for a paradigm shift in rice research to meet the challenges of the future decades for ensuring food security?

There have been several critics of



green revolution technologies who blame these for the present crisis. Semi-dwarf varieties of 1970s over depended on high inputs like fertilizer, water and pesticides. These also displaced a plethora of locally adapted genetically diverse varieties and brought down the genetic base with few varieties being cultivated over large areas. With rapid progress in field of agricultural biotechnology, new tools of crop improvement are emerging. We now have an alternative to green revolution technologies that may be addressed as gene revolution technologies. Harnessing the power of this advancing science through the precise tools, it is now not only possible to address food security but also nutritional security. We can stretch the agri-biotech canvas to foresee solutions emerging for problems of climate change, for conservation and sustainability of biodiversity and productivity of agro-ecosystems and for threat of heavy metal pollution in our water and land resources. The possibili-

ties and prospects of utilizing these new technologies for enhancing rice productivity for food and nutritional security are examined here.

Breeding Strategies for Post-Green Revolution Era

Most traditional varieties in tropical and subtropical Asia grown during 1960s matured in 160-170 days and many were photoperiod sensitive. These were suitable for growing one crop of rice a year during the rainy season. Considering the demand for food for the population, plant breeders developed varieties that matured early with higher yield potential. The key to the success was the selection of the genotypes with rapid vegetative vigor at the earlier growth stages. This helped farmers to grow two rice crops during the year in areas where good irrigation facilities existed, or introduce a non-rice crop in the rice-based system depending on the resources available. While the profitability in rice farming increased with new varieties, a relatively small

number of improved varieties, however, replaced thousands of traditional ones, thereby reducing the genetic variability of the rice crop. The reduction in biodiversity, coupled with vegetative growth and continuous cropping, increased the vulnerability of the rice crops to insects and diseases. Scientists addressed this problem by incorporating resistance to major insects and diseases in newly released modern varieties. Large germplasm collections were screened and donors for resistance identified. Utilizing these donors, improved varieties with resistance to three major diseases (blast, bacterial blight and tungro) and three insects (brown planthopper, green leafhopper and gall midge) have been developed. Large-scale adoption of varieties with a broader genetic-base has helped stabilize rice yield and reduce the use of pesticides.

During this phase, the emphasis has also been on development of grain quality suited to different regions of the country and for export. Improved scented varieties like Pusa Basmati, Sugandhamati, Yamini etc. have enhanced rice exports. While 1.1 million tones of basmati rice worth 3,000 crores is exported from the country, even non-basmati type varieties are exported to the tune of 3.0 million tones worth another 3,000 crores of rupees in foreign exchange.

Development and Use of Hybrids

Convinced of the potential of hybrid rice technology to enhance productivity and production of rice, in light of the remarkable success of the Chinese in this field, Indian Council of Agricultural Research (ICAR) initiated a goal oriented project in December, 1989 to develop and utilize hybrid rice in Indian Agriculture. First set of hybrids were developed and released in 1994. Till now 43 hybrids have been released, 28 from public sector and 15 from private sector. The hybrid rice seed production and cultivation packages have been developed and optimized. During the year 2009, hybrids were cultivated in an area of 14 lakh hectares. It is expected that during the next five

years hybrids will cover 2-3 million hectares. The popular hybrids being cultivated in the country are 6444, PHB-71, KRH-2, Sahyadri etc. More than 20 private seed companies are actively involved in hybrid rice research, development and large scale seed production. Over 95 percent of the hybrid rice seed in the country is produced by the private sector.

By cultivation of hybrids farmers are obtaining an additional yield advantage of 1-2 t/ha, the additional net profit being in the range of Rs. 3,000 – 5,000 per ha. In hybrid rice seed production, seed yields of around 2.0 t/ha are obtained with a net profit of Rs. 25,000 to Rs. 30,000/- per ha for the seed growers.

At present hybrids are cultivated in Uttar Pradesh, Chattisgarh, Jharkhand, Bihar, Haryana and Punjab. Some of the major constraints to further expansion of hybrid rice are unacceptable grain quality, lack of resistance to major pests and diseases and higher seed cost. Research efforts to overcome these constraints are underway. Recently released hybrids like DRRH-3, Suruchi have excellent cooking quality. It is expected that hybrid rice will play a major role along with the New Plant Type (NPT) varieties, in raising the productivity and production of rice in the coming decades.

Development of aerobic rice adapted to water stress conditions

Water stress is an important abiotic stress limiting rice yields across the world. Traditionally rice crop requires almost thrice the quantity of water when compared to maize and wheat. The progressive reduction in water resources across the world necessitates the development of alternative strategies to combat water stress in rice. One such strategy is the development of “aerobic rice” which can survive moderate drought. Biotechnology can help in development of aerobic rice through the application of molecular markers, genetic engineering and genomic tools. Novel molecular and biotechnological methodologies can be used to identify stress-related genes and use

them as probes for selection of tolerant genotypes and for generation of transgenic plants. Similarly, identification and utilization of molecular markers linked to gene(s) associated with drought tolerance can tremendously boost the capacity of rice cultivars to resist water scarcity.

Deployment of Biotechnological tools

The efforts of rice breeders have no doubt brought the rice yield levels to such a stage where at least for the present, food production growth will outrace population growth. But we should not be complacent as the vagaries of monsoon and disturbing trend with respect to soil health are bound to destabilize rice production and we must therefore be ready to face the challenges of the future by judicious and prudent application of biotechnological tools. From a breeder's perspective, biotechnology helps to add precision in the breeding process to become more target oriented and purposeful compared to traditional breeding. Biotechnology can help in improving rice breeding through:

1. Transfer of economically important traits across genus/species barrier into the rice gene pool (i.e. Broadening the genetic base)
2. Manipulation of target trait without disruption to the non target regions of the rice genome (i.e. Increasing efficiency in selection)
3. Shortening the breeding cycle

The three broad applications of rice biotechnology that are expected to contribute both directly and indirectly towards rice improvement efforts in India are discussed here.

DNA marker technology

The application of molecular markers in rice improvement started with the efforts of Cornell University and IRRI using RFLP markers for development of molecular linkage maps in rice. The first restriction fragment length polymorphism (RFLP) map of rice was developed in 1988. Later

a comprehensive genetic map was developed with more than 2250 DNA markers. RFLPs being laborious and costly were then replaced with more robust, simple to use PCR based markers like microsatellites or simple sequence repeats (SSR), Inter-simple sequence repeats (ISSRs), Sequence tagged sites (STSs) etc. These simple PCR based markers help breeders to track the introgression of the target genes across segregating progenies. Markers tightly linked to the gene(s) of interest can be used at any crop stage for testing the presence of the gene(s) without waiting to observe its phenotypic manifestations. In addition, markers, which are co-dominant (eg. Microsatellites) also help us know the allelic status of a gene and thus are very helpful in recurrent/backcross breeding programs for introgression of recessive but agronomically important gene(s). More than 25 agronomically important rice genes have already been tagged with markers and can readily be deployed by breeders in breeding programmes.

A successful use of marker-aided selection (MAS) has been shown in pyramiding four Xa-genes for bacterial blight resistance. A similar success story with respect to development of bacterial blight resistant rice cultivars through marker assisted selection has been reported by the research group at Punjab Agricultural University, Ludhiana. DRR, Hyderabad has also been working towards this objective and breeding lines of the elite cultivar 'Samba Mahsuri' with three bacterial blight resistance genes (Xa21, xa13 & xa5) are ready for field evaluations and preliminary tests suggest that these lines do possess excellent BLB resistance along with grain quality and yield similar to that of Samba masuri. This material has been developed through an Inter-Institutional collaboration between Centre for Cellular and Molecular Biology, Hyderabad and Directorate of Rice Research, Hyderabad.

Genetic engineering for rice improvement

Genetic transformation is another

tool that promises to revolutionize Indian rice production scenario. The most important advantage of transgenic technology is the capacity to mobilize useful genes from non-rice gene pool to rice with least disruption to rice genome. Ever since the publication of the first reports on successful production of transgenic rice plants of Japonica in 1988, a large number of rice varieties have been introduced with agronomically and economically important genes. Direct DNA transfer methods such as protoplasts, biolistic method and Agrobacterium-mediated methods are being used routinely in rice transformation in the biotechnology laboratories across the world including India. Transgenic indica rice tolerant to biotic stresses such as insect pests and disease causing organisms like viruses, fungi and bacteria have been developed and tested by research groups worldwide. Transgenic rice with herbicide resistant gene has also been tested under field conditions.

In India, transformation studies initially involved standardization of various gene transfer techniques. The marker genes freely available in public domain to most researchers like *gus* and *hygromycin* resistance were widely used for confirmation of transformation events. Subsequently, genes that confer resistance to pest or disease were targeted and within a few years, Nayak and co-workers reported the development of first transgenic rice with Bt gene in 1997. Since then, several groups started working on transfer of different genes into important genotypes of rice, most notably the introduction of Bt genes such as *cry1A(b)*, *cry1A(c)* to obtain resistance against yellow stem borer. Research groups in India have recently succeeded in transferring Bt genes into indica rice cultivars such as IR64, Karnal Local



and Pusa Basmati using *Agrobacterium* strategy. Similarly, work is progressing in development of transgenic rice resistant to bacteria leaf blight and sheath blight using constructs with Xa21 and Thaumatin like proteins. Production of transgenic plants of cv. Chaithanya possessing *gna* lectin gene which confers resistance against sucking insect pest of rice has been reported.

Engineering rice to survive adverse abiotic stresses is also receiving attention. The abiotic stresses, which limit rice yields, include Salinity, alkalinity, drought and cold. Traditional breeding has contributed significantly to salinity tolerance and salt tolerant varieties like CSR10, CSR11, CSR27, CSR30 etc. have been developed in India. But unlike biotic stress resistance where a single gene conferred resistance can effectively combat the pest/disease, abiotic stress tolerance is complicated due to the involvement of many genes. Studies using molecular markers basically aim at tagging and mapping of genes/QTLs associated with abiotic stress tolerance. Once tightly linked markers are available for such QTLs associated with the tolerance traits can be pyramided in the background of a popular high yielding cultivar. Genetic engineering is another promising biotechnology approach for de-

veloping rice cultivars with enhanced abiotic stress tolerance. It is beyond doubt that transgenic technology offers more powerful solutions for incorporation of complex traits like abiotic stress tolerance compared to traditional breeding approaches.

Nutritional quality improvement is another area where genetic engineering is playing a critical role. Considering the inadequacy of rice with respect to human nutritional requirement and the non-availability of enough genetic variation in rice gene pool with respect to nutritional traits, researchers worldwide have targeted deployment of transgenes from other taxa for nutritional improvement of rice. Three genes - two from daffodil and one from a bacterium *Erwinia uredovora* - have been used to provide the biosynthesis pathway for the production of beta-carotene, a precursor of Vitamin A, in rice. Transgenic rice, known popularly as Golden Rice, has already been produced through transformation on a japonica rice variety, T309 and recently in an indica rice IR64. Since the inventors of the technology have donated it free-of cost to developing countries like India, Department of Biotechnology and Indian council of Agricultural Research have formalized a programme to transfer the beta-carotene biosynthetic traits to locally popular Indian rice varieties through marker assisted backcross breeding and genetic transformation. Directorate of Rice Research, Hyderabad, Indian Agricultural Research Institute, New Delhi, University of Delhi, South Campus, New Delhi and Tamilnadu Agricultural University, Coimbatore have been entrusted with the responsibility of developing Indian version of 'Golden rice'.

Ferric chelate reductase gene allows plants to absorb more iron from soil, thus, widening the scope of rice varieties with high iron uptake. Similarly soybean Ferretin gene has been cloned into rice and have reported two-fold increase in iron content in rice grains. It has been reported that a thermo-tolerant phytase gene from *Aspergillus fumigatus* has been transferred to rice and this has re-

sulted in tremendous increase in iron content in rice grains due to degradation of iron chelating phytic acid by the phytase enzyme. Similarly, over expression of cysteine-rich protein, which increases the cysteine content that may substantially degrade phytate during food preparation and digestion, is another exciting development in using biotechnology for nutritional improvement.

Transgenic technology is also being employed to attempt to convert rice from C3 to C4 plant. It is hoped that through this the photosynthetic efficiency and consequently, the yield can be increased tremendously.

The researchers at the Washington State University have made efforts in engineering C₄ photosynthesis pathway, using an *Agrobacterium*-mediated transformation system. They have independently introduced into rice three maize genes encoding the C₄ photosynthetic pathway enzymes: phosphoenolpyruvate carboxylase (PEPC); pyruvate orthophosphate dikinase (PPDK); and NADP-malic enzyme (ME). The transgenic rice plants expressed high levels of these genes and the maize enzymes remained active in rice plants. Most importantly, PEPC and PPDK transgenic rice plants exhibit higher photosynthetic capacity than untransformed plants, mainly due to an increased stomatal conductance (i.e., more atmospheric CO₂ becomes available for fixation). Preliminary field trials conducted in China and Korea also show 10-30% and 30-35% increases in grain yield for PEPC and PPDK transgenic rice plants, respectively. A further enhancement of the photosynthetic capacity of rice will require engineering a limited C₄ pathway of photosynthesis by simultaneously expressing the three previously mentioned key enzymes in proper cellular compartments. Ultimately, for the most efficient operation of the pathway to concentrate CO₂ around Rubisco in the leaf, the concomitant installation of Kranz leaf anatomy will be essential.

Application of Genomics for Rice Improvement

Similar to DNA marker technology

and rice transgenics, rice genomics is another area full of prospects. The developments in the last five years have been explosive and we now have a complete sequence of the rice genome. As the rice genome is being completely sequenced, biotechnologists have started a systematic assessment of the phenotypes resulting from the disruption of putative gene sequences with genetic resources such as mutants, near-isogenic lines, permanent mapping populations, and elite and conserved germplasm. Functional genomics, to a large extent, is analogous to the extensive germplasm screening that has allowed the extraction of useful traits in conventional breeding programs, yet with DNA sequence level precision on a global genome scale. The judicious utilization of the sequence information through functional genomic analyzes will certainly offer solutions to many a breeding problems through means hitherto not thought of. The availability of rice genome information is the foundation for the identification of orthologous genes in cereals and also facilitates the sequencing of other cereal genomes. An international collaboration was established for completion of rice genome sequencing and to coordinate the concerted utilization of sequence information for the benefit of humankind. This initiative called the International Rice Genome Sequencing Project (IRGSP) is publicly funded and has 8 countries as its members. IRGSP has recently released completion of rice genome sequencing to ten-fold redundancy.

Crop and Resource Management

Crop and resource management research intensified with the introduction of management and input responsive, photo-insensitive plant type based high yielding rice varieties. The latter provided ample opportunities for increasing cropping intensity depending on the resources available and developed, indicating the need for development of management technologies for intensive and efficient use of resources and inputs to realize the yield potential with en-

hanced factor productivity of evolved rice varieties and the production system. Combination of cultural and input management strategies involving identification of nutrient efficient varieties, integrated management of nutrients with balanced use of inputs, appropriate crop residue and organic/ green manuring practices, use of modified fertilizers and production potential of cropping systems and their sustainability were some of the areas of research pursued.

The unique system of soil puddling for rice establishment, weed and water control not only benefited rice growth and nutrition, but also favoured loss of nutrients like nitrogen through several means from the system resulting in low N use efficiency. Rice derives more than two-thirds of its total N from native soil pool and about 25-35 per cent from the applied fertilizer N. Nitrogen losses through volatilization and leaching accounted for about 50 per cent from fertilizers such as urea (Rao and Shinde, 1985). Coating of urea with suitable materials to control transformation of applied N in soil reduced N loss and increased its utilization by rice. Neem cake-coated urea (NCCU) applied as basal dose performed better than split-applied prilled urea under uncontrolled water situations in diverse soil types. Neem-cake possesses both urease and nitrification-inhibition properties, and a 10-15% higher efficiency through NCCU than prilled urea is common. Placement of fertilizer N in the reduced zone of soil decreased gaseous loss and improved use efficiency of the applied N. Urea supergranules (USG) developed for placement at desired depth, i.e. 10-15 cm, were extensively tested across the country. The field trials indicated 6 to 30% higher efficiency due to basal placement of USG over the conventional split application of prilled urea. Subsurface application of urea solution in the root zone of rice 10 days after transplanting by an indigenously fabricated applicator was also found equally effective in improving use efficiency of applied fertilizer N. Under controlled irrigated systems application of N fertilizer in 2 or 3 split

doses depending on the duration of the crops to match with plant requirement of modern HYVs, preferably incorporating basal dose in the soil and top dressing after draining water improved N use efficiency (Rao and Kundu 1995). About 26 per cent of N efficiency was attributed to poor water control generally encountered in rainfed low land systems. Real time N management guided through chlorophyll meter or leaf colour chart enhanced N use efficiency substantially and saved 20- 30 per cent of N fertilizer .

Water management showed strong interaction with the efficiency of applied N as well as that of water. While rotational irrigation at 7 day interval resulted in significant yield reduction and increase in N loss through ammonia volatilization showing seasonal variations (Rao, 2002), a 4- day cyclic irrigation optimized water use with no loss of grain and applied N. A net saving in irrigation water to the extent of 18-24 per cent could be achieved in transplanted irrigated rice with rotational irrigation resulting in substantial improvement in water use efficiency (DRR, 2003). Rice varieties differ in their response to nutrient and water management indicating importance of choice of varieties for integration to ultimately reach high input and resource use efficiency. Rice varieties like Swarna, Rasi, IET 15342, IET 11771, IET 12884 and hybrids were observed to be more efficient in utilizing nitrogen while Rasi, IET 12884 and hybrids recorded higher water use efficiency by 22 per cent over continuous submergence.

Grain yield response to phosphorus application is substantial in most of acid and heavy clay soils. Dipping of rice seedlings in super phosphate soil slurry before transplanting or nursery application of P proved effective in terms of cost reduction with no yield loss and saved nearly 40 per cent of P fertilizer, while as P source, DAP or ammonium polyphosphate (APP) proved superior to SSP for their higher P use efficiency. Application of mixture of phosphate rock and SSP or phosphate rock alone

(applied 2-3 weeks before planting or sowing) were efficient P sources for rice particularly in acid soils of pH 6.0 or below. Varieties such as Rasi, Vikas etc, showed considerable tolerance in low soil P fertility and also responded to P application indicating choice of such varieties for different levels of crop management.

Management of potassium (K) involves its application in single or split doses depending on soil type and crop / variety demand. In high rainfall areas with coarse-textured soils, split application of K (half at planting and half at panicle-initiation stage) gives higher efficiency. Based on the research findings, split application of K in rice has been recommended in Andhra Pradesh, Kerala, Orissa and Uttar Pradesh. Benefits of split application of K in rice have also been realized in West Bengal and North-Eastern hills regions. The productivity of rice hybrids is improved by split application of K (basal and at PI stage) to support high grain filling demand of the hybrids. In intensively cultivated rice crop systems with total productivity of more than 10-12 t/ha it is preferable to apply higher (25-50%) dose of K to maintain nutrient balance in the system and prevent its depletion for sustaining long term productivity of the system. Recycling of rice residues not only supplied substantial K into the system thereby saving fertilizer K, but also maintained favourable soil quality and its productivity.

Almost half of the rice growing soils are deficient in Zn. It was found that Zn deficiency in rice can be alleviated by applying 50 kg ZnSO₄/ha at transplanting once in 2 or 3 seasons. However, the optimum rate varies with the type of soil and its deficiency status, variety and method of Zn application. Rice yields decline appreciably with a 10-20 days delay in Zn application on Zn-deficient soils. Broadcasting and mixing of ZnSO₄ into soil is the most efficient method. Mid-season correction can be done with foliar sprays of 0.5 % ZnSO₄ solution. In salt affected soils it is advisable to double the dose of ZnSO₄. Scarcity of labour and increasing

wages make the manual weeding less efficient and uneconomical. Several herbicides like butachlor, oxadiazon, anilophos and oxyfluorfen were found effective in controlling common weeds in lowland rice. Recent research has shown that use of herbicide combinations like butachlor + 2, 4-D Na, anilophos + 2, 4-D EE, pretilachlor + 2, 4-D EE, bensulfuron-methyl + butachlor etc. control wide spectrum weed flora and were cost effective in transplanted rice. Butachlor + safener, Pretilachlor + safener or Pyrazo sulfuron ethyl gave best control of weeds in direct-sown rice under puddle conditions. Rice crop established by broadcast sowing of seeds under puddled conditions generally suffers from uneven growth and gives lower yields than a transplanted rice crop. Line sowing of sprouted seeds at 20 cm spacing with a row seeder produced excellent crop stand and similar yields to that of transplanted crop. Varieties like 'Vikas', 'IET 9994', 'IET 10402' and 'Jalapriya' performed well.

Crop Protection through Integrated Pest Management

Major focus of recent research in field of crop protection has been on development of specific pest and multiple pest resistant rice varieties for different rice ecologies, studies on variability of pest populations, identification of new effective and eco-friendly chemicals, development and evaluation of alternative strategies for regulation of pest populations, development of weather based pest forecasting systems and formulation and on farm evaluation of integrated pest management packages for various situations.

New sources of broad spectrum resistance against insect pests and their biotypes have been identified in a concerted network program. The results of this multi-location evaluation covering 15,820 accessions of germplasm during 1993-99 period identified 276 accessions resistant to blast, 50 to bacterial leaf blight, 28 to sheath blight, 282 to brown plan-

thopper, 74 to stem borer and 395 to gall midge. Utilising some of these sources of resistance breeding for multiple pest resistance was intensified. Some of the recently released pest resistant varieties display multiple resistance.

Effective, economic and eco-friendly insecticides for need based application in the management of insect pests have been identified. These include fipronil (75 g a.i. ha⁻¹), carbosulfan and chlorpyrifos (1.0 kg a.i. ha⁻¹) as granular applications and sprays of fipronil (50 g a.i. ha⁻¹) against pest complex and of thiomethoxam and imidacloprid (25 g a.i. ha⁻¹) against leaf and planthoppers. Commercial neem formulations



were found to be moderately effective against BPH, WBPH, GLH and leaf folder under greenhouse conditions.

Among the newer formulations of fungicides evaluated capropamid 30 SC for blast, thifluzamide 2 SC for sheath blight and Opus 12.5 SC for false smut were highly effective. Procarb and copper hydroxide (3 g/l) were effective against false smut. Isoprothiolane, kasugamycin, tricyclazole and carpropamid were identified as effective and blast specific fungicides and Validamycin, thifluzamide, and hexaconazole as sheath blight specific fungicides. Among biopesticides, Achook and Neemgold for blast control and AFF-3 for sheath blight control appeared promising. Biocontrol agent like fluorescent *pseudomonas* strain controlled sheath blight disease either alone or in combination with carbendaz-

im. A combination of fluorescent *Pseudomonas* sp. and *Bacillus* sp. was also effective in controlling sheath blight. But *Pseudomonas fluorescense* was found ineffective in reducing blast and in preventing yield loss. An entomopathogenic nematode *Rhabditis* sp., was found to be potential against stem borer and leaf folder. *Trichogramma japonicum* and *T. chilonis* has shown promise against stem borers and leaf folders. Use of sex pheromone in population monitoring and pest control through mass trapping and mating disruption has been demonstrated on large scale FLDs and on farm trials.

Effective integrated disease management strategies against blast and sheath blight involved cultivation of resistant varieties and need based fungicide application. For BLB it involved cultivation of resistant varieties and judicious nitrogen application. IPM package for insect pests under rainfed rice production systems consisted of resistant variety, balanced fertiliser application, release of *Trichogramma* egg parasitoids, use of pheromone traps against yellow stem borer and need based application of pesticide as the situation demands. Such a package effectively checked pests and resulted in increasing net profits of the farmers.

Conclusions

In view of the growing demands from the ever increasing population, it is imperative that rice production and productivity need to be enhanced through the existing yield barrier through application of modern tools of science. Anticipatory, strategic and basic research on rice needs to be strengthened with financial and policy support to meet the future challenges of climate change, water crisis and land and labour shortages. It is also equally important to make rice cultivation more profitable and less labourious.

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Augmenting Export of Spices through Value-Added Spice Products

Blessed with varied agro-climatic conditions and agriculture bio-diversity, India is an abode of the production of wide range of spices crops. India offers world with different kind of about 63 spices from wet land to arid land spices. Some of the economically important spices are chillies, black pepper, ginger, turmeric, cardamom, coriander, cumin, fennel, fenugreek, ajwan, dill, cloves, nutmeg, cinnamon, saffron, vanilla etc. The increasing trend towards eating ethnic or orientale foods in the developed countries and the increasing affluence of consumers in Asian and Latin American and Middle Eastern developing countries have lead to the increase in world spices consumption. As a result, the world import of spices recorded a 6% annual growth rate during the last decade. This increase in world spice consumption holds good promise in the coming years for the spice industry both domestic as well as international.

Current scenario of spices in India

The area and production of spices in India shows an annual growth rate of 1.5% and 5.3%, respectively during the last decade. The present spices production in the country is in the order of 4.10 million tones from an estimated area of 2.60 million ha (2007-08). Chilli is the major spice crop occupying about 29% of area under cultivated and contributing about 30.4% of total spices production in the country. Turmeric accounts for 20% of production and 7% of area, garlic accounts for 20% of production and 7% of total area under spices. Seed spices accounts for 13% of production and 37% of area, pepper 2% of production and 9% of area of the total spices in the country. In India every state grows one or more spice

es. But Gujarat occupies the highest area under spices in the country and is closely followed by Rajasthan (mainly seed spices cultivation). The other states in decreasing order of area are Andhra Pradesh, Kerala, Karnataka, Madhya Pradesh, Orissa, Tamil Nadu, Maharashtra, West Bengal and Uttar Pradesh. But the trend for production deviates, the leading highest spices production state in India is Andhra Pradesh (due to chilli and turmeric) and is followed by Gujarat, Karnataka, Rajasthan, Tamil Nadu, Madhya Pradesh, Orissa, Uttar Pradesh, Kerala, West Bengal and Maharashtra. India is not only the largest producer but also the largest exporter of spices in the world.

India exported 0.47 million ton of spices valued at US\$ 1168.40 million (Rs. 5300 crores) during the year 2008-09, to more than 150 countries in the world. The Indian spice export which was to the tune of 2.25 lakh tons valued Rs. 1231 crores during 1996-97 rose to the all time high 4.7 lakh tons valued to Rs. 5300 crores during 2008-09. The export of various spices and spice products from India during the last three years is given in Tabel 1. The major items exported from India are pepper (7%), chilli (33%), turmeric (14%), seed spices (22%), spices oil & oleoresins (7%), others including cardamom, cinnamon, cloves, ginger, saffron etc. (17%). Spices exports have registered substantial growth during the last one-decade, registering an annual average growth rate of 11.1% in value terms and 6% in quantity. During the year 2007-08 onwards the export earnings from spices have surpassed 1 billion \$ mark for the first time and registered an all time high both in terms of quantity and value in spice exports. In 2008-09 the export of spices from India has been 0.47 million tonnes valued MLN



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US \$ 1168.40 million registering an increase of 42% in value over 2006-07. India commands a formidable position in the World Spice Trade with 48% share in Volume and 44% in Value (Spices Board, 2010).

Challenge of climate in spices production:

Climate change, a cause of concern globally also have impact on spices crops, due to erratic rainfall, more demand for water, and enhanced biotic and abiotic stresses. However, the changes will not only be harmful, as enhanced CO₂ concentration may enhance photosynthesis and increased temperature may hasten the process of maturity. Increased temperature will have more effect on reproductive biology and reduced water may affect the productivity but adaptive mechanism like time adjustment and productive use of water shall reduce the negative impact. Due to effect of climate change, crop losses due to severe disease and pest incidence have been reported in black pepper, cardamom, ginger, turmeric and seed spices. These challenges could be addressed through identification of the gene tolerant to high temperature, flooding and drought, development of nutrient efficient cultivars and production system for efficient use of nutrients and water. Strategies have to address

the enhanced water efficiency, cultural practices that conserve water and promote crop. Development of climate resilient spices crops which are tolerant to high temperature, moisture stress, salinity and climate proofing through genomics and biotechnology would be essentially required. This would need highly prioritized research to address the impact of climate change. We must have also to enhance the knowledge to address all the strategies which can convert the challenges into opportunity. Concerted and integrated efforts with effectiveness and efficiency will be essential to meet the ever increasing demand. Looking into population growth, declining land, water coupled with challenges of climate change has created much greater concern to meet demand for spices for the growing population. The challenges before us are much greater than before, and have to be addressed with strategic approaches utilizing innovations in science and technology.

Challenges in Spices trade:

Over the past decade, the Indian Spices industry has made quality, the cutting edge of its global game plan. The present trend in export of spices shows that, India can take over the world market, which seemed to be slipping out of its hand in the recent past. One of the major causes for worry for domestic spices industry is the low farm productivity in the majority of spices grown leading to higher cost of production. There is need to improve the production system for achieving high productivity. The major constraint faced by India in exporting spices is the fall in unit prices of spices in the international markets. This is due to the increased supply from newly emerged competitors like Vietnam, Thailand, China, Guatemala etc. These producers have no domestic market, which make them to push their entire produce to the international market, making the traditional exporters like India to bear the brunt. India though a major producer of spices, exports only around 8-10% of its production as it has a strong domestic market. The major constraints

in export of spices are the lack of surpluses at international competitive prices for export, quality issues, port congestions, lack of infrastructure and credit. The situation is gradually changing India to become one of the major importers of spices also. In some traditional item like pepper, where India was once a major player, the situation has drastically changed to make India a major importer.

Before 2001-02, Indian spice industry was protected from import of spices from outside. Due to WTO agreement, India has removed quantitative restrictions on import of spices and other agricultural products since 1999-2000. Due to similar agro-climatic conditions prevailing in other countries and also very high price realized for selected spices new countries are emerging as major producer of spices. Lack of adequate domestic demand and lower cost of production in these new emerging countries poses a major threat to Indian spices industry. Therefore, the import of spices has gone up since 2001-02, to the tune of 90000 metric ton valuing to Rs. 64,550 lakhs. To keep ourselves afloat as a major player in the world spice market, concerted efforts are required for maximizing the yield and profit so that increasing import can be stopped and besides meeting the internal demand, lion share in export of spices globally could be retained. Further, there is need to export value added products, rather than raw spices. The value added products from spices thus assume great importance.

Role of value added products:

The consumption of spices is increasing steadily with the improvement in the living standard of the countries all over the world. Markets for spices are inelastic as a person cannot consume more than a limited quantity of spices with any amount of persuasion and propaganda. The expansion of trade in spices will be invariably achieved by means of induction of value added spice products in the market. The term value-added products in general indicate that for the same volume of a primary prod-

uct, a high price is realized by means of processing, packaging, upgrading the quality or other such methods. The value added spices products provide some advantages as more volumes can be handled per unit area, encourage growth of ancillary industries and fetches increased foreign exchange.

It is observed that about 70 % of the total trade in spice consists of whole spices. The balance is made up by spice oleoresins and oils, curry powder, ground spices and spice mixes in bulk as well as consumer packs. Spices in their raw forms have certain disadvantages. A whole or ground spice does not impart their total flavour readily and moreover, on being finely ground they lose their aromatic constituents partially, on account of their volatile nature, it is variably of flavour strength and quality. It is bulky for storage and often unhygienic due to bacterial and rodents contamination. Some of these defects can be reduced by extracting oil and oleoresin of spices. The market is changing towards use of value-added spice products than raw spices in view of their various advantages. Globally the people are becoming more and more conscious about the sanitary requirements, microbiological levels, pesticide residues. Therefore, emphasis should be on production of more value-added spice products which are almost free from contaminants.

India is exporting raw spices as well as various value added spice products to around 70 countries. There are excellent facilities and vast scope in the country for making oils and oleoresins, curry powder, etc. There is a conscious effort now for exporting more value added forms of spices instead of supplying them as raw spices as has been done traditionally. The spice export in India is expected to reach a level of Rs. 5500 crores in the current financial year. India can easily reach the figure of Rs. 8000 crores earned as foreign exchange in the coming years, if more and more value added products are discovered and marketed globally. India is becoming the global leader in value

added spice product development and export. During the year 2008-09, about 41 thousand ton of value added spice products to tune of Rs. 2300 crores were exported from India. The value added products from major spices, which are prepared and exported from India are enlisted in Table 2.

India holds near monopoly in value addition and value added products in spices. Spice oil and oleoresins, dehydrated green pepper, pepper in brine, freeze dried pepper, frozen pepper, spice whole or powdered forms in consumer packs, ground spice mixture and pre-mixed seasoning are few products from India which are much valued abroad. India meets 70 percent of the world demand of spices oils and oleoresins at present.

The important kinds of value added spice products and their status for export from India is given here.

1. Spice oil and oleoresin

The spice oils are extracted by steam distillation. The essential oils thus obtained are endowed with the major part of the flavour and fragrance properties of the spices. Spice oils are the volatile components present in most spices and provide the characteristic aroma of the spices. Spice oils have the major advantages such as standardisation, consistency and hygiene. The standard of quality expected in a spice oil will differ depending on its end uses. Therefore, these oils are custom-made to meet the exact requirement of the user. Spice oils are mostly used in food, cosmetics, perfumes and personal hygiene products like toothpastes, mouthwashes and aerosols, besides in a variety of pharmaceutical formulation. India is a leading exporter of spice oils to West Europe, USA and Far East.

India enjoys the distinction of being the single largest supplier of spice oleoresins to the world. The export of spice oils and oleoresins during 2008-09 has reached a record high of 6,850 M.T. valued to Rs. 720.5 crores. This export is against 1355 M.T. valued to Rs. 71.6 crores in

1993-94, registered an increase of about 5 times in quantity and 10 times in value.

The substantial increase in export is mainly due to the increase in export of paprika/capsicum oleoresins and garcinia extract mainly to USA, Spain, Japan and Korea. The spice oils and oleoresins account for more than 80% of export earnings from value added spices. Oils and oleoresins of pepper are largely exported from India followed by oils and oleoresins of ginger, chilli, turmeric and other seed spices. In the developed countries spice oils and oleoresins are mainly used both in food industry and non-food industry. The spice oil and oleoresins industry is poised to achieve a growth rate of 30% a year for the next five years. This growth has to be induced by diversification in production of value added spices with focus on maintaining quality as per ISO which will help exports to the exacting markets of Europe and Japan.

2. Encapsulated spices

Encapsulation offer protection of flavor from deterioration/oxidation. In the production of spray dried spices, the essential oils and or oleoresins are dispersed in the edible gum solution, generally gum acacia or gelatin, spray dried and then blended with dry base such as salt or dextrose. As water evaporates from the spray dried particles, the gum forms a protective film around each particle of extractive. The protective capsule prevents the spice extractive from evaporating and from being exposed to oxygen. The encapsulated oil of pepper, ginger, turmeric, garlic are gaining value in the market.

3. Ground spices

The spices are milled to the degree of fineness such as cracked, coarse grind, fine grind etc. as required by the user. There is a considerable heat evolved during the grinding operation resulting in flavour loss or modification. To overcome this problem, spices are now milled at low temperature by feeding spices are liquid nitrogen simultaneously into the milling zone.

The cryomilled spices have better retention of aroma, colour and less of moisture.

Pepper, cardamoms, chilli, ginger, turmeric, coriander, cumin, celery, fennel, fenugreek and cinnamon are the major spices ground to powder and then exported in the value addition consumer packs. Different countries follow different patterns of distribution. The importance of quality, packaging and utilization of modern techniques such as cold grinding cryogenic plants and spray drying equipment are points to be considered in the development of ground spices.

4. Curry powder:

Curry powder is made from a blend of several spices, the number varying from a minimum of 5 to more than 20 spices depending on the end use. Various spices viz. turmeric, garlic, chillies, coriander, cumin, fenugreek, fennel and black pepper constitute the many raw materials used in quality curry powder. Cloves, cinnamon, nutmeg and cassia are also added in different preparations to obtain different blend and help in improving aroma and flavour of curry powder. Manufacturer of curry powder generally do not reveal their formula and blends may differ widely between manufacturer. Apart from their traditional use in oriental cooking, curry powders are finding place in industrial food, such as instant snacks and curry powder flavoured sauces and soups. India is the major supplier of high-quality curry powders and spice mixes to the world.

The international trade in curry powder is expected around 20000 tons per annum. The export trade in curry powder is dominated by India. During 2008-09, the export has surpassed the previous highest to Rs. 164 crores. The export is 13250 M.T. valued to Rs 164 crores as against 8415 M.T. valued Rs 67 crores in 2004-05. Outside Europe, the most important market for curry powder is the Middle East, Iraq, Australia, USA, Canada, Nigeria and Japan. The exporters should assure quality through effective and efficient quality control



system particularly sanitary and phytosanitary measures as per the ISO to capture the large segment of international market.

5. Consumer packed spices:

The spices exported to the developed countries are consumed in three main segments viz. industrial, retail and institutional. Different packaging media are used according to the consumers preference for those parts of spices which are sold by retail. The popular packaging media are glass bottles, rigid plastic containers, metal containers and flexible pouches. By exporting consumer packed spices, higher unit value for the same quantity can be earned. The prices of such retail spices, higher unit value for the same quantity can be earned. The prices of such retail spices, higher unit value for the same quantity can be earned. The price of such retail spice packs are higher between 50-100% when compared to the prices of bulk, depending upon the packaging media, weight of the pack and value of the raw material. The weight of re-

tail packs generally range between 30 gm to 200 gm. However institutional packs range from 500 gm to 1 kg in weight are also retailed under some brands. There are competitors for every spice and new competitors with low prices are edging out India in the world market. Therefore it is necessary to take steps in establishing a brand image for India spices and create brand loyalty among the consumer world wide.

6. Natural Colour and Enriched Extracts

Curcumin in turmeric and Carotenoids in chillies are the natural colour components extracted for use as natural colours. The natural colours or their blends have wide applications from food sector to pharmaceuticals, dyes and cosmetics. India is a large producer of turmeric, and Indian Oleoresin Industry is one of the largest supply sources of a wide range of turmeric extracts in liquid and dry form. The range of products offered by Indian industry covers a wide spectrum of purity for the colour

user, providing versatility in application. India produces two varieties of Paprika type chillies. The color value in this ranges from 125 ASTA to 175 ASTA. Kaddi variety is grown in Karnataka and Tomato variety in Andhra Pradesh. In the last few years India has emerged as a competitive and effective source of Paprika type Oleoresins. India's production of this extract is rising and India aims to capture a fair share of Paprika Oleoresin market in the years to come. *Garcinia Indica* (Kokam) and *Garcinia Cambogia* are two spices widely grown in the slopes and plain of evergreen forests of Western Ghats in South India. These two spices have distinct medicinal properties for curing obesity. Hydroxy citric acid is the principal component which is extracted and enriched for preparation of pharmaceutical products. Both these varieties of tamarind have wide applications in pharmaceuticals and therapeutical areas. A range of branded anti obesity drugs available around the world use Hydroxy Citric Acid since it is natural and herbal in

origin.

7. Processed spices:

The processed value added spice products are dehydrated, frozen or freeze dried green pepper and canned pepper, green and pink in brine. The technology for above products has been mastered in India and handsome quantity of such value added products are marketed in the international market. In the early 1970's, the dehydrated green pepper and pepper in industry entered into the advanced area of freeze-drying and frozen green pepper manufacture. The exports are mostly confined to Europe, Japan and USA. The export of such processed products of spices has appreciably grown. Still there is tremendous scope for India to expand export in the international market.

8. Organic spices:

The growing demand for organic crop products has led to the development of international trade for organic spices. India is now one of the countries exporting organic spices. Exporters specializing in organic production have been successful in achieving the international standard prescribed for spices. Europe is the world leading market for organically produced spices. The global market for organic spices is expanding rapidly due to growing awareness of health benefits of such products. At present, Indonesia supplies the US with organic spices and herbs. If India can step up production of such spices as per EC organic food standard, we can capture a good portion of world market. The total global organic spice trade is expected to around 1500 metric ton valued to US\$ 6 million. The main organic spices traded by volume are pepper (39%), ginger (19%), turmeric (11%), cardamom (8%), chilli (7%), cloves (7%), nutmeg (7%), vanilla (1%) and others (7%). India exported 250 tonnes of different organic spices during 2005-06 as against 25.33 tonnes in 1996-97. The largest producers and exporters of organic spices are Sri Lanka (28%), India (12%), Indonesia (10%), Tanzania

(10%), Madagaskar (8%) and Guatemala (8%). The organically produced spices fetches a premium in the international market and prices are higher by 20-50% and in some cases even 100%. In order to give fillip to the production an export of organic spices, it is suggested by the veterans to choose compact areas for establishing organic spice estates.

Recent trends in processing and value addition:

Processing

Since most of the preliminary processing of spices is done at the farm, it is mostly done by traditional methods. Improved and more scientific methods need to be popularized to get good quality products. Prime importance has to be given to microbiological safety of spices and their products. Measures such as good agricultural practices (GAP), good manufacturing practices (GMP), quality management systems under International Standard Organisation (ISO9000) and hazard analysis and critical control points (HACCP) help reduce or eliminate contaminants in spices. The time has come to improve our production system so as to compete in the international market and there is also a great need for value addition of the produce. Minimum hygiene requirements should be maintained during production, harvest and postharvest activities in order to avoid contamination. The past efforts have yielded results and recent trends in processing and value addition are needed to be adopted for making available the high quality of spices for the well aware society which is now lucrative to small culture of marketing.

Grinding and packaging:

Grinding forms a very important unit operation especially in the post harvesting of spices requiring special attention as it involves additional problems of volatility and loss of aroma from essential oils, apart from obtaining smaller particle sizes. The main aim of grinding in particular spice grinding is to obtain smaller particle sizes, with good product quality in

terms of flavor and colour. The optimum size of the grind for each spice depends on its end use and accordingly the conventional methods normally employ a hammer mill (coarse grinding), plate mills (domestic use) or pin mills (fine grinding). During conventional grinding that is grinding without cooling the spices, the temperature increases to over 90 C can occur in fast rotating mills which leads to substantial losses in light evaporative essential oils which lead



to loss in quality.

Cryomilling or freeze grinding

Flavour loss can be minimized by providing suitable cooling arrangements to the milling zone. Pre-cooling of the spices also can minimize flavor loss. Since the use of liquid nitrogen for quick freezing came into use, the advantages of freeze grinding of spices have become obvious. Here liquid nitrogen comes in direct contact with the material at very below normal temperature..

Sterilization of spices:

The sterilization of spices can be effectively done by heat, steam or chemicals, use of low temperature, dehydration, desiccation, lyophilisation or irradiation. Among the various methods of sterilization steam sterilization or chemical fumigation are economical than irradiation. Steam sterilization leaves no chemical residue and is ideal for both whole and ground herbs and spices. Depending upon the type of spices, the sterilization is achieved by thermal treatment

using steam and high temperature short time (HTST) process in bringing down the microbial count to a commercially acceptable level. Whereas for chemical fumigation for sterilization of spices are ethylene oxide (ETO) and propylene oxide (POP). ETO is reported to be carcinogenic by inhalation and hence POP is preferred.

Irradiation

Irradiation is becoming an increasingly accepted technique to sterilize spices and the common dose applied to spices is 3 to 10 kGy. By law, a spice irradiated once cannot be irradiated a second time, therefore, bulk irradiated spices must be well labeled to avoid a second irradiation if it enters as an ingredient in meat or other product that will be irradiated. The laws allowing radiation on foods vary greatly by country within the European Union. The basic objectives of irradiation of spices are disinfestations, shelf life extension, hygienization and sterilization. In accordance with international regulations such as CODEX general standards for food irradiation, the source can be radioisotopes (gamma rays cobalt-60 or cesium-137) or machine sources (electron generated). The chemical differences between radiation processed foods and non-irradiated foods are too small to be detected easily. The rough composition of food remains largely unchanged, some minor losses in vitamins may be encountered. Today, more than 40 countries have approved the use of radiation processing technology for different food commodities including spices. Some of the countries that have approved irradiation of food and spices are EU, Argentina, Australia, Belgium, Brazil, Canada, Chile, China, Croatia, Czech Republic, India, Indonesia, Iran, Israel, South Korea, Malaysia, Mexico, New Zealand, Poland, Pakistan, Peru, South Africa, Thailand, UK, USA, Vietnam and Yugoslavia.

New Extraction techniques

Super critical fluid extraction

The use of super critical fluid extraction (SCFE) of organics from complex sample matrices have several advantages over traditional extraction methods. The oil obtained is of excellent quality and has monoterpene to sesquiterpene ratio much less than the steam distilled oil. The recoveries of volatile oil have been higher than steam distillation method. The essential oil obtained from SCFE has excellent fixative character. SCFE process will be viable for the production of high value stable priced products for specialized use in food and pharmaceutical industry



6. There is need to develop domestic market for organic spices through concerted efforts by popularizing healthy and safe organic spices to sustain the Indian spice industry.

Conclusion

For long, Indian exports mainly consisted of bulk packaged raw spices. Now with the changing market trends, consumer's preferences and the emergence of supermarket, the focal point of export has shifted towards value added spice products. The major value added products offered are spice oils, oleoresins, ground spices, curry powder, and consumer packed spices, organic spices and processed spice products. Our country has expertise and world class facilities to manufacture all these products which now dominate the international market. The last decade in India, has improved the share of the value added spice products in the export basket to 32%. India can easily cross the figure of Rs. 8000 crores earned as foreign exchange by end of 2012, if more and more value added spices products are marketed globally. To further expand the market for Indian value added spice derivatives, marketing oriented approach should be followed and care must be taken by the industry for the formulation of right products, its advertisement and efficient export promotion.

Principal Scientist (Horticulture)
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Strategies to be adopted

1. Spice industry should be modernized by lending greater private sector partnership for diversification, value addition and export promotional research and seed and planting material production programs
2. Refinement of production related technologies and their transfer can bring perceptible changes in the productivity of the spice crop.
3. There is need to develop bulk handling techniques, organic farming and residue free integrated pest management technology (IPM).
4. Post harvest losses should be minimized by standardization of proper packaging of the spice and adopting low cost eco-friendly on farm storage structures
5. With the opening of global markets and removal of quantitative restrictions under WTO, export-import scenario should change at a much faster pace. Maintenance of uniform quality standards for domestic and export markets should be seen on priority.

Wheat rusts in India with special emphasis on Ug99

A new virulence of stem rust of wheat

S. S. Singh¹, Jag Shoran² and M. S. Saharan³

Since the initiation of the Green Revolution in the mid sixties, India achieved remarkable increase in production and productivity of wheat. India is now the second largest producer of wheat in the world and wheat production had touched a record of 80.71 mt during 2009-10. This achievement in India's wheat production has been perhaps the most important and unparallel in the history of developing world. The launch of the Green Revolution and rise in production coincided with productivity growth in the magnitude of 2-3% at national level saving crores of rupees to Indian treasury.

Wheat rust diseases and their recurrence under Indian conditions

Wheat crop is infested by three rusts, namely, yellow rust or stripe rust (*Puccinia striiformis*) (Pst), brown rust or leaf rust (*Puccinia triticina* Eriks.) (Ptr) and black rust or stem rust (*P. graminis tritici* Eriks & Henn.) (Pgt). Under Indian conditions, stripe rust favouring comparatively low temperature is prevalent in the northern hills, adjoining northern Indo-Gangetic plains and Nilgiri and Palni hills of southern India. Otherwise, this rust has never been observed in rest of the wheat growing parts of the country due to non-availability of desired levels of favorable temperatures during wheat growing season. There are 28 races of this rust known to exist in India. The leaf rust has capacity to flourish under varying temperatures and hence it is prevalent throughout the country and there are as many as 48 races of leaf rust reported in India. Since the stem rust needs comparatively higher temperature to get established and hence it is always observed in the central

and peninsular regions of the country including the Nilgiri hills. There had been historically no known epidemics of stem rust in the northern plains of India, while this rust had caused serious yield losses to wheat crop in central and peninsular parts till resistant varieties were introduced to phase out the susceptible cultivars.

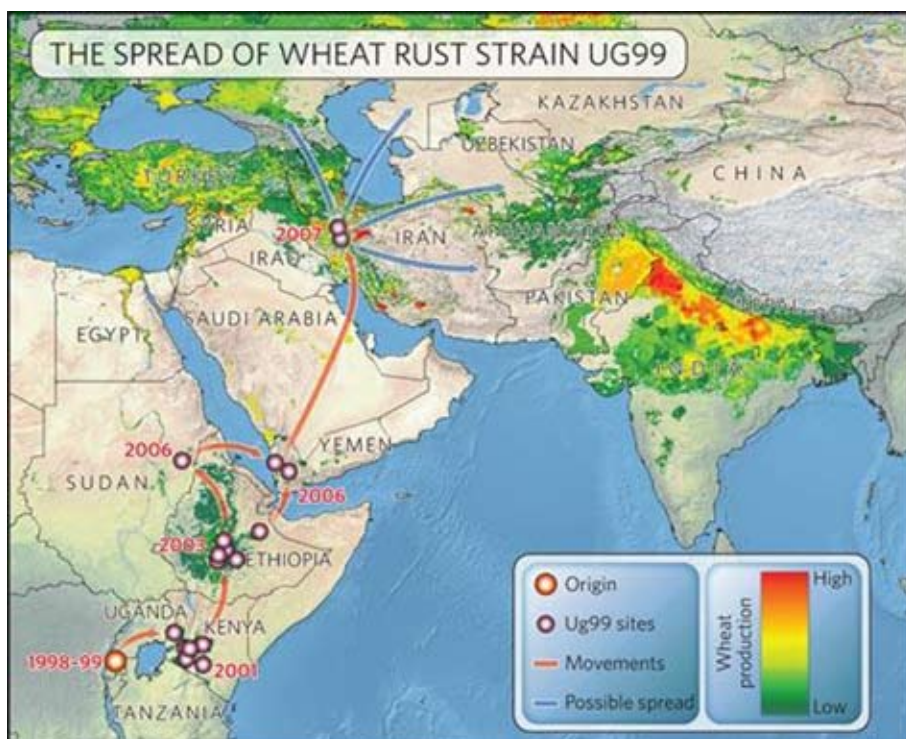
Why stem rust so dangerous?

Stem rust a catastrophic disease because of its capacity to cause complete annihilation of wheat crops over wide area. Stem rust, the most feared of all wheat diseases, can turn a healthy crop of wheat into a tangled mass of stem that produce little or no grain. It has caused major famines since the beginning of history. In North America, huge grain losses occurred in 1903 and 1905 and from 1950-1954. A urediospore may germinate in less than an hour, send out germ tube inside the plant within six hours or even less and produces a new

crop of 50 thousand to 450 thousand urediospores within ten days. Each spore can then repeat the process as long as wheat is growing. On an acre of moderately rusted wheat, there are about 50 thousand billion urediospores, each one capable of surviving a long air journey and starting infection many miles from the place where it was produced.

Possibility of arrival of Ug 99 in India and inflicting crop losses

The Yr9 virulence (pathotype) of stripe rust known as 46 S 119 originated in Africa in early nineties and later on took a route via cooler region of northbound hills of Turkey, Iran, Iraq, Afghanistan and Pakistan to reach India in 1996. To counter Yr9 virulence, resistant wheat variety PBW 343 was put under cultivation besides another resistant variety WH 542 was being grown in the wheat granary of north-west India to avoid any yield losses to be caused by this race. Yr9 virulence inflicted losses



in wheat in Syria, Iran and Pakistan, it failed to make similar impact in India due to cultivation of resistant varieties. However, due to altogether different climatic conditions favoring survival and recurrence of stem rust, it is quit unlikely that the Ug 99 race of stem rust will also follow the same route as adopted by Yr9 virulence. Historically, there is probably undocumented record available in the literature to support the movement of stem rust from Africa to India via the route predicted for Ug 99, however, the entry of Ug 99 into the Indian wheat fields can not be denied by other means. The arrival of Ug 99 in India through aerial route or direct human interference can not be ruled out. Even if Ug 99 comes to India, it will be flourishing in the southern hills and the adjoining areas of peninsular and central India rather than in northern hills in India, Ug 99 will also follow the suit and is highly unlikely that Ug 99 may survive under comparatively much cooler conditions of northern hills and cause significant yield losses in the northern parts of the country. Practically the environmental conditions and flora of hilly areas located in the northern latitudes and southern parts (near to equator) are not identical and no wonder this could be the reason that the stem rust flourish in southern hills of India rather than northern hills at identical altitudes/heights under different latitudes.

Countering the menace of Ug99

No chemical control of rust diseases appears to be practical for commercial cultivation of wheat. The best way to counter any of the rust diseases is in form of the host-resistance meaning by that the genetic factors responsible for providing resistance against rust disease should be utilized in breeding process for developing rust resistant varieties. The most common and environmentally sound means of combating wheat diseases is through the use of host resistance. The concept of gene deployment defined by Nagarajan *et al.* (1984) as "A centrally planned, properly executed, strategic use of useful



vertical resistance genes over a large geographical tract to minimize the risk of epidemics or pandemics of plant diseases." Taking a clue from this concept, the presence of *Puccinia* path was demonstrated in India, when the epidemiology of black rust was investigated. This path was divisible into sub zones depending upon the time and mode of arrival of primary inoculum and thus opened up the plausibility of gene deployment in Central and Peninsular India to combat black rust of wheat. The success of gene deployment strategy adopted for management of wheat rusts in India can be envisaged from the fact that there were no major wheat losses due to rusts in India since last three and half decades when neighboring countries (1994-96) and countries like United States of America (1998) faced rust epidemics. So much so, stem rust has been pushed to a status of as if eradicated from this country.

Genes effective against Ug99 are: *Sr28*, *29* and *Tmp* from *Triticum aestivum*, *Sr2* and *13* from *T. turgidum*, *Sr22* and *35* from *T. monococcum*, *Sr36* and *37* from *T. timopheevii*, *Sr3* and *Sr39* from *Aegilops speltoides*, *Sr33* and *45* from *Ae. tauschii*, *Sr40* from *T. araraticum*, *Sr24*, *25*, *26* and *43* from *Thinopyrum elongatum*, *Sr44* from *Th. intermedium* and *Sr27*, *R* and *1A/1R* from *Secale cereale*.

Two Ug 99 variants carrying separate virulences for *Sr24* and *36* have also been identified in 2008. Most of these except *Tmp* are from alien relatives of wheat but are available in the background of common bread wheat and can easily be utilized in hybridization programme. The possibility of other unknown resistance genes present in certain wheat cultivars against Ug 99 can also not be ruled out. Both short term and long term strategies need to be adopted to counter the menace of Ug 99 effectively.

Short term strategy: Fortunately the Ug 99 race of stem rust is not present in India, the help of CIMMYT, Mexico, under the aegis of Borlaug Global Rust Initiative (BGRI) was sought for screening the Indian wheat genotypes under natural condition of disease epiphytotic at Njoro (Kenya) where Ug99 is prevalent in severe form. During 2005 and 2006, the screening of Indian wheat cultivars, germplasm and genetic stocks under natural epiphytotic conditions at Njoro (Kenya) has led to identify at least eleven commercial wheat varieties [GW 322, GW 273, HI 1500, MP 4010, HD 2781, HW 1085, HUW 510, UP 2338, DL 153-2, HI 8498 (durum), MACS 2846 (durum)], three genetic stocks (FLW 2, FLW 6, FLW 8) and as many as 15 advance generation wheat strains (PBW 575, HD 2946, HD 2948, UP 2680, UP

2684, HP 1901, WH 1038, WH 1039, HUW 606, Raj 4119, Raj4120, Raj 4121, Raj 4124, Raj 4125, Raj 4132) which are resistant to Ug 99 race of stem rust. **Long term strategy:** As a long term strategy for countering the menace of Ug 99, many of the resistance sources identified in form of cultivars, genetic stocks or advance generation materials, have been utilized in hybridization programme and over 500 new crosses have been successfully made at various wheat breeding centres in the country. The genetic markers available for various *Sr genes* effective against Ug 99 can be applied to practice marker assisted selection (MAS) in the segregating progenies of targeted crosses for selecting resistant plant/progenies for Ug 99 even in the absence of the disease epidemic. Or, advance generation bulks developed from the targeted crosses can be tested against Ug 99 at Njoro (Kenya) for identifying the resistant ones. The more appropriate breeding approach can be utilize more than one *Sr genes* in combination of *Sr2* group of genes for the development of wheat cultivars with durable resistance against Ug 99 in particular and stem rust in general. However, it is once

again reiterated that mere resistance against Ug 99 will not be suffice for developing new varieties. The resistance against other important stem rust races prevalent in India along with resistance/tolerance against other diseases like leaf rust, stripe rust, leaf blight, powdery mildew, loose smut, Karnal bunt etc. is also important in the development of improved wheat cultivars besides, ensuring acceptable grain attributes and quality characteristics. Above all, the desirable agronomic-trait like proper plant height, maturity duration, threshability and capability to respond and withstand high level of inputs like fertilizers and irrigation, are also necessary for a variety to be successful with the farmers. Infact, a successful breeding strategy takes into account various important traits and come out with high yielding cultivars combining an optimum or maximum possible magnitude of different desirable characteristic. Therefore, a breeding activity can be considered a continuous process and it takes time to deliver a worthwhile and useful product in form of a variety with the result country has been capable of providing food security to a population nearing 1.2 billion.

Conclusion

Wheat rusts are the most important wheat diseases caused by *Puccinia* fungi. Although, the occurrence of new races in *Puccinia* fungi is not an unusual phenomenon, but the appearance of Ug 99 race of stem rust in Kenya carries special significance world over. This is because of the fact that Ug 99 has knocked down the stem rust resistance gene *Sr31* which had been providing wide spectrum of resistance against stem rust disease in modern wheat varieties. Till date, Ug 99 could not be detected in India. There are nearly two dozens of Indian wheat varieties in seed chain which have been found to be resistant against Ug 99 race of stem rust. Both short and long term strategies to combat the menace of Ug 99 have been brought out. It is not a important issue to debate on whether or not the Ug 99 will reach the Indian wheat fields but, the more important point is to pin-point the wheat growing areas which could become vulnerable to Ug 99 in the country. Nobody can deny this fact that sooner or later the Ug 99 may reach in our country through natural or extraneous means. For Indian wheat programme, too, it was a serious concern that the leading cultivar PBW 343 covering about 6 million hectares possesses only *Sr31* gene against stem rust. Fortunately, timely steps have been initiated by the Directorate of Wheat research/Indian Council of Agricultural Research and also through Borlaug Global Research Initiative to combat this threat of Ug 99. India being aware of the serious consequences black rust of wheat can cause, became core member of the global rust initiative that was launched to address the threat of Ug 99. Realizing the potential and magnitude of the threat, DWR under the aegis of ICAR took pro-active steps to prepare against this threat and strategic actions were initiated to address this threat.

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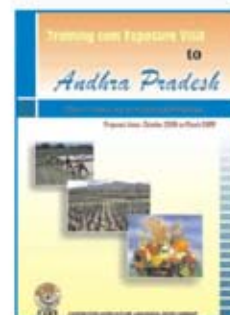
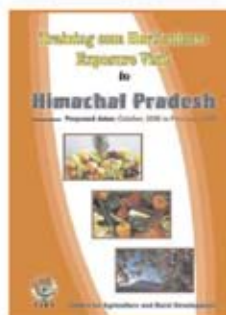
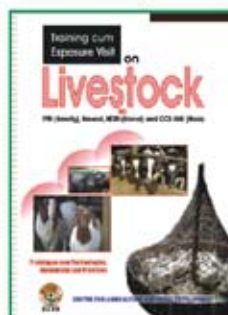
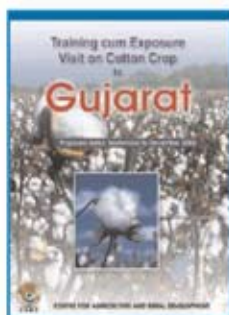


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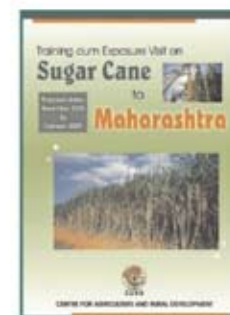
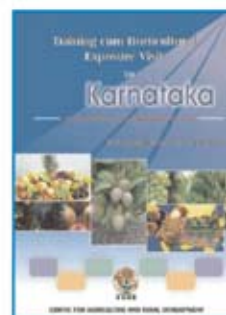
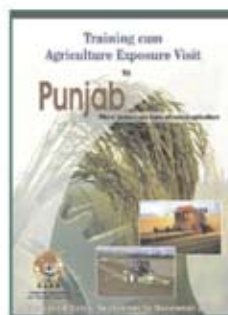
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Focussed Crops

Empowering Smallholder Dryland Farmers Through Inclusive Market-Oriented Development

"Sometimes our fate resembles a fruit tree in winter. Who would think that those branches would turn green again and blossom, but we hope it, we know it."

This quote by German playwright, novelist and dramatist Johann Wolfgang von Goethe is the dichotomy defining the life of the over 600 million rural people living in the tropical drylands of Asia and Africa.

The tropical drylands are changing rapidly, and the challenges are mounting. The globalization and liberalization of food markets is having greater impact on the demand for and supply of dryland crops. Environmental threats such as climate change, land degradation and biodiversity loss are adding new dimensions to longstanding challenges of poverty, food insecurity, drought, increasing population pressure, and rising costs of food and inputs in the dry tropics.

A 'perfect storm' of these converging pressures is threatening to tighten its stranglehold over the drylands and its smallholder farmers. It will severely curtail agriculture's ability to

respond to growing future food and feed needs of half of the people living in dryland Africa and one-third of those living in dryland Asia who earn less than one dollar a day! As per the UNDP Human Development Index (HDI), tropical dryland countries in sub-Saharan Africa (SSA) rank among the lowest in the world in human well-being, occupying half of the lowest 10% of positions!

With the Intergovernmental Panel on Climate Change (IPCC) categorically warning that the drylands are one of the areas most at risk of suffering from climate change, the situation looks gloomier. Though smallholder farmers in this region are portrayed as passive and powerless victims of subsistence farming, there is hope for them.

In the drylands of Asia and sub-Saharan Africa, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) works in tandem with partners to fight poverty, hunger and environmental degradation. ICRISAT envisions "a prosperous, food-secure and resilient dryland tropics." Towards that vision, it pur-



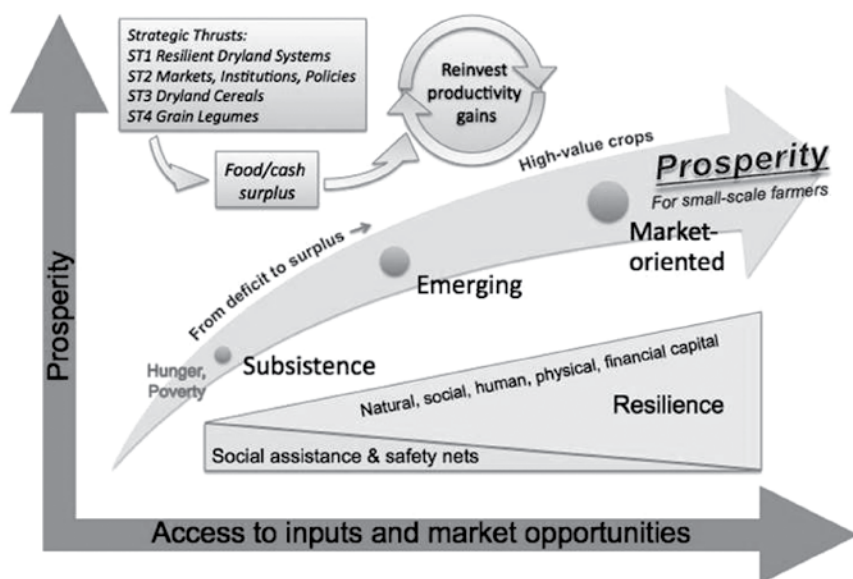
Dr. William D Dar

sues a mission to "reduce poverty, hunger and environmental degradation in the dryland tropics through partnership-based science with a human face."

Dryland poverty rates are declining in Asia, but not in sub-Saharan Africa. Analyses by the World Bank and ICRISAT have found that access to markets is key to escaping poverty. Gleaned from its rich knowledge base spanning 37 years in partnership with institutions, strategic studies, long-term village-level studies, as well as global studies by the World Bank, the Institute has adopted Inclusive Market-Oriented Development (IMOD) as a guiding principle to empower smallholder farmers to grow their way out of poverty. IMOD is a dynamic progression from subsistence towards market-oriented agriculture. It starts by increasing the production of staple food crops, converting deficits into surpluses that are sold into markets (Figure 1).

The emergence from subsistence to market-oriented agriculture reduces poverty, because markets create demand for a wider diversity of higher-value foodstuffs and agro-industrial products, stimulating agro-enterprises that raise rural incomes (as well as creating opportunities beyond agriculture). This creates greater resource access, stability, security and productivity. This pathway to prosperity employs a systems perspective founded on purposeful partnerships

Inclusive Market-Oriented Development



in setting priorities to ensure that all the important issues along the pathway are addressed holistically.

In the World Bank's global model spanning three stages of economic development – agriculture-based, transitional and urban – in which poverty decreases as societies move along this pathway, ICRISAT works in the predominantly agriculture-based, low reward-high risk drylands of Africa dominated by subsistence farming. The agglomeration index is low in dryland Africa [35 for West and Central Africa (WCA) and 25 for Eastern and Southern Africa (ESA)]. ICRISAT's crops account for approximately 40% value-share of dryland income in WCA and 20% in ESA, implying that higher potential impacts from our crops are achievable. ICRISAT strives to reduce poverty in this region by developing equitable, sustainable, resilient systems that connect smallholder subsistence farmers to higher-value markets.

On the other hand, the largely transition-phase economies of Asia have a higher agglomeration index of 52 compared to Africa. Our village-level studies in India reveal that many of the village poor have found greater opportunities in cash crops, reducing the value-share of ICRISAT staple food crops in their total income portfolio. The poor also provide the urban population with higher-value food products.

Our work spanning the development pathway also encompasses safety nets, tolerance, coping and resilience strategies; soil/water/nutrient conservation; more nutritious and diverse crops for farm households; integration of trees, crops and livestock (Figure 2); fertilizer access and crop response; market access; high-value crops; higher value products and traits; agro-enterprise incubation; and efficient small-scale irrigation.

Achieving our targets of halving rural poverty, hunger and malnutrition and increasing the resilience of dryland farming requires partnerships to ensure the effective harnessing of inclusive market-oriented development. ICRISAT does this by developing system, policy and technology

options and building capacities. It is involved in 190 active partnerships. Public-private partnerships (PPP) have proved their productivity in several watersheds sites and created win-win situations for all stakeholders involved. Since 1972, ICRISAT has trained over 15,000 specialists from 48 countries, including 620 in post-graduate degree programs (Masters and PhD) through partnerships with universities worldwide.

Smallholder farmers lack access to markets to sell their produce, without which the cash needed to invest in inputs to increase farm productivity becomes scarce. Together with national agricultural research systems (NARS), ICRISAT works closely with farmer's groups focused on smallholder needs, to turn land users into decision makers. Mariah in Malawi is assured a market for her groundnut produce through the 100,000-member strong National Smallholder Farmer Association of Malawi (NASFAM), which provides agricultural advisory services for groundnut production. She accesses improved technologies (made available by ICRISAT) by participating in adaptive trials for the control and management of aflatoxin. If her groundnuts are aflatoxin free, NASFAM will offer her an additional bonus price per kilo!

Women in the drylands are less empowered, have very limited access to production resources, and have restricted roles in certain production and marketing activities. Malnutrition is a scourge that stalks 42% of children in dryland Asia and 27% of those in Africa. IMOD enables poor women to participate and benefit, thereby ensuring equitable development and the development of the next generation.

ICRISAT is helping women's groups to gain access to

the seed and skills that they need to grow and export high-value crops like pigeonpea in East Africa. In Niger, a group of 120 landless women in the Dosso region started growing hardy indigenous vegetables in degraded land using ICRISAT's Bioreclamation of Degraded Lands system on a 7 hectare field in June 2006. Today, they are proud that the degraded area has grown to 70 hectares of lush and productive greenery. They are additionally using crops such as a new short-duration okra cultivar jointly developed by AVRDC. At present, 5000 rural women and their households are benefiting from these technologies.

ICRISAT has also supported the setting up of 2500 African Market Gardens (AMGs), a low pressure drip irrigation system combined with high-value crop diversification enabling the commercial integration of fruits, vegetables and trees in the dry Sahel.

ICRISAT is proactively engaging women as leaders in its farmer-to-farmer knowledge-sharing and training activities in areas such as crop management, participatory plant breeding, crop processing, marketing and agro-enterprise development. We are building on successes that have engaged women in enhanced high-value skilled operations near the household such as tree grafting in West Africa, and in bio-energy tree nursery cultivation (Figure 3) and bio-





pesticide production in watersheds in Asia.

In West Africa, ICRISAT supports the development of local seed companies under the West Africa Seed Alliance (WASA) by supporting breeders in national breeding programs to develop and release improved varieties of a range of food crops; establishing a network of agro dealers; supporting new and existing seed companies to produce and market improved quality seed; and supporting seed trade harmonization at the regional level (Figure 4).

In Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Jharkhand, Chhattisgarh, Orissa, Uttar Pradesh and Madhya Pradesh states, ICRISAT encourages and helps smallholder farmers to go into the production and storage of self-pollinated varieties of legumes.

The Hybrid Parents' Research Consortia (HPRC) with its 30-member 3 consortia, ensures synergy between Public (ICRISAT) and Private Sector seed companies by dealing with

CMS systems, developing high-yielding disease-resistant hybrid parents (Figure 5) and training for transfer of hybrid seeds production technology. ICRISAT has stimulated more than 108 joint ventures with agri-business entrepreneurs in India over the past four years. It has helped partners to explore novel outreach approaches in Africa using mechanisms such as warrantage/microdosing. ICRISAT has helped farmers in places like the Limpopo Province, South Africa, by facilitating the creation of a public-private partnership between the Limpopo Department of Agriculture (LPDA), SASOL Nitro, a fertilizer manufacturer and Progress Milloling, a grain milling and trading firm with a network of rural retail outlets that sell fertilizer. Together, they tested the idea that selling smaller than-usual size packs of fertilizer (10 kg instead of 50 kg) would help overcome the constraints.

History has shown that agricultural surpluses can provide a pathway out of poverty to smallholder farm-

ers since these can be stored or sold into markets to earn income, serving as a buffer in times of hunger. The higher incomes help them buy food as well as inputs such as seed, fertilizer, labor, tools, livestock, insurance and education. These inputs in turn stimulate farm productivity and prosperity. This virtuous circle thus leads to another round of investment and productivity growth, creating a self-reinforcing pathway out of poverty.

Agriculture matters because the continuation of poverty is in no one's interest. As novelist Arthur Koestler once said, "Statistics do not bleed". Numbers do not capture the suffering of every one of the undernourished and chronically hungry people. Hence we need to take agriculture along a road where it can feed the world's hungry and improve the life of smallholder farmers. Not to do so would be the ultimate betrayal of the poorest of the poor.

Director General, ICRISAT

PESTICIDES INDUSTRY, AGRICULTURE AND DATA PROTECTION

Pesticides play an invaluable role in ensuring crop productivity. Unlike other inputs such as seeds, fertilizers, water and farm implements whose proper usage directly contributes to productivity, pesticides like insurance provide the umbrella which protects the crop, whatever be their productivity, as also the investments the farmers make in agriculture.

Yet regrettably the pesticides use in India is abysmally low as can be seen from the following data.

Pesticides consumption in India is lowest at 0.6 kg / hectare compared even to Pakistan; and wholly inadequate when compared to other highly crop productive countries.

In fact the Standing Committee of Parliament on Chemicals in 1992 estimated crop losses of Rs. 90,000 Crores (\$ 19 billion), and the Agriculture Minister in response to a Parliamentary Question on 2nd March, 2007 stated that pest diseases and weeds cost 30% of crop losses which calculates to an astounding loss of Rs. 1.48 Lac Crores (\$ 31 billion). Besides poor awareness, failed Govt. extension services, one of the major reasons for this loss is the wholly inadequate availability of a variety of solutions to the Indian farmers, and most of the registered products are very old. This can be seen from the following facts:

What is the reason that India has registered only 225 molecules so far,

Country	No. of Products Registered
INDIA	225
US	755
EUROPE	600
PAKISTAN	495
VIETNAM	432

India: 112 herbicides, 8 insecticides, 4 fungicides registered Yield 1000 – 1240 kg / ha.
Brazil: 171 herbicides, 159 insecticides, 104 fungicides Yield 2870 kg / ha

even when much smaller countries like Vietnam and Pakistan have almost double the same?

This has primarily been due to the regulatory regime wherein, on applying with a Rs. 100 fee, anyone can get a “Me Too” registration and without having to submit any worthwhile data.

While this was a very desirable policy when the Insecticides Act was implemented in 1972, but in the long run, the unintended effect has been the massive proliferation of registration of over 1300 units throughout India. Reportedly over 125,000 registrations have been issued. Such proliferation has seriously jeopardized the very objective of the Insecticides Act whose opening lines say “An Act to regulate the import, manufacture,

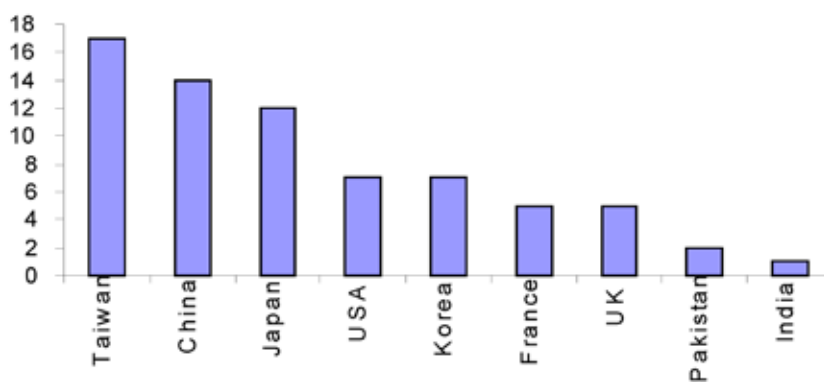


Salil Singhal

supply of spurious and sub standard products.

In the new Pesticides Management Bill (PMB) the Govt. has attempted to correct the situation by offering 3-year Data Protection (DP) to any molecule

Pesticide Consumption



(Based on reply by the Minister of Agriculture, Govt. of India on 10.09.2007 in Parliament)

sale, transport, distribution and use of insecticides with a view to prevent risk to human beings or animals, and for matters connected therewith”.

Can we really regulate 1300 units and > 1.25 Lac registrations effectively in India?

It is a great paradox that while on the one side the registration data for new molecules undergoes huge scrutiny, but a ‘Me Too’ registration is granted merely on the basis of what is called chemical equivalence. This has encouraged unhealthy competition and

registered for the first time in India. In fact the Standing Committee of Parliament and Agriculture in their hearing on the PMB almost all the 15 MPs present raised serious concern about the quality of pesticides being supplied. In their collective wisdom, the peoples representatives proposed to raise data protection to 5 years, against 3 years as proposed by the Ministry of Agriculture.

However, the proposal of DP in the PMB has seriously divided the Industry between the molecule discoverers

i.e. MNCs in India. (because India does not have the wherewithal to discover molecules), and the Indian pesticides industry, who essentially depend on sourcing the technicals (a.i.) as raw materials, and for reverse engineering a.i. manufacture.

The Indian industry feels that they will be restricted to copy / reengineer new molecules for the 3/5 year period of DP. This will therefore, hurt their business growth, as also prevent them to introduce these molecules in their product range.

This segment also feels that by a 3/5 year DP, the farmers shall be forced to pay very high pesticides prices. The example of an insecticide is oft quote where, at the time of introduction, it was sold at Rs. 3200/- per litre. But after tens of 'Me Too' registrations, the prices have come down to Rs. 700/- per litre. It is claimed the business of this molecule has steeply risen to 20 Lac litres from the initial 2-3 Lac litres.

The case of the molecule inventors (who are MNCs) is that each molecule costs more than \$ 250 million and around 8-10 years to discover and commercialize. An independent study of 14 MNCs in this business says that they spent \$ 2.32 billion in 2007 and expect to spend \$ 2.94 billion in 2012 in new product R&D. Even to register a new product in India, there is an expenditure of few Crores to generate data for safety and efficacy under Indian conditions. Hence, they need DP to compensate their cost of innovation. Inversely, if DP is not offered, then they would not care to bring new molecules to India. This is called "Safeguarding Innovation". It is also a fact that almost all countries such as USA, EU, Japan, Latin America, South East Asia all provide DP from 10 to 15 years. Even in China there is a 6-year DP.

MNCs also point out that under the TRIPS Article 39.2 countries must "prevent information lawfully within their control from being disclosed in a manner contrary to honest commercial practices." and 39.3 wherein TRIPS members are enjoined to "protect such data against unfair commercial use".



This DP debate has been going on in the Industry for the past 30 years, and it has never been easy to balance the interests of both sides.

Undoubtedly the arguments of both sides have reasons for their position on DP, and the Govt. of India was indeed hard pushed to take the required decision on the subject of DP.

The PMB has very appropriately addressed the concerns of both side very well, and come out with a win-win formula.

First and foremost, the Govt.'s decision for DP must be seen in the context of the needs of Indian agriculture, rather than in the needs of industry. The Govt. has recognized that without DP, India will not be able to get newer/better products in India. The priority of agriculture over that of the pesticide industry is unquestioned and unquestionable!

I am personally convinced that DP is vital for Indian agriculture without which the quest for increasing agriculture productivity will hugely suffer. This viewpoint is based on the following:

1) It is obvious and true that MNCs have not introduced any molecules in India as long as India did not respect the patent regime (which came about in 1995) and granted 'Me Too' registrations. This has prevented the availability of newer and better solutions to the Indian farmers. We

continue to use not only outdated molecules but even outdated formulations.

Even the formulation technology has not changed for the old molecules for past 30 years because it costs money to develop and register; and nobody wants to do it because of the prevalent 'Me Too' regulatory regime, which permits the subsequent registrant to copy the formulation for free, and sell. Therefore, as an Industry and in national interest, I believe, we have a responsibility to offer the best and the latest to our farmers.

Just as we urban consumers want to buy the latest plasma / LED TVs, refrigerators, cars, motor cycle etc. for our quality of life, the farmers deserve the best of agri input products for enhancing their crop productivity and therefore their livelihood.

Hence as an Industry we must provide a conducive regulatory environment wherein newer crop solutions are made available to the farmers offering them a wide range of products. And history has shown that without DP, new molecules will not be introduced for Indian farmers.

2) It is argued that when patent protection is available, then why DP is needed.

This is indeed a very “industry interest” argument and not one of “agriculture interest”. The core issue is that farmers need new products (new solutions), and for them the issue is not patented or non-patented: and non patented need DP!

The fact is that there are a huge number of excellent products that are well suited to Indian agriculture, but their patents have expired: and MNCs will not introduce them because it costs huge sums for Indian registration and product stewardship. With DP these will also come into India.

- 3) Two decades ago, we decided to be part of the globalized economy and it is unwise, if not futile to try and swim against global practices. If we are signatories to the WTO regime and the TRIPS Agreement, it is morally essential that we abide by their tenets in letter and in spirit.
- 4) The point about cheaper availability of products is misconstrued. Taking the case referred above, and given the dosage of 100 ml per acre, such steep price reduction results in irresponsible use. A farmer who would have earlier spent Rs. 320/- per acre, can now apply the same molecule almost 5 times at the same cost of application per acre. Is that what we want and encourage?
And coming to sales reaching 20 Lac litres of this product, we must recognize that pesticides are not

hair oil or soap, but need to be used only in recommended crops at recommended time, at recommended dosages / applications.

We cannot flog pesticide products on every crop and everywhere.

It is not surprising that many of the molecules have developed resistance at a much faster pace in India, due to this proliferation and flogging, resulting in the farmer losing these products in his armour for his battle against pests.

We must prevent this at all cost: and this is what “regulation” really means.

- 5) Generic molecules have always offered, and always will offer, competition to DP or patent protected molecules. Hence “high” price argument does not work. It is unfair to say that our farmer is not sagacious enough to take the right call on his costs. No product can succeed if the price proposition does not offer its expected competitive value.
We do need to let the farmer decide on this.
- 6) DP is also very important for product stewardship. Every new product needs farmer training in use, evaluation of its use over a period of time, its competitive efficacy etc. over several reasons before it can gain acceptability: and this costs a lot of money, time and effort.

Many products, specially herbicides and fungicides, require to be used in closely monitored conditions, which in turn require massive expenditure on training and product development by the Company launching a new molecule. But all this get nullified if ‘Me Too’ registration are granted within a short time and compete on lower prices and unhealthy competition with no commitment to product stewardship. This

takes away the incentive and the affordability for products stewardship training and development to farmers.

- 7) If the concern is high prices due to lack of competition, then we should build an eco system where a huge number of products compete with each other rather, than hundreds of brands of the same product competing with each other: Multi product brand is completion in excellence, where as 100s of me too brands breed unhealthy competition and dubious business practices.
The Brazilian example explains this effectively.
- 8) Lastly the argument that Indian industry will not grow, is misplaced. The current 3-year regime is already in place and 22 molecules have been registered in India. Within three years, many will no more enjoy the DP, and the Indian industry can go ahead and copy them.
Also several new molecules are in the pipeline and which shall be available on the expiry of the DP period to Indian industry to copy and obtain ‘Me Too’ registrations. Even if this now goes to 5-years, this would only change the cycle time, but certainly does not mean the end of the Indian pesticides companies.

Data Protection needs to be seen in the context of Indian agriculture, and neglecting this would seriously jeopardize Indian agriculture which we cannot now afford to do, given India’s growing population with the need for food security on the one hand, and better quality food aspirations of the growing middle class on the other. The Indian pesticide industry has tremendous potential and should really focus on how we should all come together to enlarge the plant protection umbrella for our farmers, and contribute to the growth of Indian agricultural economy.

**Chairman & Managing Director,
PI Industries**



Indian Private Vegetable Seed Industry- Impact on Food and Nutritional Security

1. Introduction

India is home to a very strong and vibrant seed industry. Globally, India stands at the 3rd place in the size of seed market in terms of quantity, next to USA and China. The Indian seed market has shown a consistent growth from 1970s. The last two decades have been very dynamic, with major contribution from private seed industry. The current Indian seed market size is estimated to be approximately Rs.8000 Crores (1.8 Bil USD).

There have been two important phases of growth in Indian agriculture. The first one was ushered through the introduction of high yielding Rice and Wheat varieties in late 1960's; this green revolution has helped India to attain food security. However, this phenomenon was generally restricted to the irrigated regions of the Country. The second phase of growth, the last two decades; has been silently led by the Indian private seed industry. The growth in this phase has been more wide spread across India in raising the farmers' income and in turn the rural livelihood phenomenally. The major contribution made by the private seed industry in launching hybrids in rainfed crops like cotton (65% rainfed), Bajra (65% rainfed) and Maize (50% rainfed) has made this growth more equitable. This has been primarily driven by increased productivity achieved through introduction of high yielding hybrids from the private industry and improved varieties from public sector in all segments of crops like cereals (Rice, Wheat, Maize, Jowar, Bajra), oil seeds (Sunflower, Soybean etc.), fiber crops (Cotton and Jute) and vegetable crops (Tomato, Okra etc.). Thanks to the adaptation of recent advances in biotechnology and plant breeding, India has made important progress in productivity and production of many crops. Today, India is not

only food secure but also progressing towards nutritional security because of better genetics developed by Public and Private sector. We are now self sufficient in crops like rice and wheat and net exporter in crops like cotton and maize. Challenges still exist in producing oil Seeds and Pulses.

Advances in crop genetics and adaptation of advanced agronomic practices in vegetables have increased the Indian food production and have helped to keep pace with the growing population. The world population is expected to grow to 8 billion by the year 2025 making the food and nutritional security the most important social issue. Horticultural crops have been greatly expanded due to reasons of economical, social and nutritional security in the country. It is estimated that in this decade we will be having surplus vegetable production and will become a net exporter of vegetables also. The improvement in vegetable genetics has been a contribution of private seed industry. Vegetables and fruits contribute to health security that is of paramount importance for the general well being of the population while grain crops provide the much needed nutritional security

2. Indian Seed Industry : A historical perspective

From a public sector dominated industry during 1960's, the Indian seed sector has evolved into a multi faceted industry with large private sector participation and an increasing emphasis on R & D. The foundation of organized field crop seed production program in the country was laid with the establishment of National Seeds Corporation. However, over the past four decades there have been several changes and improvisations in the system, by the private seed industry in order to bring it in tune with requirements that are unique to Indian agriculture.



Uday Singh

3. Structure of Seed Industry:

Public Sector: Generally, seed industry in India owes its strength to the public sector program. Several improved OP varieties were developed from public Institutes and these replaced the local varieties popular with the growers. In general, the Government deals with regulations and seed certification ensuring availability of high quality seeds to growers.

The research in public sector is well spread out and organized. Work is carried out in over 25 agricultural universities, ICAR sponsored research Institutes and National Research Centres besides the All India Coordinated programs conducting trials in varied conditions. This network is one of the largest in the agricultural systems in the world.

Private Industry: Technological skills and expertise in breeding, production and quality control along with marketing skills have put private sector as efficient developers, producers and marketers of hybrid seeds. The ultimate success of this enterprise can be measured from the profits that accrue to the grower.

The private seed industry relying

on varieties/germplasm from public institutes and from international institutes, were quick to develop and deliver hybrids. It was soon clear that major vegetable crops imported from temperate countries cannot replicate similar yields in all agro climatic conditions demanding local and customized research. Imports are now made mostly in crops like cabbage, cauliflower, carrot, coriander and beetroot valued at 34 Mil USD.

4. Indian Vegetable Seed Industry and its structure

The lack of organized statistics in the vegetable sector has masked the contribution of the private seed industry. The hybrid vegetable seed market in India is estimated to be around Rs.1500 Crores (300 mill USD). Table -1 provides details of the major crops for hybrid seeds. It is reckoned that the Indian vegetable seed market is growing at a rate more than 10-15% a year. During the decade 1998-2008 there was a remarkable increase in market size of vegetable hybrid seeds (194%). It is anticipated that during the next five years also the growth will continue at a rapid pace (45.4%). Among the different crops vegetables are the fastest growing sector in the world (AVRDC 2006). No wonder that more and more arable land is being turned over to veg-

etable cultivation and the demand for quality seed is growing.

Seed industry in India is very heterogeneous in terms of ownership, scales of operation and functioning and integration of research, production and marketing units. The private seed companies are structured in any one of the following ways.

- Local companies trading in Op seeds; Indian companies selling F1 hybrids developed abroad.
- Indian owned companies with production and marketing capabilities but have tie up with foreign companies for R&D.
- Indian owned companies developing, producing and marketing of hybrid seeds. Some of them have enlarged their sphere of activity by opening offices in other countries.
- Foreign companies (MNCs, transnational) with JV or subsidiary in India having R&D, production and marketing capabilities. They bring in germplasm and technology from abroad.
- Foreign companies marketing hybrids developed by their parent organization abroad.
- Indian companies relying on contract seed production for export and also or domestic market.

Operations by foreign seed companies have increased exponentially

in India, directly or indirectly. Furthermore, need for new technologies like marker assisted selections, transgenics, phytopathological skills, induction of haploids, novel or new gene(s) for disease resistance, abiotic stresses or male sterility have intensified. Many of these global companies through their own research or through collaborative projects with foreign Universities of repute have access to these technologies. It is anticipated that many of these new technologies will be put into use in developing new hybrids by the seed companies.

5. Developing Vegetable Hybrids for India:

Developing hybrids for the Indian diversity is a challenge. Thanks to the major Indian vegetable seed companies who have been able to connect to this diverse requirement and evolved adaptable hybrids to the requirements. Below are the critical intersects:

- Multiplicity of varieties in different regions of India: A critical insight is needed before decisions are made on research allocations on segments to concentrate. This also makes it difficult to market new varieties unless it conforms to the existing OP variety. This includes chillies, eggplant, besides cabbage and different maturity groups in cauliflower. Some of the available segments in major crops wherein hybrids have been introduced and are growing in popularity. In most crops the segmentation based on regions as in chillies, cabbages and now in tomato.

Tomato: Dual/Regular, Acidic, Acidic-TLCV resistant, Oval – TLCV resistant, BW resistant, Indeterminate

Chillies: Fresh light green to dark green small, Fresh light green to dark green long, Red dry medium pungency small and long sized, Red dry high pungency, Red dry wrinkled, Bajji

Melon: Cantaloupe, Yellow Canary, Galia, Honey dew

Watermelon: Icebox, Sugar baby, Jubilee large oval, Jubilee large round, crimson sweet, Black Head

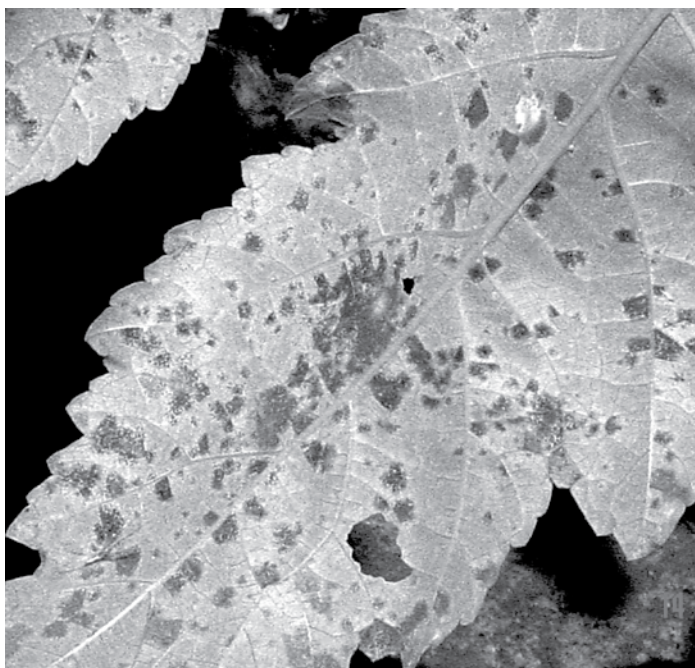
Brinjal: Manjarigota - purple stripes, Small purple round/oval, Very dark

CROP	Estm. Market Size F1, 2009 (Tonnes)	Estm Market Size F 1, 2009 (Crores)
Watermelon	110	50
Melon	18	23
Tomato	55	165
Ridgegourd	35	11
Chilli pepper	60	108
Cabbage	35	39
Cauliflower	40	60
Sponge gourd	25	5
Bottlegourd	100	18
Bittergourd	80	18
Cucumber	40	28
Okra	1,400	140
Brinjal	35	18
Capsicum	1	4
Total	2,028	685

purple small, Oval medium size, green purple stripes, Small round green, Small oval purple, Manjarigota - purple stripes with no spines, Long green

Cabbage: Large flat tolerant to rain & heat, Round light green early 1-2kg, Round to green tight, 1.5kg, Small (1kg or less), Round to conical, Semi flat, 1.5-2kg, Very small and very early; all with good adaptability & field holding

- Industrial needs: Segmentation can be complex in crops like chillies wherein, the industry has a dominant role to play in terms of required values for pungency and colour. Tomato for processing requires certain fruit biochemical traits like brix, viscosity and lycopene besides high yields and other fruit quality attributes.
- Crop diversification: The Indian gourds, cucumber and acidic tomatoes popular in South India were anchored in OP varieties till a couple of years ago. However, now there has been a rapid shift to hybrids in these segments.
- Transportability and shelf Life: In India the tomatoes, melons, travel distances more than 1000 km by road (Poor roads, poor packing and poor storage conditions) to reach the destination market. The



SERIOUS DISEASES ON IMPORTANT VEGETABLE CROPS

Crop	Serious Diseases	Remarks
Tomato	TLCV	Variations in strains & biotypes in vector; different R gene(s) required
	GBNV	Presently very serious. No source of resistance reported.
	Late blight	Races to be worked out and resistant gene(s) incorporated.
	Bacterial wilt	Stable highly resistant gene to be incorporated
	Alternaria blight	Stable resistant gene to be incorporated.
Chillies	Virus complex	Many viruses. Differences between regions.
	Anthraxnose	Variation in pathogen. Resistance source with simple genetics not yet available.
	GBNV	Getting to be serious. No resistance reported.
Watermelon	Bud necrosis	No resistant variety yet.
	Fusarium rot rot	No resistant variety yet.
Melon	Virus complex	No resistant variety yet.
	Gummy stem blight	No resistant variety yet.
Cucumber	Virus complex	No resistant variety yet.
Okra	YVMV	Stable high resistance not available
	ELCV	Stable high resistance not available

Indian private vegetable seed industry could breed for successful hybrids, which have high LSL.

- Pests and diseases of significance in tropics & sub tropics: Majority of them are specific to these regions and this is one of the major reasons for hybrids developed abroad not being successful. There are reports of outbreak of new pests and diseases

in most vegetable crops. Moreover, new races of the fungi and strains of the virus appear necessitating the need for local research. A list of serious diseases on important vegetable crops is provided in Table – 2.

In tomato the TLCV is a major constraint in production. This is a devastating disease in summers but is now prevalent in other seasons as well. Differences in strains exist and different sources of resistances are required for North & South of India. Moreover available resistance is succumbing to the disease. GBNV causes serious economic losses in tomato and no source of resistance has yet been reported. Resistance breeding for late blight and bacterial wilt is confronted by prevalence of differences in races. Chilli harbors a multitude of viruses and breeding for multiple virus resistant is an important task. Chilli can be a major export earner if fruit rot resistance can be combined with tolerance to sucking pests and chemical sprays avoided. In watermelon, varieties resistant to Fusarium or Bud necrosis virus have not been developed yet. Similarly, in melons we need resistance to virus complex. In okra it is mandatory now

to release hybrids with resistance to YVMV and ELCV (enation leaf curl virus). Hybrids with combined and yet high stable resistance will be the target.

The Private Indian seed Industry has invested significant funds in meeting these challenges and thereby creating a Win – Win situation for both growers and the entrepreneur.

6. Role of Private Vegetable Seed Industry in Hybrid Seed Production

The National Seed Replacement Ratio (SRR) in vegetables which was only 20% in 1980's is today considered to be above 70% and growing with each year. Further, with the rapid pace of introducing innovative biotech technologies playing a prominent role in new product development, it is estimated that a significant and rapid conversion from OP cultivation to hybrids will happen in all most all the crops in vegetables. This shift to hybrids will lead to increased requirement for hybrid seed production in various vegetable crops. These challenges of higher production requirement have been tackled by well organized and developed production system in the private seed industry. Private seed industry has geared up to the challenge and started exploring various ways, like approaching new areas in India and other regions

Table 3. Seed Replacement Rate of major vegetables

Crop	SRR (%)
Brinjal	63.4
Cabbage	100
Cauliflower	86.4
Chilli	83.7
Gourds	73.5
Melons	89.2
Okra	92.4
Tomato	99.3
Beans	62.2
Onion	87.3
Peas	93.5
Others	72.6

Source: Agriculture Today, January 2002)

Table 4. Area of Production of major vegetable crops in India 2007-08

CROP	AREA (IN 000' HA)
Tomato	572
Brinjal	566
Chilli	765
Okra	409
Onion	805
Cabbage	265
Cauliflower	321
Peas	314
Potato	1786
Sweet potato	126
Tapioca	270
Others	2370
Total	8568

Source: Indian Horticulture Database, 2008 (Publ.Feb,2009)

of the world, training man power for effective pollination, protected cultivation etc. In addition to this industry is also working on developing the hybrids based on CMS and gynocious technologies.

7. Indian vegetable production and seed requirement

India is next only to China in area and production of vegetables and occupies prime position in the production of cauliflower, second in onion and third in cabbage in the world. The area and production of major vegetables during 2007-08 is estimated at 8.57 million ha with a production of 127.1 million tonnes (including chilli) and average productivity of 16.1 tonnes per ha. More than 40 kinds of vegetables belonging to different groups, namely, solanaceous, cucurbitaceous, leguminous, cruciferous (cole crops), root crops and leafy vegetables are grown in India in tropical, sub-tropical and temperate regions. Important vegetable crops grown in the country are tomato, onion, brinjal, cabbage, cauliflower, okra and peas.

To meet the Nation's food and nutritional security needs, it is important to make available to Indian farmers a wide range of seeds of superior qual-

ity, in adequate quantity on a timely basis. The seed replacement rate of major vegetable crops (Table 3) in recent times is quite encouraging and there is a huge demand for quality seeds of vegetable crops within the country in addition to export opportunities. Area and production of major vegetables (Table -4) in the year 2008 makes the rapid growth evident.

8. Concurrent Developments:

- Seed quality of commercial seeds is of a high order and there has been a continuous up gradation of quality of seeds indicating the self imposed regulation by the companies on quality of seeds supplied. They are fungicide treated coated with coloured polymers. Most of the companies have quality control labs of high standards. ISTA accredited labs are also now in place in India and helps in providing necessary documentation for exports.
- In India most of the private companies sell seeds which have more than 90% germination and high degree of purity and this exceed the standards set out under the seed act. Besides the conventional GOT, many of the companies routinely use sophisticated molecular tools markers to assess seed purity.
- Commercial seed production for export and domestic markets is carried out through contract production. Contract farming concept has been very successfully employed for benefit for both the parties in seed production. Seed production employs more than 7lakh people directly and indirectly.
- Plant variety protection and farmer's act of 2001 and New Seed Policy of 2002 have been passed. According to the latter act, all varieties will have to be registered. Although there may be delays, it is expected that will benefit seed industry.

9. Biotechnology in Vegetable Crops and its impact

Considerable work on biotechnology related to vegetable crops is in progress in India. Research areas under this field include development of DNA markers and transgenics. The frontier area of biotechnology has opened up another avenue for enhancing productivity of crops through developing transgenics with tolerance / resistance to abiotic and biotic stresses. Work on transgenics is underway in both public sector and in the private sector. ICAR, DBT and Agricultural Universities have fully fledged projects on transgenics. Cotton hybrids with Bt gene(s) to counter bollworm attack have been successful in India

and this technology is now being pursued in other vegetable crops for protection against fruit borers. Bt Egg plant from MAHYCO as well as IARI is in final stages of testing. Research on okra and tomato with Bt gene is being vigorously pursued and are already slated for field trials.

Many of the large seed companies intensively pursue their in-house biotech research projects. They work with gene constructs from abroad, from another company or from a public institute. The Government of India has been encouraging research on transgenics with funding and training programs. The Government is also proactive with policies and guidelines on release of transgenic crops. DBT has put in place a regulatory process with clear guidelines to follow while releasing transgenics. In cases where resistant gene(s) has not yet been sourced as in GBNV of tomato and bud necrosis of watermelon, transgenics could be an alternative approach. In vegetable crops abiotic stresses still pose a problem in terms of extending areas or seasons. Drought tolerance and salinity tolerance are important areas of research wherein traditional breeding efforts have not yet helped develop lines/hy-

brids. Work in M.S.Swaminathan Research Foundation has provided vital clues on useful genes for drought and salinity tolerance. Partnership with such research institutes will provide a strong platform for developing hybrids that can extend vegetable cultivation in water deficit and salinity prone areas.

10. Protected Cultivation

There has been significant increase the area under protected cultivation in the recent past and it is forecasted to grow rapidly because of the encouragement provided by the Government through subsidies for erec-



tion of plastic houses. On the other hand growers are benefited by realizing a better price and productivity especially during the adverse weather conditions. The growth is also going to be driven by the demand from the consumers for better quality produce. Protected cultivation is expected to keep the price in check by ensuring availability during offseason also. Presently the seeds for protected cultivation are being provided by multinationals. Although in the future Indian private vegetable seed industry could gear up of this challenge of high precision.

11. Conclusion & Challenges

The contribution of the Indian seed industry to provide India the food and

nutritional security can be judged by significant increase in the rate of adoption of hybrids developed by the private sector. The Indian farmer considers seed as the most critical input among all the agricultural inputs and his decision making is purely based on the performance in his own field. The seed used has a direct impact on the net returns of the farmer.

Now, High yielding hybrids, which are adaptable to various agro climatic zones and seasons, are in place. These hybrids are bred to produce uniform quality of fruits with better transport ability, disease resistance and taste for the consumers.

The Government is also funding several projects for rural area development including increasing food supply and all these will generate higher and better seed usage. Shift from OPVs, increasing share of hybrid market, new areas coming under vegetable cultivation, growers irrespective of size of operations taking to hybrids and above all the inherent advantages of F1s in terms of yield, adaptability and fruit

quality besides value addition like disease resistance are some of the major reasons for the growth of this industry. Growers are ready to invest in new hybrids and technology. Social gains from private hybrids can also be gauged from the benefits that accrued to small farmers using hybrid seeds. Adoption of improved hybrid technology is also contributing to the success.

The private vegetable seed industry in India has set the ball rolling to arrive into an era of matching the world standard of productivity, nutritional security, year round availability.

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Indian Seed Industry to Look Outwards

Indian seed industry has grown well in past 20 years starting from Rs. 800 crores in 1990 it achieved an impressive Rs. 7,000 crores in 2008. The main driving force has been economic liberalization and New Seed Policy of 1988 of the Government of India which simplified regulations and encouraged more investments. However, we still got to go a long way to catch up with other global leaders in seed business as suggested by the following statistics (Source: ISF 2008):

Country	Seed business (US\$ million)
U.S.A.	12,000
China	6,000
France	2,370
Brazil	2,000
India	1,500
Japan	1,250

India ranks fifth but we are still way behind to reach third rank which should be our minimum target. India will become one of the three largest seed markets of the world in next 10 years.

Technology travels on seeds:

Seeds are the carriers of new technologies and this value addition helps in improving production and socio-economic conditions of the farmers. Therefore, we need to embrace new technologies. This could be explained further by quoting the case of Bt cotton hybrids in India. As evidenced by the following figure (Fig.1) production and productivity of cotton witnessed a very significant increase in our country in the recent years

There are controversies regarding some new but expensive technologies and their restricted benefit to progressive and large farmers only. This is perhaps not the case with Bt cotton as small and marginal farmers are adopting and harvesting advantage of this technology (Fig.2)

Seed Exports:

Whereas, other countries are exporting seeds to consolidate their global trade, we, in India, are not doing so presently. Indian seed market is Quite big and it will grow many folds in the times to come but besides



Dr. Jagveer Sindhu

catering the growing seed requirements in the domestic market, we also need to take our due share in the global seed markets. The following data shows India's seed exports and imports ports in 2008 (Source: ISF 2008)

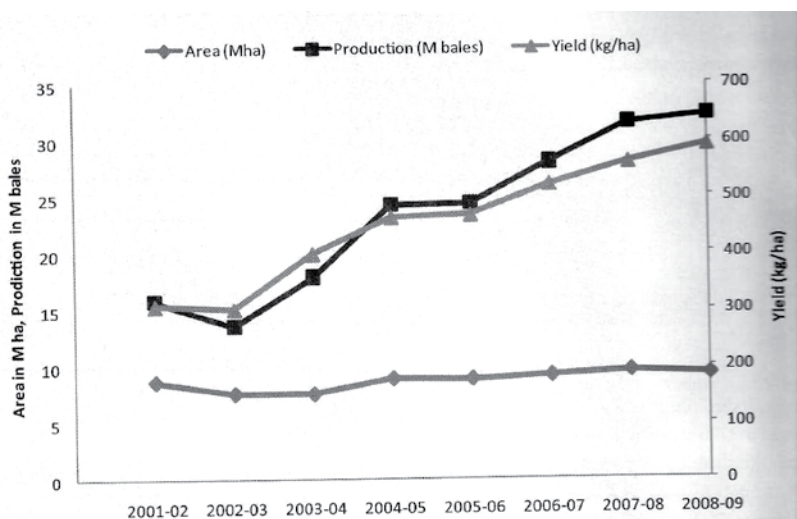
Seed Exports-Field crops: US\$ 16 million

Vegetable crops: US\$ 9 million
Total: US\$ 25 million

Seed Imports- Field crops: US\$ 13 million

Vegetable crops: US\$ 19 million
Total: US\$ 32 million

Fig.1: Cotton hectareage, production and yield in India (2001 to 2008)

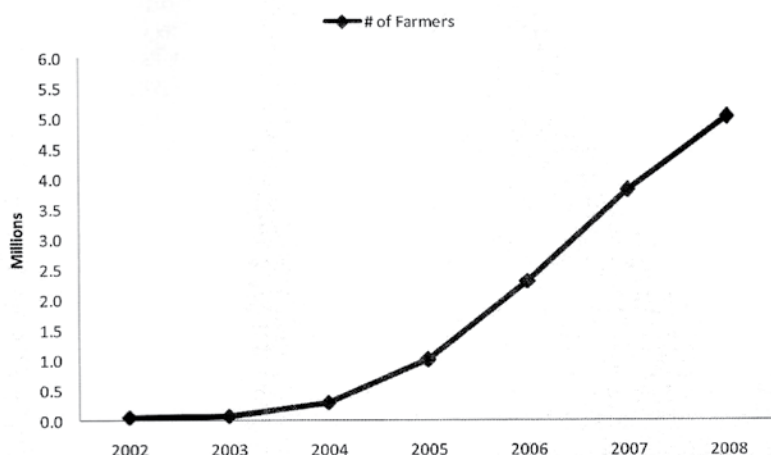


(Source: Ministry of Textiles, Govt. of India 2008)

Thus Indian seed imports overweigh exports. One of the important reasons for big seed business in USA is their seed exports. That country exports seeds worth US\$ 1,176 million annually. In order to grow further Indian seed industry should also plan seed exports.

The entire third world looks towards India to assume leadership role in global seed trade. This is more true for African continent where Indian seeds can adapt very well. Besides south Asia where India needs to become the key source supplier of quality seeds, several south-east countries in Asia also offer good opportunities for Indian seeds. A few In-

Fig. 2: Number of small farmers adopting Bt cotton hybrids in India (2002 to 2008)



(Source: ISAAA 2008)

dian seed men have been exploring market opportunities in both Asia and Africa but this is not enough.

Africa offers big opportunities for Indian seeds:

Indian seeds would perform well in several countries of Africa and recent initiatives to improve agriculture in Africa by the World Bank,

FAO, and some philanthropic organizations like The Rockefeller Foundation, Ford Foundation, Bill Gates Foundation, etc. are beginning to show that African farmer understands the value of good seed. Harmonization of seed laws in many countries of West coast and East African block are positive steps and, therefore, encourage investments in seed business in those regions. Purchasing power of the farming community is reported to be increasing and important input like seed will be his priority. Some multinational seed companies of Europe and USA have already started business. Chinese are testing hybrid rice while Australians are selling sunflower seed to African farmers. Surprisingly, Indians are not moving forward though our seeds will do much better than others in Africa. Sorghum and Pearl millet are major food crops in many countries and Indian seeds will do wonders under some farming conditions.

Focused approach for seed business development in Africa:

Africa is a very big continent and there

exists great variability in soil types, climate, socio-economic conditions of farmers, food requirements, etc. Therefore, one needs to prioritize the countries and the seeds for exploring business opportunities. One should also be aware of the existing seed laws, trade rules, phytosanitary requirements, etc. For Indian seeds, the flowing countries may be prioritized due to various reasons:

East Africa: Kenya, Tanzania and Uganda

North Africa: Egypt and Sudan

South Africa: Zambia and Zimbabwe

West Africa: Nigeria, Ghana, Senegal, Mali and Burkina Faso.

Open pollinated varieties seeds are presently used by a majority of farmers but adoption of hybrid seeds is increasing. All crop seeds could be exported but the following seeds may be trialed and marketed in the initial stages:

Field crops: Sorghum, Millet, Corn, sunflower, rice and cotton

Vegetable crops: Tomato, hot pepper, okra, eggplant, watermelon.

Seed system in Africa: Bill & Marinda Gates Foundation and the USAID have already initiated the process for a planned seed growth in Africa. South Africa and Egypt have already very well defined seed rules and a good system is in place. East African block countries, Viz, Kenya, Tanzania and Uganda are in the process of harmonizing the seed regulations

and this will be accomplished soon. Process for harmonization of seed regulations, has already been completed in west

Africa. West African Seed Alliance (WASA) is supported by PASS (Programme for African Seed System) which aims to develop a commercial seed industry in Africa. Testing of seeds in trials for two seasons for field crop is mandatory for registration while vegetable seeds could be marketed after one season testing only. Four main objectives of

WASA are as follows:

1. Arranging trial conduction in the west African system.
2. Registration of varieties in ECOWAS (Economic co-operation of West African States).
3. Establishment of distributors and dealers network and establishing seed processing facilities.
4. Training people for commercial seed system development.

African Seed Trade Association (AFSTA) is making good efforts to organize seed industry in the continent but lot more is required to be done in future.

India to help in seed development in the region:

With a large task force of agricultural scientists and a developed seed industry, India should take this opportunity to establish good seed export business and invest in developing seed business in Africa. India based ICRISAT (*International Center of Research for Semi Arid Tropics*) did good work on sorghum, pearl millet and pigeon pea in different parts of Africa and identified some promising genotypes. Likewise Taiwan based World Vegetable Center-AVRDC (*Asia Vegetable Research Development Center*) is engaged in identifying good vegetable seeds for African farmer. Indian seed entrepreneurs have got good access to these seeds and can plan a good portfolio for African markets. It's the time for Africa and it's the time to plan and act fast.

Former Director, Asia and Pacific Seed Association

FERTILIZER SCENE

India is an agrarian economy with 60% of the population directly or indirectly depending on agriculture. Contribution of Agriculture to the National GDP was 44.92% in 1967. Subsequently, it has been declining and its contribution in 2008 was a low 17.47%. This is mainly because of increasing contribution of services, on the one hand, and relatively lower price of agricultural products as compared to manufactured goods, on the other.

India is the 3rd largest producer and consumer of fertilizers, next to China and America. India's fertilizer

last five years was as under:

Continuous are being made by the industry to increase domestic production of fertilizers and improve availability of major fertilizers in the country to meet the growing demand. The production of Urea, DAP and complex fertilizers for the last five years is given below:

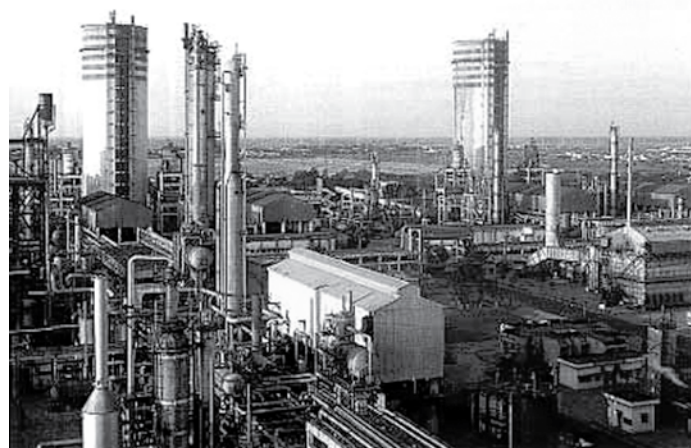
India consumes about 25 Million tons of nutrients N, P and K annually. Of the total, nitrogen contributes about 15 Million tons, Phosphorous about 6.5 Million tons and Potash contributes about 3.3 Million tons. Though India has the production capacity of

13.05 Million tons of nitrogen and 6.2 Million Tons of P₂O₅, capacity utilization is at 84% and 55% respectively. This lower production capacity utilization is mainly due to Government Policy and feedstock

cause of concern. To bridge the gap between demand and production, import of fertilizers is showing an increasing trend. The import of different fertilizers for the last five years has been as below:

Though the fertilizer consumption in India is growing steadily at 7-8% year on year, fertilizer use efficiency is going down. Response to NPK (Kg of food grain/Kg of NPK) has gone down from 12 in 1969 to 3.5 in 2008. This is mainly due to imbalance in the use of various nutrients, particularly secondary and micro nutrients limiting productivity.

In order to increase the fertilizer use efficiency and check the subsidy out go, GOI has introduced Nutrient Based Subsidy (NBS) for decontrolled P&K fertilizers. In essence,



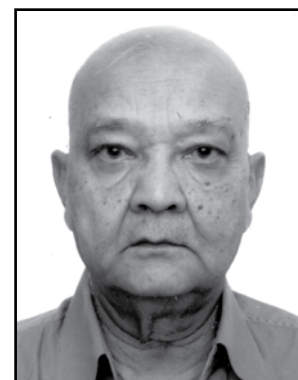
consumption (over all and per hectare consumption) is growing and it is likely to increase further. Nevertheless, per hectare consumption in India is not high compared to other agriculturally developed countries in the world. Consumption of Urea, DAP, NPK and MOP stood at 52.66 million tons during the year 2009-10. Sales of various fertilizers during the

constraints.

Increase in the consumption of fertilizers compared to production is a

Year	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
UREA	202.63	200.98	203.08	198.58	199.22	211.12
DAP	51.84	46.28	48.51	42.12	29.93	42.46
COMPLEX	53.64	67.64	74.64	58.50	68.48	80.93

Year	Yearly Sales (In lakh MTs)						
	Urea	P&K Fertilizers					Grand Total
		DAP	MOP	Complexes	SSP	Total P&K	
2005-06	221.91	67.51	28.01	67.00	24.00	183.00	403.00
2006-07	244.85	69.24	23.93	74.64	28.06	195.87	440.72
2007-08	261.67	75.55	27.92	58.50	19.97	181.94	443.61
2008-09	266.47	99.04	40.89	71.22	23.00	234.15	500.62
2009-10	264.48	103.92	46.74	82.03	29.44	262.13	526.61



Dr. Pratap Narayan

(in Lakh MTs)

	Urea	DAP	MOP
2005-06	20.57	28.27	45.28
2006-07	47.18	28.75	34.48
2007-08	69.28	29.90	44.20
2008-09	56.66	66.31	43.46
2009-10	52.09	57.60	49.08

the subsidy is now based on nutrient content instead of product based. This implies that the maximum retail prices will be determined by the companies after taking into account the subsidy receivable from the Government. The present approach marks a departure from old regime where Government determined retail price, cost of production as well as subsidy. However, Urea continues to be under price control with high subsidy. Consequently, the recently introduced NBS policy seems to have failed to change the consumption pattern with most farmers still preferring to use Urea, the cheapest fertilizer. Consumption of Urea has increased in the first few months of NBS Policy, contrary to the expectations that it would lead to balanced use of fertilizers.

Pricing policy

The Fertilizer Industry has been under Government control and the subsidy/concession scheme was introduced from November 1977. Fertilizer subsidy regime has led to increase in production and consumption of fertilizers during the last three

decades and consequent increase in food grain production within the country. Successive Pricing Policies have centered around keeping the fertilizer retail prices to farmers artificially low and adopting a cost control approach to contain the increasing subsidy rather than focusing on strategies for higher food grain production to meet the increasing domestic demand. It has been observed in the last few years that the agricultural productivity to additional fertilizer usage in the country has fallen sharply, leading to near stagnation in agricultural production.

The fertilizer industry suffers from low profitability as compared to other sectors and works in a highly regulated environment with cost of production and selling prices being determined by the Government. The industry has thus stagnated with virtually no new investment for over a decade due to highly regulated environment in this sector. Since 70 to 80% of the revenues of fertilizer companies depend on Government Budget, the focus of the industry is towards the Government rather than the farmer.

Effects of Regulation

The subsidy schemes such as Retention Pricing Scheme, Group Concession Scheme and New Pricing Scheme may have served the country well by increasing the consumption of fertilizers. However, such Schemes have impacted agricultural productivity and consequently resulted in low nutrient uptake efficiency and increasing multi-nutrient deficiencies leading to declining soil health. There has been no focus on soil test based crop-specific application of fertilizers to minimize wastage of nutrients.

Following are the effect of Regulation of the Fertiliser Sector:

- Although fertilizer consumption has increased, regulation has led to over-usage of Urea, due to low prices, excessive fertilization with imbalance in nutrient usage, deterioration in soil quality, lower agricultural productivity and environmental concerns. As a result, the desired improvement in farm income has not taken place.
- Indigenous production of fertilizers has stagnated due to Government control over MRP and payment of subsidy under the Pricing formula, which is inadequate to cover operating and financing costs.
- The current fertilizer policy is primarily cost focused and it fails to promote integrated nutrient management. Fortification with micro nutrients is not adequately compensated in the policy.
- The policy does not support organic matter and acts as an obstacle in the introduction of customized products based on local soil and crop requirement. The barrier is the fixation of farm gate price.
- Due to inadequate budget provisions, the payment of subsidy to fertilizer manufacturers is perpetually delayed increasing the cost of operations, which is not compensated.
- The pricing policy is not conducive enough to attract private investors, as other competing sectors provide better returns. Hence no fresh investments for new capacity additions have taken place. The fertilizer companies have perpetually remained sluggish on Capital Markets with no interests from public investors or FDI.

To attract fresh investment in the Urea sector, the Government of India should announce a long term policy conducive to new investments.

Ex Director General, FAI



An Overview of Edible Oil Industry in India and Future Strategies

Dr. D.M.Hegde and Dr. R.Venkattakumar

Oilseeds are the second largest agricultural commodity in India after cereals occupying 13-14% of gross cropped area. They are cultivated in an area of 27.56 million ha, with a production of 27.72 million tonnes and productivity of 1005 kg/ha (2008-09). They account for 1.4% of gross domestic product (GDP) and 8% of value of all agricultural products (2007-08). About 14 million farmers are involved in oilseeds production and a million in processing. While contributing 12-13% of the dietary energy to the population in the country, vegetable oils also contribute 1.5 to 1.7% of national exports and about 15-17% of the agricultural exports of the country (2006-07). The diverse agro-ecological regions in the country are favourable for growing all the nine annual oilseeds which include seven edible oilseeds viz, groundnut, rapeseed-mustard, soybean, sunflower, sesame, niger and safflower and two non-edible oilseeds viz, linseed and castor. Among different oilseeds, groundnut, rapeseed-mustard and soybean account for about 80% of the oilseeds area and 88% of oilseeds production in the country. Apart from this, a wide range of other minor oilseeds of horticultural and forest origin including coconut and oil palm in particular are also contributing to the vegetable oil requirement of the country. In addition, substantial quantity of oil is obtained from rice bran and cotton seed.

The per capita consumption of vegetable oil is rising continuously and is 14.1 kg/year in 2009-10 and this demand in the country has created a big gap between domestic production and consumption filled by liberal imports. As per the recent projections by DAC-Rabo Bank, the per capita consumption of vegetable oils is likely to rise to 12.60, 14.57 and 16.38 kg/year by 2010, 2015 and 2020 respec-

tively. The per capita oil consumption during 2009-10 itself has surpassed the projection for 2010. This amounts to vegetable oil requirements of 14.8, 18.3 and 21.8 million tonnes respectively by 2010, 2015 and 2020. Assuming an average oil recovery of about 30% from major oilseeds and proportion of different oilseeds constant in the coming years, the country needs to produce atleast 44.8, 55.5 and 66.0 million tonnes of oilseeds by 2010, 2015 and 2020 respectively. Considering the oilseeds output in 2008-09 as 27.72 million tonnes, the country needs to more than double the oilseeds production in the next 10 years requiring an annual growth rate of nearly 6% which will be a tall order, requiring efforts much beyond what is being ostensibly pursued until now (Hegde, 2009).

Indian edible oil industry-present scenario

Indian processing industry suffers from several maladies like outdated technology, lower rates of utilization of installed capacity, low oil recoveries and high unit costs. Reservation of oilseeds output for small scale processing is depriving the farmers and consumers of the benefits of lower costs of modern processing technology, while putting up the costs for consumers. The cost of vegetable oil processing in India is very high as compared to the countries like China and USA mainly due to smaller capacities, low technical efficiency and low capacity utilization. Additional inefficiency arises from non-integration of solvent extraction units with expeller units and hence, significant amounts of expeller cake are not solvent extracted resulting in considerable losses of oil and meal products. The lack of adequate integration between expelling and solvent extraction units alone is costing the country



Dr. D. M. Hegde

Rs.2500 crores annually (Prasad, 2007). Fragmentation, low technical efficiency and excess capacity of India's oilseed processing industry are largely the result of regulatory and trade policies followed by the government (Hegde, 2007).

The technical inefficiencies in oilseed production, on an average have been found to be 1/4 to 1/3 and even higher at farm level/ processing unit level along with allocative and scale inefficiencies. The combined technical inefficiencies in the oilseeds sector (production and processing) have been found to be 1/2 to 1/3. If prevented/ minimized, the oilseed production of the country could be double than the existing (Mruthyunjaya, 2007). Under utilization of resources reflects a poor-resource base of the farmers and have implications for optimum utilization of inputs and production of outputs, both on-farm and in processing unit to reduce allocative and scale inefficiencies. Lack of assured market for oilseeds and lack of timely and assured supply of quality seeds and raw material for processing have been found as important factors contributing to the poor performance of the oilseed industry. The standards set by the oil importing countries after liberalization were very high, at times giving impression that they were used as trade barriers.



ers. Exporting countries especially the developing and under developed countries were caught in the web of stringent quality parameters. Against such a background, it has become not an easy task for India to maintain its participation in oilseeds international trade. It is apparent that quite a good deal of domestic exercise has to be resorted to by India in the matter of quality upgradation. India needs to attain global competitiveness, that is to say ability to produce globally acceptable quality and at globally comparable cost (Subramanian, 2007). There are uncommon opportunities to add value to different oilseeds and oils, which must be fully exploited, which will eventually enhance the competitiveness and sustainability of these crops (Hegde, 2007). Complete value addition to castor oil before exports alone can fetch additional earning of Rs.30000 cores from the present level of Rs. 2253 cores during 2008-09. There is a lot of scope for the industry to exploit the by-products obtained during vegetable oil processing for value addition. This will ensure effective quality control in vegetable oils that are vulnerable to adulteration by unscrupulous elements affecting the health of population. The farmers' share in the retail price of vegetable oils will increase installing a sense of confidence in the oilseed growers, which alone can help the uptake of modern

crop production technology and consequently higher oilseeds production (Hegde, 2007). India is concerned about the low raw material production and high processing capacity. Efficient oilseeds processing industry is a basic prerequisite for maximizing economic returns to the oilseeds farmers and indeed to the society. Efficiency in oilseeds and oil processing industry benefits all stakeholders like farmers, processors and consumers. Research and development strategies for improving the efficiency of oilseeds processing industry are very important to enhance the productivity and quality of the oil (Prasad, 2009).

Supplementary oil sources

The country is presently utilizing just half the production potential of supplementary oil sources. India is the least expensive cottonseed producing country along with Argentina in the world. Net cost of production of cotton lint is lowest in India due to high value of cottonseed that finds many uses in the country. India produced 10.05 lakh tonnes of cottonseed oil (2008-09), which is 11% of the total seeds produced, but report says that around 7 lakh tonnes of cottonseed oil is being lost every year due to wrong feeding of undecorticated cottonseed oil cake containing oil (traditional processing). If this lacuna is rectified through scientific processing, around 17.20 lakh

tonnes of cottonseed oil annually can be produced at a cheaper rate in the country. The country has the vast potential of growing oil palm. The farmers have now realized that oil palm is a potential paying crop compared to the competing crops. India produced 74000 tonnes of palm oil during 2008-09 from an area of 1.30 lakh ha. However, the country has a potential to bring an area of 10.76 lakh ha under oil palm in 14 states. To increase the production of palm oil and reduce its import, there is need for strong political will and commitment in the development of the crop as it is being done in Malaysia and Indonesia. Promotion of the cost-effective technologies to produce cheaper oil palm will improve the palm oil production status of the country.

The country has an estimated potential of 6 lakh tonnes of oil from tree borne oilseeds (TBOs). However, only 1 to 1.5 lakh tonnes of oil is being extracted from TBOs presently. Neem (*Azadirachta indica*), simarouba (*Simarouba glauca*), mahua (*Madhuca indica*), karanja (*Pongamia pinnata*), ratanjyot (*Jatropha curcas*), jojoba (*Simmondsia chinensis*), kokum (*Garcinia indica*) etc are some of the important TBOs of the country. Of late, corn oil has demand from the market, particularly for human consumption because of its higher nutritional content than the other vegetable oils that are being used by majority of the population of the country. Presently, 2 million tonnes of maize is used by wet milling industries, with an oil recovery of 3.5% (70000 tonnes). With extensive and systematic breeding programmes, the lines which have 6% oil content have been developed and are being utilized in the development of lines with further higher oil content. This means, the success in this venture would result in more and more corn oil availability in the market for human consumption in the near future. Rice bran oil is also supplementary oil, which attracts the edible oil industry. Rice on polishing yields 8.5 % bran, which contains 15 to 20% oil. India is the largest producer of rice bran (9 million tonnes),

which can yield about 14 lakh tonnes of rice bran oil. But the country produces only around 8.5 lakh tonnes of rice bran oil (during 2008-09) that indicates the scope for increasing the production of rice bran oil in the country. India's production of coconut oil is around 4.65 lakh tonnes and its share in the country's edible oil consumption is 3.5%. The decline in coconut production in the country resulted in decline in the production of coconut oil and in turn the higher prices of the coconut oil. The higher prices of coconut oil coupled with import of substitute oils at a cheaper rate resulted in decreasing consumption trend of coconut oil. However, it becomes very essential to encash the premium physical and chemical



properties of coconut oil through formulating appropriate strategies for repositioning of coconut oil, given its versatility to save the oil industry from its possible collapse.

Impact of global recession on Indian edible oilseed industry

Worldwide recession or slowdown or mini-depression came to India a bit late. In fact, during the initial months of the third quarter in 2008, India prob-

ably benefited from the worldwide slowdown because energy prices fell (India, being a massive importer, is very much affected by high energy prices), interest rates were reduced and credit was liberalized. However, from November 2008, particularly since 26/11, Indian economy has been suffering and growth rates have fallen dramatically. A slowing economy will definitely affect vegetable oil consumption. India's per capita consumption will increase primarily as a result of low prices due to duty-free imports and lower all round import duties. India also will be one of the very few countries whose vegetable oil imports will actually increase year after year (Mistry, 2009). The current global economic slow down is a source of worry for the exporters of castor oil and other derivatives in India, the world's largest producer. Although, the expected bumper production and higher productivity of castor seed are welcome news, traders are apprehensive about the response of slump-hit global markets. During 2008, an estimated 335000 tonnes of castor oil and derivatives were exported (Satyanarayanan, 2009). The Indian soybean farmer is receiving less for his beans than his US and Brazilian counterparts. In the past years, Indian domestic price of oilseeds and oil were at a big premium to world prices.

Hence, there was need to impose import duties. But the situation has been changed due to recession. The Indian soybean farmer is competing with most-efficient oilseed farmers in the world. And yet, the current market prices in India are about US \$ 8 per bushel. At the present scenario, Indian agriculture does not need depressingly low prices. Indian agriculture will flourish if prices rise from

their depressed levels and take millions of farmers out of generational poverty (Mistry, 2009).

Apart from these issues, due to the changing country's customs duty and customers' preferences also, the edible oil scenario is changing. Demand-supply equation is also coming into play and it is one of the reasons why sesame oil is the costliest. The sunflower oil was the second costliest during last year is now cheaper than mustard and soybean. This is because of the scrapping of customs duty of sunflower oil imports to compensate soaring inflation and rising cooking oil prices. As a result, despite being seen as premium oil, it rules at three-year low. The decline in production of sesamum during last five years made sesame oil as the costliest one. In groundnut also, the same scenario is prevailing. Mustard oil was one of the cheaper options but the consumers' preferences have changed the situation. People are becoming aware of the health benefits of mustard oil and hence the change in preferences of consumers towards mustard oil and it made headway in the north and eastern parts of the country. Palmolein continues to be the cheapest. Consumers continue to buy palmolein because the price is ruling below Rs50/kg. Barring soybean and mustard oil, other cooking oils are currently ruling at two years low, thanks to the zero customs duty (Business Line 2009).

Impact of global climate change on oilseed crops in India

Studies conducted on soybean using CROPGRO-soybean model have projected 50% increased yield for a doubling of CO₂ in central India (Lal et al., 1999). However, a 3oC rise in surface air temperature almost offsets the positive effects of doubling of carbon dioxide concentration. Increased temperature reduced the total duration of the crop (and hence productivity) by inducing early flowering and shortening the grain filling period. Soybean in central India was found to be more vulnerable to increase in maximum temperature than minimum temperature. A decline in daily

rainfall amount by 10% restricts the grain yield to about 32%. The study concluded that acute water stress due to prolonged dry spells during monsoon season could be a critical factor for soybean productivity even under the positive effects of elevated CO₂ in the future. If maximum and minimum temperature rises by 3°C and 3.5°C respectively, the soybean yields in Madhya Pradesh will decline by 5% compared to 1998 (Mahapatra, 2009). In groundnut cv. TMV-2, biomass production was 29% higher in elevated CO₂ (660 ppm) than in ambient CO₂ (Rao, 1999). Response of two oilseed crops viz, sunflower (*Helianthus annuus* L.) and groundnut (*Arachis hypogaea* L.) under two conditions viz, elevated CO₂ (600 ppm) and ambient CO₂ (365 ppm) in open top chambers (OTCs) indicated that total dry weight and its components viz, stem dry weight, root dry weight and leaf dry weight along with leaf area showed a significant increase under enhanced CO₂ conditions (Vanaja et al., 2006). Studies on mustard indicated that the elevated CO₂ increased the net photosynthetic rates, foliage, root growth and number of siliqua. The mustard plants would be able to survive in stress conditions better than CO₂ enriched environments (Upreti et al., 1995). Elevated CO₂ ameliorated the reduction in carbohydrate and oil content observed in seeds under moisture stress (Upreti et al., 1997). There was a significant increase in seed oil content in mustard and reduction in saturated fatty acid pool under elevated CO₂ of 550 μ mol/mol. High temperature during reproductive stage markedly inhibited the import of photosynthates by both upper and lower pods and pods of terminal raceme and thereby reduction of sink strength (Subrahmanyam and Rathore, 1994). The future climate change scenario analysis showed that mustard yields are likely to reduce in both irrigated and rainfed conditions. However, these reduc-

tions have spatial variation in different mustard growing regions of India (Bhoomiraj, 2008). Mustard yield shall decline by 2.01q/ha per degree rise in seasonal temperature in Haryana (Mahapatra, 2009). The studies on influence of elevated CO₂ on castor bean, a non-edible oilseed crop grown in low rainfall regions of semi-arid tropics and subtropics, indicated significant response under elevated CO₂ levels (550 and 700ppm) in terms of growth, biomass and seed yield when compared with ambient chamber control. Elevated levels of CO₂ resulted in an increase in the dry matter production as well as economic yield of castor. Analysis on impact of climate change on coconut using coconut simulation model indicated



that under all scenarios of HadCM3 projections, coconut productivity on all India basis is likely go up by 4% during 2020, by 10% in 2050 and by 20% in 2080 over current yields due to climate change (Kumar et al., 2008). Yields are projected to go up in Kerala, Maharashtra and parts of Tamil Nadu and Karnataka while they are projected to decline in Andhra Pradesh, Orissa, Gujarat and parts of Tamil Nadu and Karnataka. However, situations may vary if future irrigation sources are limited particularly in currently irrigated areas such as in Tamil Nadu and Karnataka (Kumar, 2008).

Strategies to overcome the challenges before Indian edible oil industry

Favourable policy framework for the oilseed sector is the basic prerequisite for oilseed production. The policy must aim at increasing the efficiency and competitiveness of oilseed sector, which alone can lead to sustainable development in the market economy (Hegde, 2005). Oilseeds processing should be open for modern and efficient processors, just like paddy and wheat processing. Large-scale processing operations, typically 1200 tonnes a day should be promoted. RBI credit guidelines should be reviewed to support healthy trade. The reservation of oilseed crushing and processing for small-scale industry should be removed (Shenoi, 2007). In order to improve the trade competitiveness of oilseeds, India needs to pay attention for improving efficiency in cost of production, marketing and transport and processing of oilseeds. India needs to promote aggressively the export of niche oilseeds like castor oil, sesamum seeds, groundnut and other oilseeds with specific attributes of consumer interest (Chand, 2007). Both the government and industry should focus on increasing the productivity of oilseeds to overcome the over dependency on imported oils by maintaining the price of vegetable oil through the appropriate duty structure, which would translate into remunerative price for oilseeds to the farmers; paying more attention to improve the productivity rather oilseed area; paying attention to develop value-added products from the oilseeds; larger allocation of funds for raising the farm productivity through development and multiplication of high yielding varieties and weighted income tax deduction for oilseeds extension programmes to the private sector as granted to research organizations for research activity (Mehta, 2007). India's oilseeds industry has the potential to increase its efficiency in several directions like efficient processing with the use of innovative technologies as well as better trade promotion. Further liberalization of the sector with proactive measures

by the Government in partnership with all stakeholders can enhance its efficiency and lead to higher contribution to India's economic development (Prasad, 2009). A conceptual model showing the SWOT of Indian oilseed industry and the implicative strategies have been given in Fig.1.

Coping strategies with respect to climate change

We need to understand the possible coping strategies by different sections and different categories of producers to global climatic change. In future, such adaptation strategies would need to simultaneously consider the background of changing demand due to globalization and population increase and income growth, as well as the socio-economic and environmental consequences of possible adaptation options (Aggarwal et al., 2004, Easterling et al., 2007). Developing adaptation strategies exclusively for minimizing the negative impact of climatic changes may be risky in view of large uncertainties associated with its spatial and temporal magnitude. Some of the possible adaptation options according to Aggarwal et al., (2009), include the following:

- Augmenting production by improved crop management, improved adverse climate tolerant varieties, improved seed sector, technology dissemination mechanisms, capital and information, which are the key reasons for the yield gaps.
- Changes in land-use and management include cultivating alternate crops or cultivars more adapted to changed environment; watershed management programme can yield multiple benefits. Such strategies could be very useful in future climatic stress conditions. Conservation agriculture is one of the most important strategies for combating climate change adverse impacts.
- Setting up policies for improved land-use and natural resource management, which should include incentives that would en-

courage farmers to sequester carbon in the soil and thus improve soil health, and use water and energy more efficiently. The incentives should include also for the environment service provided by the farmer.

- Increase income from agricultural enterprises by suitable actions such as accelerated evolution of location-specific fertilizer practices, improved fertilizer supply and distribution system, improved water and fertilizer use.
- Improved risk management through early warning system and crop insurance policies to encourage crop insurance and can provide protection to the farmers if their farm production is reduced due to natural calamities. In view of these climatic changes and the uncertainties in future agricultural technologies and trade scenarios, it will be very useful to have an early warning system of environmental changes and their spatial and temporal magnitude. Such a system could help in determining the potential food insecure areas and communities given the type of risk. Modern tools of information technology could greatly facilitate this.
- Recycling waste water and solid wastes in agriculture as fresh water supplies are limited and has competing uses, and would become even more constrained in changed global climate. Industrial and sewage water waste, once properly treated can also be a source of nutrients for crops. Since water serves multiple uses and users, effective inter-departmental co-ordination in the Government is needed to develop the location-specific framework of sustainable water management and optimum recycling of water.

Research agendas addressing the above said arenas are needed to be designed and implemented. Research agendas on improved water and fertilizer management in low land area, crop diversification, improved

management of livestock population, increase in soil carbon through organic manures, residue management and minimum tillage, use of nitrification inhibitors such as neem coated urea to reduce emission of N₂O, fertilizer placement practices, improvement in energy use efficiency in agriculture, increase in the area under bio-fuel, agroforestry in relation to food production are the immediate needs of the hour to cope the impact of climate change on agriculture (Mahapatra, 2009).

Suggested measures with respect to global recession

Policy makers have to exercise utmost caution in the matter of regulating imports. It must be ensured that the benefit of increased productivity flows to the growers (Hegde, 2009). Care also has to be taken not to let low international prices affect the domestic market. Political and international pressures on the government to follow import-friendly policy must be resisted. The government after a careful analysis should give a direction whether India should aim at self-reliance and self-sufficiency or go for need-based imports without unduly disturbing the food and nutritional security, since oil is critical for the health of public, the industry and the farmer. The government policies should be balanced between availability of edible oil to the consumers in reasonable quantities and affordable prices on one hand and on the other to promote domestic production without resorting to uncontrolled imports to safeguard the interests of the growers, employment, industry and health of the public. This demands a coordinated approach, frequent consultations and avoidance of pressure of interested groups and lobbies, before decisions are taken and directions issued. The decisions should also be based on international scenario, WTO obligations, trade relations, comparative advantages of prices of commodities, whether raw or refined, either to import or export.

**Directorate of Oilseeds Research,
Rajendranagar, Hyderabad**

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Livestock

Enhancing Livestock Productivity in Punjab

A Road Map

Introduction

Punjab is a leading agrarian state with an area of 53,362 sq km. The human and livestock population is 262 and 73 lacs respectively. Per capita availability of milk is 332 kg/year as against a national average of 82.4 kg. Milk accounts for 85% of animal protein in the diet. Livestock continues to be an important component of the State economy and its value of output has gone up from 24% in 1993-94 to 33% in 2003-04 (at fixed prices). Milk alone accounted for 77% of the total value of output from livestock. Annual growth rates of 4 to 5% for milk production during the last two decades have been impressive and there is scope to improve it further through technological interventions.

Punjab has rich and highly productive animal biodiversity. It has some of the best indigenous breeds of Murrah and Nili Ravi buffaloes, Sahiwal cattle and Beetal goats. A large number of Holstein crossbreds have been produced and these now are being developed into a new breed through selection. Dairy farming today is a viable alternative to crop agriculture especially in view of declining income from crop farming due to stagnation in yield levels. The movement in dairy farming is essentially coming from farmers themselves in the form of establishment of commercial dairy farms with high yielding crossbreds which have adopted intensive production system providing quality feed and fodder (silage) and specialized services. Presently about 3000 farms with 20 to 200 high yielding crossbred cows have come up in various parts of the State and their number is likely to go up to 5000 in next few years.

Population, production and economics

The total livestock population in 2007

was 73.3 lacs; the cattle (17.6 lac) and buffalo (50.0 lac) together accounted for 92% of the total livestock. The other species viz. Sheep (2.1 lac), goats (2.9 lac), horses, ponies, mules and donkeys (0.445 lac), camel (0.02 lac) and pigs (0.25 lac) were available in very small numbers. Of the total cattle, 12 lac were crossbreds and the rest low producing indigenous cattle. The proportion of females to males is around 90:10 for buffaloes and 76:24 for crossbred cattle. This suggested that males are no more being used for draft and transport purposes and that young males both of buffalo and cattle are disposed off. These need to be put to optimum use for improving profitability of dairy farming. The cattle population during 1997-2007 declined by 33%; the decline was more marked in indigenous (38%) than crossbred cattle (35%). Buffalo population showed a decline by 18%. Apparently, the population of milch animals is getting stabilized and that further increase in production would result from increase in productivity per unit animal through breeding, nutritional health and extension interventions.

Milk production per buffalo and crossbred cow based on milch animals was 1977 and 2819 kg/year as against a national average of 1016 and 1390 kg. Buffaloes and crossbreds in Punjab produced 95% and 102% more milk respectively than the national averages. It is important to mention that buffaloes, crossbreds and indigenous cows accounted for 73.4, 25.4 and 1.2 % of the total milk production thus suggesting that buffaloes shall continue to play a major role in milk production



Dr. V.K.Taneja

in the state.

Small ruminants (sheep and goat) are on decline; the major reason being reduction in pasture areas. The only way out is that sheep and goat should be raised under intensive system (stall feeding) and focus should be to have higher body weights and improve reproductive efficiency to produce more lambs and kids per female/year. Some farmers are rearing pigs especially of exotic breeds under stall feeding. Small ruminants and pigs however are unlikely to be the part of the major production system in the state.

Concerns and interventions

Breeding policy and bull evaluation: The state does not have a clear cut breeding policy. Program for identifying crossbred and Murrah

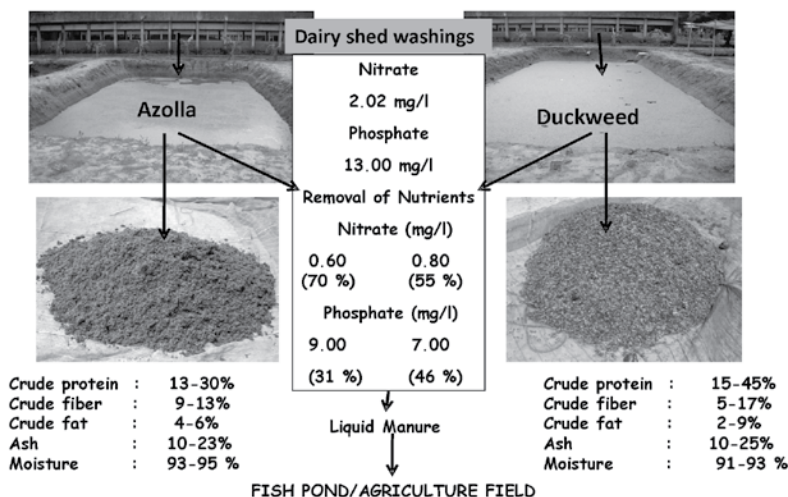
Comparison of buffalo vs cow milk

Constituents	Buffalo	Cow
Energy, cal/100 g	117	89
Fat, %	7.4	4.1
Protein, %	3.6	3.2
Casein, %	3.1	2.6
Whey, %	0.7	0.5
T. chol. In ghee, mg	278	330
Free chol, mg%	212	283
Iron, mg/100ml	1.2	0.4
Ca,mg/100ml	180	123

bulls hardly exist. The approach in cattle breeding has been to breed cows with imported semen from high yielding Holstein Friesian herds. AI coverage is around 70% in cattle and 30-35% in buffaloes. BAIF and JK Trust are being involved for increasing AI coverage in buffaloes. Most of the commercial dairy farm owners are doing AI themselves and the dependency on state machinery is minimal. Progeny testing and sire evaluation programs in small herds have not given the desired results both in terms of required numbers and accuracy. In case of crossbred cattle, a large number of farms having 20-100 crossbred cows have come up. Such herds should be interlinked and put under sire evaluation program. A mechanism of selecting young males from the farmers herd to be used as future young bull should be build up in the program. Similar approach should be adopted for buffaloes. Sexing of semen should be adopted as a part of the breeding program, and only sexed semen used both in cattle and buffalo in the State so to improve economics of dairy farming. The sexed semen of buffaloes and crossbred cattle can be exported to many countries in Asia and Middle East. Actual number of breeding bulls needed should be worked out and breeding programs for their production put in place.



Azolla and Duckweed culture – recycling of dairy shed washings (GADVASU)



Feeding, reproductive management and diseases:

Punjab is one of the very few states which have comparatively adequate feed resources and livestock farmers feed their high yielding cows and buffaloes with green fodder as a routine. Dry fodder availability is 26.4 million tones as against the requirement of 9.4 million tones. State has a surplus of 4 million tones wheat and 10 million tones rice-straw. Rice-straw is mostly burnt and is a source of environment pollution. The surplus rice and wheat straw can be exported to food deficit States. Technologies for compressing, baling and treating straw to improve protein content and digestibility are available. The cost of treatment is Rs.20-25/ quintal. The advantage is that 60% of total protein can be spared and there is no adverse effect on reproduction.

Current availability of concentrates is 2.24 million tones as against the requirement of 4.48 million tones. The requirement of concentrates would substantially go down because of reduction in number of unproductive and low producing animals and adoption of silage feeding throughout the year.

Green fodder is grown by most livestock farmers. Major fodder crops grown are berseem, maize, sorghum and oats. Silage production and feeding is very popular especially among commercial dairy farmers. Dairy Development Department and MILKFED are promoting silage production including community based silage making in areas having shortage of dry and green fodder. A subsidy of 50% is provided for community based silage production.

Higher incidence of reproductive problems are mainly due to low energy diets and mineral deficiency and these lead to high economic losses. Available data indicate that only 11% of the farmers feed mineral mixture while another 33% feed only common salt. Balanced feeding practices can overcome this problem. Hot humid months – July to September are stressful and affect both reproductive and production efficiency. Developing comfortable and low cost housing should receive priority.

Current losses due to livestock diseases in the State are believed to be around Rs 1400 crores. These losses can be substantially reduced through intensive prophylactic vaccination and strengthening disease diagnosis. The cost of vaccination against major diseases viz. FMD, HS etc would be around Rs 75 crores. Apparently, returns on investments would be much larger. Making Punjab, a Disease Free State would greatly enhance the value of livestock and livestock products. A model disease bill is essential to achieve the above objectives.

Peri-urban dairying and management of dairy farm wastes:

Peri-urban dairying with around 10 % of total milch animals is a reality today. These dairies are over crowded and management of dairy wastes is a major challenge. Necessary steps both by the owners and administration need to be taken to ensure that the dairy wastes are properly managed and that these do not pollute the environment and water bodies. Incidence of brucellosis, tuberculosis, jones, etc in animals in peri-urban dairies is high. Regular health check of these animals for important animal diseases is therefore very essential. A large number of dry and non-pregnant animals in most peri-urban dairies are not recycled. Similarly, male buffalo calves born are starved to death. There is a need to rear these male buffalo calves for meat for increasing profits from dairying.

Management of animal farm wastes both in small and large farms is not only a concern but a challenge. A number of NGOs have demonstrated that dung can be utilized through digester to produce gases (methane,

carbon dioxide). These are converted into electricity for use in various farm operations. Carbon dioxide can be separated and compressed for industrial use. The slurry is a better fertilizer as against cow dung manure. The animal farm washings which consist of urine, some dung and water can be directly used in agriculture fields; the surplus washings can be stored and water cleaned using duck weeds. Azolla can be produced using these washing. Both duck weed and Azolla can be used as feed in fish farming as fresh and in dried form to the extent of 30%. Azolla is used as green fodder for various categories of animals. The farm washing after cleaning through duck weed can be used for fish production after mixing with fresh water and oxygenation. Trials using animal washings for fish production are in progress at Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana.

Delivery of services and inputs:

The poor suitability of present model of agriculture extension to livestock is evident from the fact that only 5% of farm households access information on animal husbandry as against 40% in crops. Unfortunately, animal husbandry extension also does not form a priority with Departments of Veterinary Services which spend 1 to 3% of their budget on animal extension activities. Livestock extension activities mostly tend to be oriented towards organizing cattle health camps/ sterility camps and front line demonstration in fodder production. Training modules suited to specific needs of the farmers have recently been developed and trainings imparted by GADVASU, Animal Husbandry and Dairy Development Department.

Delivery of services especially the treatment is at fixed places. Farmers have high value livestock and need services at their doorstep. They are ready to pay for the services. There is thus a need to have a fresh look at the services needed, their delivery mode and that the existing set up of delivering veterinary services at

fixed places restructured to meet the needs and aspirations of the livestock farmers. Both MILKFED and NESTLE which collect milk from farmers provide input services in the form of cattle feed, AI, treatment and fodder seeds at farmer's door.

Value Addition: Of the total milk produced (9.3 mt), around 55% is used for domestic consumption, 31% handled by the unorganized sector and only 14% is handled by the organized sector. Major players handling milk are MILKFED, Punjab and Nestle, Moga while other players which handle less than one lac litres of milk per day are GSK, Wochardt, Reliance and Mother Dairy. It is expected that by 2025 the domestic consumption would go down to 30% and that 55% of the total milk produced would be handled by the organized sector. There is thus a need to develop cost effective technologies for developing new products and byproducts from milk so as to increase profitability from the dairy farming. Concept of clean milk production needs to be integrated in the production system. Somatic cells count should be introduced as a parameter for payment of milk. This shall reduce prevalence of mastitis in dairy animals and reduce milk losses while ensuring better quality of milk.

Around 73% of total milk production in the state comes from buffaloes. Comparative analysis of buffalo vs cow milk would reveal that buffalo milk has more energy, more fat, and more protein, less total cholesterol and more iron and calcium. In addition, activities of enzymes like lipase, protease, alkaline phosphatase and xanthine oxidase are significantly lower than that in cow milk. In addition, buffalo milk is more suitable for specialized products viz. mozzarella cheese, dairy whitener, casein and health foods. Shortage of energy in our diets is a reality and hence the high fat in buffalo milk and its appropriate use would continue.

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Biodiversity and Agriculture

Dr. P. L. Gautam, Dr. C. A. Reddy and Dr. C. Thomson Jacob

Biodiversity, encompassing variety and variability of all life on earth, is the product of over 3.5 billion years of evolutionary history. The number of species inhabiting the earth vary from 8-14 million species. So far, about 1.75 million species have been identified, including small creatures such as insects. Scientists reckon that there are actually about 13 million species, though estimates range from three to 100 million. Hence many species await discovery. Biodiversity is critical for agriculture and it has enabled farming systems to evolve ever since agriculture was developed some 10,000 years ago. It forms the basis for species of crops and domesticated animals and the variety within them. It is the foundation of ecosystem services essential to sustain agriculture and human well-being. Today's crop and livestock diversity are the result of many thousands of years of hu-

man intervention. Biodiversity and agriculture are strongly interrelated because while biodiversity is critical for agriculture, it can also contribute to conservation and sustainable use of biodiversity.

1. Indian Biodiversity

India, known for its rich heritage of biological diversity, has so far documented over 91,212 species of animals and 45,500 species of plants in its 10 bio-geographic regions. Besides, it is recognized as one of the eight Vavilovian centres of origin and diversity of crop plants, having more than 300 wild ancestors and close relatives of cultivated plants, which are still evolving under natural conditions. India is also a vast repository of Traditional Knowledge (TK) associated with biological resources. India ranks among the top ten species-rich nations and shows high endemism. India has four global biodiversity hot

spots (Eastern Himalaya, Indo-Burma, Western Ghats and Sri Lanka, and Sundaland). The varied edaphic, climatic and topographic conditions and years of geological stability have resulted in a wide range of ecosystems and habitats such as forests, grasslands, wetlands, deserts, and coastal and marine ecosystem.

India, endowed with varied forms of animal genetic resources, is traditionally considered as an important rearing centre for domesticated animals. It has vast resources of livestock (485 million) and poultry (489 million), which play a vital role in rural livelihood security. In terms of population, India ranks first in buffaloes, second in cattle and goats, third in sheep, fourth in ducks, fifth in chicken and sixth in camels in the world. The genetic resources of farm animals in India are represented by a broad spectrum of native breeds of cattle, buffaloes, goats, sheep, swine,



equines, camel and poultry. There are around 140 listed breeds of livestock and poultry in India, with 30 breeds of cattle, 10 of buffalo, 42 of sheep, 20 of goat, 3 of pig, 6 of horse and pony, 8 of camel and 18 of poultry. India has 59,353 insect 2,546 fish, 240 amphibian, 460 reptile, 1,232 bird and 397 mammal species, of which 18.4 per cent are endemic and 10.8 per cent are threatened. The country is home of at least 18,664 species of vascular plants, of which 26.8 per cent are endemic.

So far, nearly 91,212 of faunal species (7.43% of the world's faunal species) have been recorded in the country. Endemic rich Indian fauna is manifested most prominently in Amphibia (61.2%) and Reptilia (47%). As per the International Union for Conservation of Nature Red List (2008), India has 413 globally threatened faunal species. India is endowed with vast inland and marine bio-resources. It is the third largest producer of fish in the world and the second largest producer of inland fish. As such, fisheries and aquaculture play an important role in social development, economic upliftment of farmers and fisher folks, apart from contributing to the nutritional security of the country. India has a variety of wetland ecosystems, presently, 115 wetlands have been identified under the National Wetland Conservation Programme (NWCP) and 25 wetlands of international importance under Ramsar Convention. About 4,445 sq.km area of the country is under mangroves.

There are 16 major forest types and 251 subtypes. The total forest and tree cover of the country constitutes 23.39 % of the geographical area. Presently, there are 137 Protected Areas (PAs) (47,208 sq km) in the Indian Himalayan Region and 88 PAs (13,695 sq km) in Western Ghats. India's major strength in in-situ conservation lies in its impressive PA (661) network, which covers an area of 4.8% of the total geographical area of the country and these includes 99 National Parks, 515 Wildlife Sanctuaries, 43 Conservation Reserves and 4 Community Reserves, established under the Wildlife (Protection)

Act, 1972.

2. Eco system services

Biodiversity benefits human societies in a myriad of ways by providing wide range of ecological, economic, social, cultural, educational, scientific and aesthetic services. A healthy biodiversity provides a number of ecosystem services, such as protection of water resources, soils formation and protection, nutrient storage and recycling, pollution breakdown and absorption, contribution to climate stability, maintenance of ecosystems, recovery from unpredictable events. The activities of microbial and animal species - including bacteria, algae, fungi, mites, millipedes and worms - condition soils, break down organic matter and release essential nutrients to plants. These processes play a key role in the cycling of such crucial elements as nitrogen, carbon and phosphorous between the living and non-living parts of the biosphere. Wetland ecosystems absorb and recycle essential nutrients, treat sewage, and cleanse wastes. In estuaries, molluscs remove nutrients from the water, helping to prevent nutrient over-enrichment and its attendant problems, such as eutrophication arising from fertilizer run-off.

Trees and forest soils purify water as it flows through forest ecosystems. In preventing soils from being washed away, forests also prevent the harmful siltation of rivers and reservoirs that may arise from erosion and landslides. Around 99 per cent of potential crop pests are controlled by a variety of other organisms, including insects, birds and fungi. Many industrial wastes, including detergents, oils, acids and paper, are also detoxified and decomposed by the activities of living things.

Many flowering plants rely on the activities of various animal species - bees, butterflies, bats, birds, etc. to help them reproduce through the transportation of pollen. More than one-third of humanity's food crops depend on this process of natural pollination. Many animal species have evolved to perform an additional function in plant reproduction

through the dispersal of seeds.

Plant tissues and other organic materials within land and ocean ecosystems act as repositories of carbon, helping to slow the build-up of atmospheric carbon dioxide, and thus contributing to climate stabilization. Also, it provides food, medicinal resources and pharmaceutical drugs, wood products, ornamental plants, breeding stocks, population reservoirs, future resources, diversity in genes, species and ecosystems. The social benefits also accrued in research, education and monitoring, recreation and tourism and cultural values.

3. Agro-biodiversity

Agricultural biodiversity includes all components of biological diversity of relevance to food and agriculture: the variety and variability of plants, animals and micro-organisms at genetic, species and ecosystem level which are necessary to sustain key functions in the agro-ecosystem, its structures and processes. Agricultural biodiversity is essential to the world for sustainable production of food and other agricultural products. It provides the building blocks for the evolution or breeding of useful new crop varieties, biological support to production via soil biota, pollinators, and predators etc and regulates wider agro-ecosystems services, such as landscape protection, soil protection and health, water and air quality. Agro-biodiversity constitutes a unique sub-set of biological diversity that caters to the biological resource needs for developing varieties of agricultural importance in crops and animals. Biological species have been domesticated, described and used as sources of food, well-being (nutraceuticals), health-care (medicines), clothing (fibers), shelter (timber), fodder, fuel, and several other human necessities and industrial products. Industrially applicable uses of various agro-bioresources may be innovated through bio-prospecting.

Biodiversity is the feedstock for sustainable advances in crop and animal productivity, in other words, biodiversity may be the prime mover of an ever-green revolution movement

in agriculture. India stands seventh in the world in terms of contribution of species to agriculture and animal husbandry and the second largest producer of fresh fruits and vegetables globally and is largest exporter of spices and cashew. India has over 800 crop species and 320 wild relatives: millets (51); legumes (31); fruits (109); spices and condiments (27); vegetables (54); fiber crops (24); oil seeds, tea, coffee, tobacco and sugarcane (12); and, medicinal plants (3,000).

4. Indian Agriculture

Agriculture continues to be the mainstay to India's large and growing population for its sustained food security. Agriculture, as the largest private enterprise in India, is the lifeline of the economy. Agriculture is critical and crucial for our food and livelihood security and support for the economic growth and social transformation of the country. Achievement of food and nutrition security and alleviation of poverty and unemployment on a sustainable basis depends on the efficient and judicious use of natural resources. India has around 18 % of world's human population and 15 % of world's livestock with only 2.3 per cent of geographical areas, 4.2 % of fresh water resources, 1% of forest areas, and 0.5% of pasture/ grazing lands. India's geographical area is 328.7 million hectares, and the reporting area for land utilization purposes is only around 305 million hectares.

During 2008-09 the agricultural sector contributed to approximately 15.7 per cent of India's GDP (at 2004-05 prices) and 10.23 per cent (provisional) of total exports besides providing employment to around 58.2 per cent of the work force. In the recent past, the impact of food, financial and economic crises has been felt across the world. This has compromised the lives, livelihood and food security of the people. India could withstand and manage their impacts. However there is need for sustained efforts in this regard.

As per International Trade Statistics, 2009 the agricultural exports have

registered a growth of about 8.76 %. The increase was primarily because of higher exports of basmati rice, tobacco (un-manufactured), wheat, spices, meat and preparations, paper/wood products, other cereals, cashew nuts, castor oil, tea and coffee, dairy products, fresh and processed fruits, and vegetables and oil meals. India is the second largest producer of vegetables after China and is a leader in the production of peas. Besides, India occupies the second position in the production of brinjal, cabbage, cauliflower and onion and third in potato and tomato in the world. India is the largest producer, consumer and exporter of spices and spice products. The total production of spices during 2008-09 was 4.14 million metric tonnes from an area of 2.6 million hectare. India is considered a treasure house of valuable medicinal and aromatic plants, which provide raw material for formulation of indigenous medicines apart from exports. The Government of India has identified and documented over 9,500 plant species considering their importance in the pharmaceutical industry. Of these, about 65 plants have huge and consistent demand in world trade.

5. Biodiversity and agriculture

The economic value of the reservoir of genetic traits present in wild varieties and traditionally grown landraces is extremely important in improving crop performance. Important crops are often derived from only a few genetic strains. Improvements in crop plants over the last 250 years have been largely due to harnessing the genetic diversity present in wild and domestic crop plants. Hybridization of crop strains has resulted in doubling of crop production in the last 50 years. Monoculture has been reported as contributing factor to several agricultural disasters in history. The notable examples include Irish Potato blight famine (1846), rice grassy stunt virus in Asia (1970s), Coffee rust in Sri Lanka, Brazil and Central America in (1970) and US Southern Corn Leaf Blight epidemic (1970). The climate change is further complicating the

matter. This is an opportune time to reflect on root causes of these crises, and more importantly to shift policies, investments and day to day actions to those most effective for the conservation and sustainable use of biodiversity and ecosystem services. This calls for effective strategies and R&D efforts to enhance productivity and adaptation to climate change.

Strategies and plans for conservation and sustainable use of biological resources based on local knowledge systems and practices are ingrained in Indian ethos and are enshrined in the Constitution of India [Article 48A and Article 51 A (g)] in the form of environment protection. India has enacted many a legislation which relate to biodiversity. The Biological Diversity Act, 2002 provides for reaffirming sovereign rights over the biodiversity, regulation of conservation and sustainable use of biodiversity and associated knowledge. In order to implement the provisions of the Biodiversity act, the National Biodiversity Authority (NBA) has been established in 2003 at Chennai. The State Biodiversity Boards have been established in 24 states and the Biodiversity Management Committees in 14 states. The People's Biodiversity Registers have been documented containing information on bio-resources and / or associated traditional knowledge. The NBA is providing capacity building and awareness generation of stakeholders.

To conclude, biodiversity is the basic foundation of Agriculture. The agro-biodiversity provides food, raw materials to produce goods. The green revolution technologies have helped in increasing food production and improving the food security and reducing the poverty. However, monoculture and climate change besides other factors are threatening biodiversity. There is a need for effective management of biodiversity and designing of crops with higher productivity and adaptation to climate change and other stresses.

**National Biodiversity Authority,
Ministry of Environment and
Forests,
Government of India, Chennai**

Traditional wisdom for Sustainable Agri & Livestock Production

An opportunity for Better Animal, Human & Environment Health

Summary:

Animal production is poised to make a generous leap in the years to come because of the multiplicity of the related events that are taking place around the globe. Increased demand of the livestock products, ease of market accessibility, and opportunity of global trade, increased cash flow in urban & rural societies, application of science & application of new technologies in production, feeding & processing may be some of the key factors responsible for the anticipated increase in livestock production.

However, at the same time it is high time that we address some areas of quality assurance of feed & food of animal origin, maintaining the production inspite of scarcity of land, water & imminent climate change. In nutshell it is high time we integrate Animal health & Agriculture sector for better sustainability of farming community & simultaneously addressing the national food security. Needless to mention, education of rural masses for adopting new techniques will play a significant role in entire process of livelihood generation of farming community.



Anup Kalra

Introduction:

India has different climatic zones, natural resources, socio economic strata which is what makes feeding of ruminant different in various parts of the country. This is in contrast to the western part of the world. In fact in our country livestock plays a key role in the natural resources based livelihood, which is mostly confined to rural areas. In fact livestock rearing in our country is quite different for subsistence farmers, where risk management is more important than the developed market driven systems. Apart from unfriendly climate, we have problem of large human & animal population, pressure on land, scarcity of pasture land, shortage of

The traditional wisdom of ancient India existed in integration of “5F”, which meant Food, Feed, Fodder, Fuel & Fertilizer security. In the current era, Ayurved with help of modern science has worked on the above model using technological tools for addressing the needs of Animal, Human & Environment Health



M J Saxena

feed & fodder, resulting in comparatively low productivity & consequently the low economic returns.

In spite of the above, we should all be proud that livestock sector is showing better promise (growth of 4-5%) than the agriculture sector (growth of -1 to 1%). The key point to be observed here is that our majority of the ruminants are reared under suboptimal conditions, as the small livestock holders and landless together hold around 70% of our country livestock.

However, planning and involving the stake holders for holistic interactions with plants and soil, involving TRM (Total Resources Management), which means optimum utilization of the available resources including the available biomass, through its recycling would help in improving the overall **Animal & Human Health & Food Solution**.

Food: Our current challenge for its security & safety

Food apart from air is the most im-



portant thing for the living being survival. This is true globally. India looking into the concern our Government has set up **National Food Security Mission**. In view of the stagnating food grain production and an increasing consumption need of the growing population, Government of India has launched this Centrally Sponsored Scheme, 'National Food Security Mission' in August 2007. The major objective of this scheme is to increase production and productivity of wheat, rice and pulses on a sustainable basis so as to ensure food security of the country. The approach is to bridge the yield gap in respect of these crops through dissemination of improved technologies and farm management practices. The implementation of the NFSM would result in increasing the production of rice by 10 million tones, wheat by 8 million



tones and pulses by 2 million tones by 2011-12. It would also create additional employment opportunities. In this mission **Livestock is also expected to jointly play an important role**. Livestock play an important role in our lives. Apart from providing livelihood to the people in the rural & semi urban areas, they form a vital link for the food security. They provide us milk, meat which is an essential source of protein & energy. Moreover, agriculture income may come to farmer three to four times in a year whereas the income from milk is on a daily basis

Feed: To help the biocoverter for producing food

Scenario of Feed Resources:

The inadequate feed resource is the major constraint in the productivity of livestock. Since feed is the only raw material required for the production of foods of animal origin, improved supply of nutrients can bring out the full potential of the animal to the fore. Feed is also the main input factor for milk and meat production from livestock constituting 60-70% of the cost of livestock products. Inadequate feed supply is coupled with the availability of low quality fibrous feeds forming the major roughage source. The cost of feed ingredients is spiraling higher and higher with each passing day. In India, another reason for the high cost of good quality feeds is the sudden spurt in the export of these ingredients

during the last few years. It is really beyond the means of resource poor animal keepers to buy good quality feeds, as they even don't get the remunerative price for

their produce, making a vicious circle which eventually results in sub-optimal performance from their animals. There is still not a good market for good quality feed.

NIANP Bangalore has shown that the present deficit with regard to dry fodder, green fodder and concentrate has been shown to be to the tune of 11, 28 and 35% respectively. In livestock farming, it becomes very important for us to feed our livestock with proper balanced feed. The basic principle of GIGO applies here. If you feed them right, they will remain healthy & more productive during

their lifespan. As a matter of fact in our country our farmers mostly complain of less milk production & % of fat in the milk, but, often they do not realize that production is part of reproduction. In our country, we have immense problem of tackling the issue of infertility in animals or we may refer it as decline in the reproductive efficiency in animals. One of the most common factors affecting this is improper nutrition or animals being not fed the nutritionally balanced compound feed.

Value added compound Feed:

Though there is improvement in usage of cattle feed amongst farmers, however the quality of this feed is a big question mark.

Often certain value added feeds which are nutritionally balanced and also possess the herbs for improving immunity digestion, stress, production etc.

These feeds may cost little higher but are known to deliver the results. Ayurvet Uttam is one such brand in India

Another concern is safety is the high content of the chemical fertilizer & pesticides in the milk & meat which the animals produce. This comes from Agriculture by products which are used for animal feeding. These are ultimately passed on to the human beings. This has led to higher incidence of cancer. It is not only common in people who consume these crops/grains but also amongst the farmers who use these pesticides to produce these crops

Improving genetic variability in nutritional quality of straws

Straw quality differs with crops. This variation could be as high as 10-15 units, which has been studied in most of the cereal crop residues viz. rice, wheat, barley, sorghum and millets. In the crop-livestock sustainable production system, better quality of straw can result in 10% increase in productivity of ruminants. Cereal breeders have often overlooked this point. It is high time that the cereal breeders plan their breeding programmes in collaboration with animal nutrition-

ists, and thus, helps in improving the economic lot of resource poor farmers.

Biotech Feed:

The new upcoming research claims that the straw when treated with a special fungus breaks the lignin bonds & releases energy. This may even help in replacing the grain portion from the feed.

Use of trace mineral supplements

There is an urgent need for the extension agencies in the country to educate the farmers about the benefits of feeding mineral mixture/ chelated minerals to their livestock, so that their livestock can perform at optimum level with respect to production as well as reproduction.

Fodders: Nutritionally enriched green feed for Animal health

Fodder is important part of Livestock feeding & can never be under estimated. The fodders are rich in Omega 3 Fatty acid which is essential for maintaining a healthy heart, flexible joints, healthy growth and strong bones and teeth. Another constituent of importance is Conjugated Linoleic acid (CLA), which is believed to boost immune function and reduce the growth of tumors.

Enhancing green herbage

In India, the area under fodder cultivation has remained static for the last three decades at 4.5% of the total cultivable land, due to pressure of human population. The only way to increase fodder production is through intensive fodder production, especially using high yielding varieties of fodder crops. But it is important that the farmers are supplied seeds of high yielding fodder varieties, as its non availability is yet another bottleneck in enhancing fodder production. Intercropping of cereal and a forage legume can serve the dual purpose of increased grain yield (wheat) and provide good grazing. Integration of forage legumes improves soil fertility and soil structure and controls soil erosion and thus, helps in the sustainable development of agriculture

(Reddy, 2008).

In our country we do not get the green fodder round the year which affects the health of the animals & the quality of the milk which they produce.

Hydroponics: A novel initiative for green Feed:

The word hydroponics has been derived from the Greek word where 'Hydro' means water and 'Ponic' means working, i.e. Water working. Plants require 3 things to flourish- water, nutrients & sunlight; Hydroponics is a straightforward way of providing all these nutrients without the need of soil under controlled environment conditions to optimize the growth of plants. It is referred as feed because

when compared to conventional fodder, Protein content is about three times higher and Energy values are about double in Hydroponics feed. The conventionally harvested green fodder consists only of cut grass but the Hydroponics feed consists of grass, along with grain and root. This method of producing green feed has many advantages for the farmer, the ecology and the environment.

Advantages of Hydroponics

Saving of water: It takes 2 to 3 liters of water to produce 1 Kg of green feed as compared with 80-90 liters/day required in conventional system. Therefore, it uses minimal water for maximum fodder production. Water that is not used by the growing fodder is not wasted, as it can be recycled & reused again.

Marginal land usage:

Fodder production in our hydroponics machine provides huge ecological & economical advantages, as the production of lush green feed requires minimal land usage as compared to field grown grasses & fodder (only 135 sq. feet for 240 Kg fodder production against 2178 sq. feet in conventional system) This reduction in the amount of land required for maximum fodder production is an asset for both regions where agriculture is difficult & in densely populated regions that lack sufficient growing space.



Comparison of Hydroponics fodder with conventional fodder (Barley)

Nutrient	Grain Barley	Conventional Fodder	Hydroponics Fodder
Protein%	10.1	11.5	31.99
Fibre%	6.80	31.8	24.75
Energy (kcal/kg)	3900	2600	4727
Ash%	2.79	11.4	5.70

Completely natural: An important factor about growing green feed in Ayurved's hydroponics machine is that it is completely natural product. Therefore, there are no pesticides or fungicides used that could alternatively contaminate the milk or meat that are being produced.

Comparative heat values and thermal efficiency of commonly used fuels

Commonly used fuels	Calorific values in Kilo calories	Thermal efficiency
Bio-gas	4713/M3	60%
Dung cake	2093/Kg	11%
Firewood	4978/Kg	17.3%
Diesel (HSD)	10550/Kg	66%
Kerosene	10850/Kg	50%

Constant feed supply: Hydroponics technology will remove the need for long- term storage of feeds. With our hydroponics machine, a consistent supply of green fodder is guaranteed 358 days (365-7) of the year irrespective of rain, storm, sunshine or snow. Therefore, the farmer knows exactly what feed they have available every day of the year regardless of the seasonal conditions as it takes an initial investment of just 7 days to produce up to 240 kg of fresh green feed per day and a minimum of 75- 84 tons of fodder per year.

Reduction in growth time: The growing time of hydroponics plants takes as little as 7 days from seed germination to a fully-grown plant at a height of 25- 30 cm, ready for harvest. Also, the biomass conversion ratio is as high as 6-8 times. Thus, for every 1 Kg of seed 6- 10 kg of green feed is produced. However, to grow the same amount of fodder in a conventional situation, if there was sufficient water for irrigation, would take up to 12 weeks from seed germination until ready to feed out to livestock.

Reduced labor requirement: This process of growing cattle feed requires minimal man- hour ratio per day. It is as little as 2 to 3 hours per day, needed to maintain & produce hydroponics fodder, as compared to the many hours of intense labour required for growing the same amount of feed as a pasture crop.

Enhancement of Nutritional value: Hydroponics fodder is a highly effective particularly nutritious feed, which produces 3 times more protein as compared to conventional fodder. It has high energy content and very high moisture content. Feeding livestock hydroponically produced feed

may increase considerably the fertility rates of cattle. Hydroponics fodder can also help improve the quality & quantity of milk production.

Fuel: For our daily domestic & community needs

Energy is a necessary concomitant of human existence. Although many sources of energy exist in nature, it is coal, electricity and fossil oil which have been commercially exploited for many useful purposes. This century has witnessed the phenomenal growth of various industries based on these energy sources. They have application in agricultural farms and have domestic use in one form or oth-

er. Fossil oil, in particular has played the most significant role in the growth of industry and agriculture, which would be recorded in the history of progress of human race in golden words. By now, it has penetrated so deep into the mechanism of human living that man is not prepared to accept the fact that this useful source of energy is not going to last very long. But that is the fact of life. Earlier fossil oil was available easily and at lower prices irrespective of its origin of supply. It has now been scarce and costly. The immediate effect of this is that the world is in a grip of inflation and rising prices. Today, energy crisis has mainly emerged from the fear that the boons of fossil oil may turn into a bane as the disappearance of fossil oil would compel the habits and practices of living of the society to change. That is the crisis and that is the compulsion for search alternate sources of energy.

Bio-Gas as one of the Alternate Renewable Sources of Energy

It is evident that no single source of



Percent NPK & its comparison

	N	P2O5	K2O
Bio-gas slurry	1.4	1.0	0.8
Farm Yard Manure (FYM)	0.5	0.2	0.5
Town Compost	1.5	1.0	1.5

energy would be capable of replacing fossil oil completely which has diverse applications. On the other hand, dependence on fossil oil would have to be reduced at a faster pace so as to stretch its use for longer period and in critical sectors till some appropriate alternative energy sources preferably renewable ones are made available. Presently, the country is spending a fortune in importing fossil oil which can hardly be afforded for long on the face of developmental needs. Methane gas and more popularly known as bio-gas is one such alternate sources of energy which has been identified as a useful hydrocarbon with combustible qualities as that of other hydrocarbons. Though its calorific value is not high as some products of fossil oil and other energy sources, it can meet some needs of household and farms.

Major Benefits of Installing Bio-Gas Plants

It is estimated that alternative sources of energy like bio-gas plants, wind mills etc. may reduce the dependence on conventional sources of energy by about 20% by the turn of the century. Presently, the cooking media in rural areas consist of burning dung cake, fire-wood and to some extent kerosene where it is available easily. The installation of bio-gas plants would directly replace the use of above three and in saving them, following gains would be made:

- Nearly 30% of available dung which is burnt and wasted would be recovered as bio-gas plants conserve the dung while producing bio-gas.
- The dung after digestion in gas plant preserves more of NPK in the dung solids and cellulose which otherwise gets lost if heaped in the open..
- Rural people would gradually stop felling trees. Tree felling has been identified as one of the major causes of soil erosion and worsening flood situation.
- Bio-gas plants would be helpful in correcting this situation.

- In rural areas kerosene is used for lighting lantern and cooking in a limited way wherever kerosene supply has been made possible. Whatever quantity is used can be replaced by bio-gas as it can be used for lighting and cooking. This would reduce the dependence on fossil oil directly and in saving foreign exchange.
- Lastly, the most important social benefit would be that the dung being digested in the digester, there would be no open heap of dung to attract flies, insects and infections. The slurry from digesters can be transported to the farm for application in the soil, thus keeping the environment clean for inhabitation. Also, gas cooking would remove all the health hazards of dung cake or fire wood cooking and would keep the woman folk free from respiratory and eye diseases which are prevalent in the villages.

Fertilizer: For enriching the soil & its recharge

The government recent decision on deregulation of the chemical fertilizer is indicative that it is not possible for the government to foot the subsidy bill. As a matter of fact the use of synthetic fertilizer is reducing the soil fertility & affecting the food production, said a joint study by Non profit Green Peace & West Bengals'Visva Bharti University. The data quoted that in 1960 there was a 25 kg increase in grain production with each kg increase of fertilizer. In early 1990s this came down to 19 & late 1990s it was at 8kg. One of the report further mentions that micro nutrients of the soil are lost with over use of nitrogen fertilizer, urea. The fertilizer subsidy is now at Rs.1, 20000crore against Rs.60crore in 1976-77. Another study states that if these subsidies are gradually phased out in next 5 years, India will be able to save Rs.12, 000 billion. Biogas can be effectively promoted by using some these saving in our country. This would help in gradual shift to organic nitrogen fertilization of the soil.

- The average NPK content of Farm Yard Manure (FYM) is about 0.5, 0.2 and 0.5 percent respectively and it may be observed that biogas slurry is rich in NPK by more than four times than ordinary dung when converted into FYM.
- When the country is faced with shortage of fertilizers and has to spend enormous amounts for its import, the application of bio-gas slurry can replace the chemical fertilizers to a large extent.
- Bio-gas slurry or FYM not only adds NPK but it proves the soil porosity and texture

CONCLUSION

In our country feed shortage, especially the shortage of quality feeds is a serious problem. For increasing the supply of green herbage, the strategies needed are: conservation of degraded pasturelands and development of wastelands. Feeding strategies for ruminants in tropics should also include environmental protection, through reduced methane emission, apart from increasing the productivity of ruminant stock. Improving the utilization of the straw is a big opportunity & scientists are confident about the breakthrough. Similarly Green Feed from Hydroponics system is the new way of animal feeding for improving animal reproductive health. This would help in saving save the water & land as the precious resource.

It is high time we integrate these initiatives to bring prosperity to our country. This would only happen if we effectively integrate Agriculture & Livestock sectors. This will not only help us in succeeding in National Food Security mission but would help in bringing back the soil fertility & improved crop production. This may not happen overnight, but then there is always a possibility to begin at some point.

**Managing Director, Ayurved Ltd,
Delhi and CEO (AFB), Ayurved
Limited, Delhi**

Services

Taking Farm-Gate to The Value-Gate

Opportunities & Options in Agribusiness Project Design

Recent debates over the likely future direction for India's agriculture have thrown up several scenarios of possible events as we travel the road from agri production to agri consumption. A production oriented thrust at the farm level over the past 6 decades has served noble purpose to ensure adequacy for many new mouths to feed. The challenge we now face is consumption oriented, be it to meet essential social necessities, be it demand driven to suit rising levels of affordability with more money in the wallets of world's largest base of middle-class consumers.

What does this change mean? Agriculture in India is often viewed as a simple minded event, with its farmers seen to be in constant need of deep protective support. The resulting 'Policy' driven isolation has given rise to hotchpotch of tiny/small informal activities somehow juggling for business space, rightfully or even not so rightfully. No surprise therefore that both waste and wasteful practices inevitably become the lowest common identity denominator.

The distinction between value at the farm (via agriculture) and value at

the consumer doorstep (via agribusiness) is not a new concept. Farm agriculture has never ever existed in isolation of business markets for its outputs and inputs. Governments are essential managers of shortages as only they have legislated powers to enact & enforce rules & regulations. But when shortages start to emerge as surpluses, clearly, physical consumptions can never be statutorily enforced. A time for change is now coming upon us.

Just as agriculture makes the vital beginning, agribusinesses conclude the essential purpose for they alone are capable of carrying farm-gate to the intended value-gate. Businesses build upon opportunities. Spurred by stronger consuming demand now emerging from both urban and rural consumers, the search for 'good' commercial agribusiness projects occupies centre-stage attention of several tiers of participants seeking a purposeful place for profit in changing farm to fork/plate value chains.

What are the true opportunities available with farm produce which could be gainfully pursued by agribusiness project skills? What can such projects do to ensure timely quantity & quality of farm production supplies? What are technology and knowledge gaps and how can these be competently addressed and managed on the ground? What is the future impact of Policy likely to be? These are not easy questions to answer. There are some agribusiness management tools that can assist illuminate roadmaps to sense profit, to establish profit and to secure profit in the changing agriculture to agribusiness future that lies just immediately ahead.

Agribusiness Value Chains

Agriculture provides the essential



Ashok Khosla

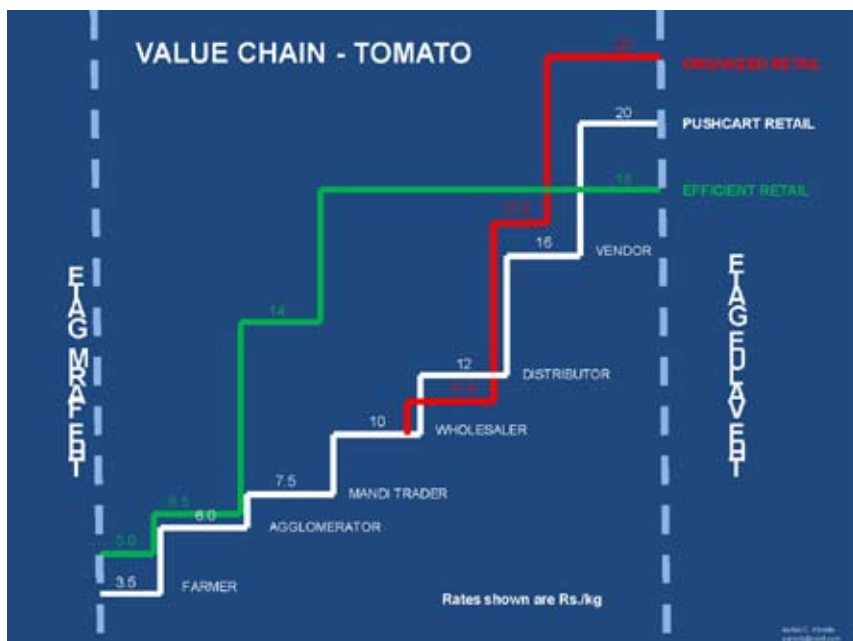
needs of food, feed, fibre and fuel. The food sector is clearly the largest and is a dynamic collage of natural products, select products, select styles of food preparation/display/consumption. There are several tiers of price affordability that cater to the vast & ever-changing diversity of individual choice. The business of food requires and supports large numbers of allied skills to capture opportunities in this the most essential commodity. Value of a product has three phases – Value Creation, Value Enhancement and Value Capture. When plotted from end to end, agribusiness value chains are better visualized as a staircase of value related activity. This staircase has Value Creation, something that can originate only at the farm level, Value Enhancement, all intermediate processes achievable through a variety of skilled methods & practices and Value Capture, the end consumption which fulfills individual needs. Every farm produce value chain has an identified farm-gate as well as its value-gate. Essentially, agribusinesses convert farm-gate into value-gate.

The Farm-Gate

India has easily the world's largest numbers of individual farm-gate products grown each year. We have about 120 million farms, mostly individually



A typical fresh tomato Value Chain from farm-gate to Fresh Retail value-gate is as under:



owned, the largest private enterprise activity in the country. Given the widespread gifts of soil, climate and toil, most farms will grow crops during 1 to 3 seasons each year. Also, during each season, farmers will grow more than one item of produce, that too with multiple varieties. In all, India's farm-gate comprises over 750 million produce lots, each identifiable for quantity, quality, variety. This enormity makes it practically impossible to fully document, confidently estimate and to precisely predict. But it is all there, available all over the country and year after year.

A part of the production is set aside for on-farm consumption, village barter trade and as seed for future planting. The surplus as farm-gate, finds several pathways to the marketplace, be it destined for parastatal purchase or for private trade at the mandi. Each item of farm produce has a natural perishability. Managing this without undue spoilage needs several players other than the farm producer, sound post-harvest handling plus suitable infrastructure.

The Value-Gate

The agribusiness value chain staircase comprises vertical risers that represent a level of value and hori-

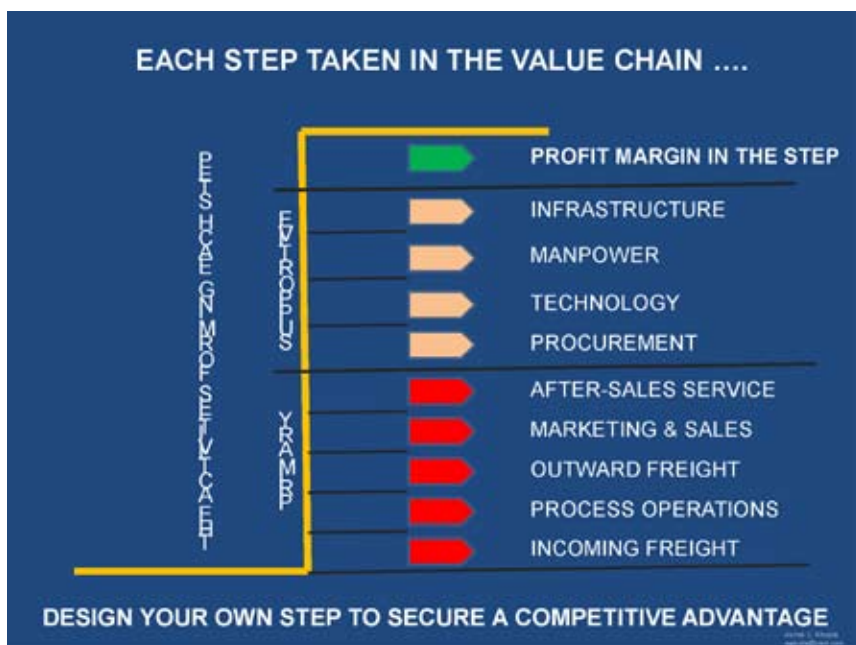
zontal treads that describe the commercial activity taking place at each step. Globally, not all staircases will finish at the same level of value since all products are not fully identical in value they can lay claim to and to receive. Such alteration is very deliberately done to enable businesses to differentiate product values from its competitors. Every staircase may not have even the same number of steps in case some commercial ac-

tivities are merged. Also, staircases need not even start at the same level in the farm-gate possesses a differentiated value.

The white path in the figure represents a 'normal' value chain which starts from a typical farm producer and ends at simple pushcart Retail. This chain features several service intermediates (aggregators, mandi traders, wholesalers, distributors and pushcart retailers) who step up the value. The red path represents an 'organized' value chain which ends at Retail by the organized sector. Because of the APMC Policy, this 'organized' value chain is compelled to start at mandi wholesalers. The product value gets pushed up, reflecting the Retail investments made. The green path represents an 'efficient' value chain that is better structured to end at Retail by the organized sector. This efficient staircase design delivers value advantages to both the consumer and the farmer.

How can such staircases be designed? Harvard Professor Michael E. Porter aptly defined the key components of Competitive Advantage that make better businesses. In this Author's value as a staircase analogy, Professor Porter's basic components are redrawn as follows:

In the above diagram, there are five Primary activities (in red) which are





business costs heads that are generally common to you and to your competitor but each item can (and must) carry a planned difference in order to better contribute to the overall value enhancement. Then there are four Supportive activities (in pink) where the nature and quality of competences created will directly influence the item costs of each Primary activity. The Profit Margin (in green) is the planned benefit that can (and must) accrue from the chosen design of the step.

The number of traditional steps in a product's agribusiness staircase can be rationalized and value maximized by linking both forward and backward. Better value-delivering efficiency in quality and quantity can be introduced through agribusiness supply chains that link growers to their markets. Agribusiness supply chains are not as simple or simplistic as their industrial counterparts. This is particularly so in India where there are easily over 750 million individual lots on offer. Opportunities abound where problems exist. Our large agribusiness canvass is riddled with value-sapping inefficiencies, contributed largely by small-only-is-best mindsets, inadequate infrastructure and Policy governance systems that date back to newly independent India. Losses by way of physical waste and value spoilage varies from product to product but a cumulative effect

ranging from 15% to 30% is not unusual.

Whilst a cluster approach has proved effective for small manufacturing & service operations, the special needs of agriculture farm-gate to agribusiness value-gate are perhaps better served by securing direct linkages. Two initiatives on the farm front deserve special mention. The first is the welcome advent of Producer Companies/Producer Groups. A key advantage from such linkage is that technology/technique transfer is better facilitated with farmers become directly responsible beneficiaries. The second is Contact Farming, a better and more reliable version of Contract Farming.

Efficient agribusiness Supply Chain have four interdependent working components, namely:

Transfer of Products

Whilst direct costs could be manageable, the key issue here is that agri spoilage does and will take place (and at incremental rates) after the farm-gate. Consolidation combined with modern & efficient post-harvest infrastructure can exponentially influence the value-gate.

Transfer of Payments

Although mandi sales attract an APMC mandi fee, actual auction practices are anything but transpar-

ent and true, the two main deficient areas being quality and weighment. The mandis are a large source for private funding for growers, perhaps the worst sufferers in the system.

Transfer of Ownership

Depending upon the product & its travel, several changes in ownership are quite usual. Each change process involves timeliness, brokerage and financing. Transaction brokers are the final authority for quality and rebates with all costs to the account of the farmer's running account.

Transfer of Information

Easily the weakest link in our farm value chain, most activity steps are motivated by personal gain and prices driven by lack of information, even misinformation. Reliable knowledge of the market needs and better technology transfer systems are critical mutual benefits for farm-gate Contract farming and/or linking to Producer Groups.

Taking India's Agribusinesses Forward

The agribusiness sector provides a direct multiplier effect of 2.5 to 3 times the GDP attributed to agriculture alone. Agriculture will always lend host support to large numbers of input and output agribusinesses, a political significance not lost in our vibrant democracy. Whilst Food processing is oft referred to as the sunrise sector, relatively very little daylight is as yet on show. Composite farm-gate to value-gate approaches can make the vital difference.

Agriculture requires the patience to watch grass grow. Agribusinesses will need to happen in a pioneering spirit, seek collaborative partnerships and beneficial linkages to access the new and emerging options and opportunities for securing productive farm-gate to value-gate projects.

This then is the challenge ahead, the opportunity ahead, a purposeful joining of our God-gifted wealth in agriculture and business savvy for which future India and the world eagerly awaits.

Agribusiness Advisor

Conditional Cash transfer program

A Magic Bullet for Reducing Poverty

In 1997, the Government of Mexico introduced a conditional cash transfer (CCT) program called Programa de Educacion, providing assistance to about 300,000 extremely poor households. The essential premise of a CCT program is a cash transfer to households, conditioned on their participation in health, nutrition, and educational services. Ten years later, this opportunity progressed to over 5 million households in all 31 Mexican states. Approximately 20 countries have adopted a pilot or full-scale CCT program, and another 20 countries have expressed interest in starting one. Most current programs are in Latin America, but others can be found in Asia, Africa, and the Caribbean, and interest is increasing among African countries struggling with extreme poverty and low human capital. CCT programs are increasingly perceived as being "a magic bullet in development".

How do CCT Programs Work?

CCT programs have the following characteristics:

They are targeted to poor households, and the cash transfers are usually paid to mothers. Some programs also include transfer such as nutritional supplements or school supplies for children. Cash transfer may be made as a lump sum or determined based on the number of children, with the amount varying by the children's age and sex. In some countries, higher transfers are paid for girl's school attendance and for secondary school attendance. In return for these transfers, recipients commit to undertaking certain actions, such as enrolling children in school and maintaining adequate attendance levels; attending pre- and postnatal health care appointments; and seeing that preschool children receive vaccinations, growth and monitoring, and regular checkups. Some programs require women to attend regular health and nutrition training workshops. Some provide resources that improve the supply and quality of

the schools and health care facilities used by beneficiaries.

As such, CCT programs aim to reduce current poverty, while also seeking to improve human capital formation and, in doing so, help prevent the intergenerational transmission of poverty.

Impacts of CCT programs:

Rigorous evaluations are often built into the programs themselves show that many, but not all, CCT programs have been successful in improving human capital outcomes. In Mexico, progress increased enrollment in secondary school by 6 percentage points for boys and 9 percentage points for girls. For girls who often drop out before secondary school those making the transition to secondary school increased by 15 percentage points. Children in the program also entered school at an earlier age and repeated fewer grades; Progressa had relatively little impact, however on school attendance rates on achievement on standardized tests, or in bringing dropouts back to school. These objectives must thus be pursued through design improvements or complementary programs. CCT programs in Colombia, Mexico and Turkey all improved secondary school enrollment but had little impact on primary school enrollment rates because these were



Dr. M J Khan

already high. Where pre-program enrollment rates are extremely high: in Cambodia, for example, secondary school enrollment increased by 30 percentage points and attendance by 43 points.

In Bangladesh, where 3 million children are still not enrolled in primary school, a small CCT program targeting the hardest-to-reach children (including street children) increased primary school enrollment by 9 percentage points though this occurred only in schools where grants were also provided to improve school quality. In Nicaragua, where primary schools enrollment was also low, the CCT program increased overall enrollment by 13 percentage points, enrollment of children from the very poorest households by 25 points and regular primary school attendance by



20 points. Two years after households stopped receiving benefits, however, enrollment dropped by 12.5 percentage points, but this was still 8 points higher than before the program, implying some sustainability of impact. CCT programs have also had significant impacts on health and nutrition. In Mexico, health visits increased by 18 percent in progressa localities, and illnesses among Children 0-5 years old were reduced by 12 percent. Young children in Honduras increased use of health services by 15-21 percentage points, though there, as in Brazil, no effects on children's illness rates were found. Some of the largest increases were found in the regular monitoring of children's growth in CCT programs in rural Colombia, Honduras, Mexico and Nicaragua.

A number of CCT programs are also associated with increased child height, which is an important measure of long-term nutritional status. Stunting was reduced in Mexico by 10 percentage points, in Nicaragua by 5.5 points and in Colombia by 7 points. Although the exact mechanism that triggers improvements is not known for certain, it may result from one or several programs characteristics, such as higher incomes that permit increased expenditure on food, growth monitoring and information about nutrition and child care, or nutritional supplements. In both Mexico and Nicaragua, for example, calorie intake increased, as did the consumption of fruits, vegetables, meat, and dairy products. In Honduras, no positive nutritional impacts were found because of implementation problems, while in Brazil, the program was initially associated with a slightly reduced weight gain, but this phenomenon was subsequently reversed. According to anecdotal evidence, mothers have kept children underweight under the mistaken belief that they would lose their benefits if children gained too much. This points to the importance of well-functioning communication between the program and beneficiaries so that conditionalities do not create perverse incentives. In turkey, insufficient or in-

correct information about the program also reduced impacts.

Some programs also address micronutrient deficiencies. In Mexico, program beneficiaries had anemia rates substantially lower than nonparticipants, though rates remain high. In Nicaragua, although mothers reported receiving the iron supplements, anemia rates were not affected, in part because they did not give the supplements to children, believing it was bad for their stomach and teeth. Both cases point to the continuing challenge of addressing nutritional deficiencies, where multidimensional approaches, rather than cash transfer or supplements alone, are needed.

CCT programs have a sharp gender focus. They have been successful in significantly increasing school enroll-



ment rates for girls, who have historically faced discrimination because educating them is not considered as important as educating boys. Research in Mexico and Nicaragua has found that CCT programs are associated with improved attitudes towards educating girls, as well as a heightened profile for women more generally. Although there has been concern and some evidence that women's program responsibilities can lead to conflicts with men, in both countries there is more evidence that the program's infusion of financial resources has reduced intrahousehold tensions.

CCT programs tend to be administratively centralized because their complexity requires standardization; hence they offer fewer avenues for community participation than many

other development interventions. Nevertheless, the programs still affect communities positively or negatively depending on their design and implementation. Programs in Brazil, Colombia Honduras, and Mexico have all found ways to integrate varying types of local input into their programs: from a beneficiary feedback system in Mexico to local input into targeting in Brazil to school-based parents organizations and quality improvements teams for the health services in Honduras to mother's assemblies in Colombia. While data based centralized targeting has generally been successful in reaching the poor and avoiding political manipulation at the local level, it has also frequently bred discontent in communities when people do not understand the targeting criteria, perceive it as unfair, or do not

have access to a functioning appeals mechanism. Exploring country-specific options for participation could lead to programs that are even more effective in achieving their primary goals, while increasing collective and individual empowerment.

Development and Implementation Issues.

Are CCT programs too Expensive?

The concern that governments in poor countries can't afford CCT programs should be considered within the context of the large sums spent by many governments on programs directed to the nonpoor. Energy subsidies, for example are typically highly regressive and often more costly than CCT programs: Egypt spent 8 percent of gross domestic product (GDP) on energy subsidies in 2004, and Indonesia spent 5 percent in 2005. Bailouts of insolvent contributory pension funds are another example. The expansion of Brazil's well-targeted CCT program, Bolsa Familia, to cover the bottom quintile of the population would cost about 0.4 percent of GDP, while the Brazilian government now spends nearly 10 times that amount covering the deficit in the main federal pensions programs, which deliver more than 50

percent of their benefits to the richest quintile. These are not isolated examples: many other countries spend considerable amounts of money on industry subsidies and military expenditure. In some very poor countries, particularly in Sub-Saharan Africa, donors and nongovernmental organizations (NGO's) have stepped in as partners with governments considering or implementing CCT programs, viewing them as potentially cost-effective approaches to increasing human capital—for example, by protecting children in households affected by AIDS.

Is Conditionality Necessary?

An important question being debated as new countries consider cash transfer programs is whether to impose conditionalities. Are conditional cash transfers in fact better than unconditional ones when it comes to achieving objectives, and if so for what objectives and under what conditions? Three broad arguments support conditionality: the first relates to the externalities associated with certain types of human capital investments. For example, when making decisions about their children's care say decisions about girl's schooling parents may not take into account the benefits that society derives from educating girls and as result they underinvest in girl's schooling relative to optimal levels from a societal perspective. Conditionally can be an effective means of increasing these investments. Second, sociocultural biases against schooling may be imposed by more powerful groups (for example, men) on the less powerful (for example, their daughters), and conditionally provides stigma associated with welfare payments if conditions are seen as part of a social contract between beneficiaries and the state. Finally, conditionally may be required for reasons of political economy. Politicians and policy-makers are often evaluated by performance indicators, such as changes in school enrollment or use of health clinics, and the impacts of CCT programs provide a basis for sustaining public support. Conditionality has also increased the credibility of programs where, historically, the public has often been suspicious of

antipoverty efforts that were deemed ineffectual.

Are CCT programs Sufficient as a Poverty Reduction Strategy?

CCT programs as currently designed are important parts of a poverty reduction strategy that aims to improve the health, nutrition, and education of young children in the short term and their income earning potential in the future, ultimately reducing the likelihood they will remain poor as adults. Other complementary strategies are needed, however, for people at other stages of the life cycle. Mexico's *oportunidades* is partially addressing this by offering 1.) benefits throughout high school; 2.) a cash incentive for high-school graduation conditional on its investments in higher education, a productive activity, health insurance, housing, or continued savings; and 3.) a cash transfer for beneficiaries 70 years of age or older. Of course, poverty reduction also requires other approaches to promote economic development and job creation.

Would all developing countries benefit from a CCT program?

With a proven track record, CCT programs are a powerful approach not only to reducing poverty, but also to improving various educational, health-related, nutritional and other welfare-related outcomes. That said, not all CCT programs have functioned as well as their designers had hoped. CCT programs are not for every country and no two countries should necessarily adopt identical programs. In assessing whether a CCT program is appropriate, four main issues come to the fore:

1. What are the current levels of specific human capital outcomes? If enrollment rates of primary school children are nearly 100 percent, it makes little sense to condition transfer on primary school enrollment. If, however, enrollment rates were only 70 percent, greater scope would exist for a CCT program. Although the extent of this scope would only be revealed through further disaggregation of enrollment rates. For example, are the rates uniform across rural regions or

for boys and girls? If pronounced regional, gender, or ethnic differences are present, a CCT program targeted to those lagging groups would be more effective than a countrywide program.

2. Why are specific human capital outcomes too low? Do they reflect an income constraint, such as parents needing the income that children bring in when not in school? Or are schools non-existent, too far away, or considered unsafe for children to travel to or attend? Whether low school enrollment rates or poor nutrition outcomes reflect constraint at the household level or the absence of adequate service provision needs to be determined prior to initiating a program. CCT programs are ideal where the supply of supporting services is good but underutilized; they are much less effective when supporting services are limited. In such cases, improvements to the supply precede or accompany the launch of a program. In some countries CCT programs have provided a strong impetus for improving services.
3. Is there high-level political support for a CCT program? By design, CCT programs require coordination across different sectors, most notably social welfare, education, and health. This implies that interministerial coordination will be necessary, which is difficult to achieve. An influential political champion of the program is needed to ensure that this coordination occurs. In Mexico, for example, strong support from inside the Ministry of Finance was an important factor in Progres's success.
4. What administrative resources are available? Is the necessary intersectoral coordination feasible particularly when both transfers and supply-side interventions are envisaged? The level of complexity of program design should reflect administrative capacity.

CCT programs—while not a magic bullet—are worth serious consideration as part of an integrated poverty alleviation strategy.

Chief Editor, Agriculture Today

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Major Initiative

Sustenance of Small Holders' Dairying: Emerging Challenges!

PRELUDE

Structural changes are taking place in the institutional frame work, world over, to face with the immerging challenges vis-à-vis opportunities of the free market. This includes organizational consolidations cum institutional restructuring, besides transformation from the conventional to the Information and Communication Technology (ICT) driven business processing systems!

Such changes are taking place in the firm and non-firm sectors, globally. Nonetheless, in the developing countries, as compared to the developed nations, changes are occurring at a much faster rate in the non-farm sector than farm sector. In these countries, the reform is usually led by the socio-economic factors like rapid urbanization, rising disposable income, etc, in the demand side; whereas the supply side is generally influenced by the increasing flow of public/ private investments, foreign direct investments, inputs cum environmental issues, etc.

All those factors are equally influencing the dairy sector too, globally!

However, the dairying system and the institutional frame work distinctively differ between the developed and developing nations. Dairying and Animal Husbandry activities, in general, are practiced commercially in the developed world, mostly by the big milk farmers, having large land and animal holdings. Therefore, the milk production, processing and marketing in the developed countries are technology cum productive oriented and investment driven system. In contrast, in the developing countries, the milk production and processing systems continue to remain mainly socially oriented small holders' domain, which are labour intensive, crops residue dependent sub-system of agriculture. Nonetheless, the milk processing and marketing systems, since the latter part of the last century, have been gradually transforming from manual to mechanised systems, though the majority yet are dependent on the traditional systems. This dichotomy has been the cause of concern for the sustenance of the small holders' dairying, in the prevailing unprotected free market



*Animesh Banerjee**

environment.

An attempt has been made here to focus briefly the progress, problems as well as the policy measures that are required for sustenance of the small holders' dairying, with specific reference to India.

SMALL HOLDERS' DAIRYING

Smallholders' dairying is a major activity, in India, which is holding the largest numbers, around 350 million farmers (70 million rural households), who keep dairy animals. Out of these 260 millions milk farmers (52 million households) are small, marginal and landless. The herd sizes of these farmers vary from 1-2 to about 6. Amongst these farmers, around 65 million farmers (13 million rural households) are connected with the dairy cooperative institutions, in India. They have been socio-economically benefited due to an effective institutional framework which provides them the best value for their produce. Besides they are supported with the technical input services like artificial insemination, veterinary services, feed supply, assured payment, bonus, credit facilities, etc. Other than the individual member benefits, the village community as a whole are being benefited by having roads, schools, hospitals, etc., built out of the surpluses generated by the milk cooperative institutions. Thus, it has been causing social engineering





model. At present, the cooperative institutions are registered under the Society Act of the State government, where the State Registrar is the final authority. Sometimes, the politicians, to derive the political mileages, use the State machinery at the cost of professional interest of the cooperative institutions. For instance, a State Minister or Civil Servant often become Chairman or Board member of the cooperative institutions and use their influence in decision making, especially in the areas of employment and commercial activities. Such lacunas have been deterring the professional

to a diverse, multicultural and highly stratified Indian society.

The balance 39 million small households of dairy animal, who are not connected with any effective institutional framework, are being faced with numerous constraints, which include non profitable price, shortage of quality feed and fodder, low genetic potential of dairy animals resulting in low productivity levels, non-availability of institutional finance, unreliable breeding services, poor animal health care facilities, poor extension services, poor rural infrastructure such as roads, electricity, water, etc. The other constraints have been the high transaction costs, poor marketing infrastructures, lack of information about price and markets, poor knowledge, inaccessibility to the specialized vaccines and drugs and last but not the least, exploitation by the middlemen/milk dwellers. These constraints have been eroding the comparative advantages of the small holders' dairying, in India.

POLICY MEASURES

The following policy measures are called for to enable greater participation of the small holders:

- Improve infrastructures in rural areas
- Introduce an effective disease control cum veterinary care, at an affordable price
- Enhanced research and devel-

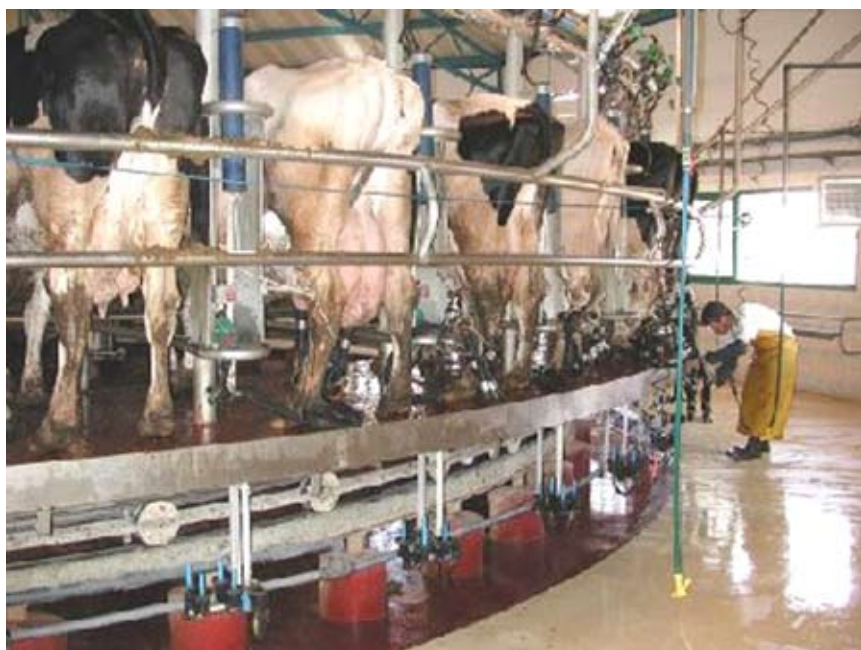


opment, especially in the areas of low cost homegrown technologies

- Create a favourable investment environment for smallholders
- Awareness about product quality, hygiene, and sanitation
- Effective implementations of quality, hygiene and sanitary standards.
- Provide appropriate institutional framework for market access and best value realization of the products.

No doubt, the 'Anand Cooperative Model' has successfully demonstrated how to facilitate growth of the small holders' dairying, in India. However one of the major issues faced in replicating the 'Model' is the State interference in functioning of the

growth of cooperative institutions, in India, besides becoming as successfully as the cooperative institutions, in OCEANA, OECD and EU nations! It is important to note that in recent past, with the opening up of the markets, private corporate/multinationals are coming forward to participate specially in the areas of processing and marketing in the dairy sector. This has created additional market pull in the Indian dairy sector. Thus, the supply side's role of is becoming more significant in the dairy sector. The cooperative institutions are mainly dominating the supply side, in organized dairy sector; whereas the traditional dairying system continues to remain unorganized, generally handled by the milk dwellers/middleman.



In the prevailing competitive environment to safeguard the interest of small dairy holders' vis-à-vis the cooperative institutions, it is necessary to amend the existing archaic cooperative act and rules, to facilitate replication of the 'Anand Model'. Besides, the new concept of Producers' cooperative company should also be explored in the country. The Producers' Cooperative Company can register under Companies Act and function similar to any private corporate. However, to maintain the cooperative ethos, the voting right of the share holders in the producers cooperative company does not commensurate with their share holding as in the private corporate. Critics, however, fear that such an attempt may affect the fundamental principles of cooperatives and big producers might dominate over the small holders. Nonetheless, the concept as stated above should be attempted and based on the experience suitably modifications may be carried out, as needed. While the institutional models may vary according to the situational demands, small holders being the main stakeholder, in India, their participation has to be ensured. To empower as well as enhance the ability of small holders to sustain in the prevailing

competitive market environment, following steps may be initiated:

- Milk productivity cum production enhancement.
- Research must acknowledge the role of smallholders, while focusing on such technical parameters as breeding systems, herd recording, feeding systems and the multiple uses of animals, management of reproduction, health as well as milk harvesting systems.
- Improve essential dairy services of the decentralized community driven village delivery systems.
- Promote micro-financing system besides encourage women self-help groups as thrift and savings societies for meeting the credit needs of the small holders.
- The smallholder mixed farming is generally more environment friendly than large-scale livestock production. Hence, if micro-enterprise status is given to the smallholders' dairying, it is likely to help the sector in deriving the best benefits of the global carbon trade.

Some steps to narrow the knowledge gaps of the small holders are suggested, as under:

- Promote village-based extension mechanisms
- Examine the effects of changing level and structure of demand on current marketing chains and responses of producers
- Examination of value chain from primary product to the final market in order to understand where value can be added for small dairy holders.
- Impact analysis of policies on export and import of dairy products and processing equipments.
- Impact analysis of HACCP/food safety standards legislation, co-operative and contract laws.
- Build credible alliances with the private corporate as well as NGOs, dairy research and education institutions
- Distributional impacts of policies on credit services, health services, breeding services, etc.

LESSON LEARNT.....

The Indian dairy development experience establishes the fact that in a country, where huge population of smallholders exist, dairying cannot be transformed radically to a productive cum technology oriented and entirely profit driven commercial enterprise, at par with the developed dairying nations. It has to transform gradually with the changing socioeconomic conditions at the grassroots. Till such time, it has to continue as the labour-driven smallholder micro-enterprise having low input-output cost ratio, adopting home grown technologies. And it is extremely relevant in a scenario where unemployment is mounting along with economic disparities as well as social disorder! Challenge, however, is the sustenance of smallholders, which can be done, as referred above, by empowering and involving them in the developmental process supported with suitable institutional frame work and policy environment!

**Advisor Dairy Food Sector;
Honorary Chairperson, Milk Panel
Agro-Vision 2020**

Emerging Areas

Conservation of Biodiversity and checking Biopiracy through Capacity Building and Patent Literacy

Dr. SS Chahal

Biodiversity is backbone of genetic improvement of living being. India is fortunate to possess diverse ecosystems, soil types and climatic conditions because of which it has vast and diverse bioresources. It is one of the world's eight centers of origin of crop plants. At least 165 food crop species and 320 wild relatives of crops are estimated to be originated from here. With about forty six thousand recorded species of plants and more than 91 thousand of animals, it is one of the few countries enriched with 'mega biodiversity'. Declaration of this year as Biodiversity Year means to highlight the importance of these invaluable but dwindling resources and to generate awareness for multiplying our efforts for their conservation. Particularly, agrobiodiversity has alarmingly declined in India because of many reasons like adoption, dependence and wide spread cultivation of fewer high yielding varieties; deforestation, developmental activities, monoculture, meager reforestation that too by mono-tree-plantations and shifting cultivation, etc.

What initiatives should be taken to conserve and utilize agrobiodiversity?

Realizing its inherent and multidimensional value, India has identified biodiversity conservation as a priority area and a number of multilateral agreements have been ratified for its promotion. Thousands of valuable but vulnerable species are threatened with climate change and habitat loss and may face extinction before they are discovered. But those which are known must be conserved and preserved. Focus on tribal areas will be highly fruitful because of intense ethno-botanical links between livelihood

and local flora and fauna in these areas. Providing incentive measures, establishing regional, block and village level contacts and maintaining biodiversity registers, discouraging mono cultivation practices, restoration of damaged eco-systems, promotion of "Beej Bachao" activities will greatly accelerate biodiversity conservation. It is pragmatic to undertake collaborative, network long term research projects on related issues by



different universities and other institutions. Importance of conservation by novel biotechnological tissue culture techniques and maintenance of gene banks cannot be undermined. In this respect efforts of National Bureau of Plant Genetic Resources (NBPGR) and National Bureau of Animal Genetic Resources (NBAGR) are highly desirable. Further, to identify more 'hot spots' and intensify exploration, Protection of Plant Variety and Farmer's Right Authority (PPV&FRA) and National Biodiversity Authority can play a major role in this endeavour. Taking advantage of climatic diversity, preservation in cryogenic gene banks can be augmented more by replicating facilities created by the Defense Research and Development Organi-

zation of our country under prima frost conditions at Chang La.

It is of prime importance to promote capacity and bring precision in technology to exploit available wealth of biodiversity that we have, may it be crop or livestock improvement or novelties in medicine. It can be possible only through substantial enhancement of investment for research.

Biopiracy has emerged as a big malpractice. How is it affecting our interests in agriculture and other sectors?

India is badly bitten by biopiracy. More than two thousand patents are granted every year in foreign countries which are related to Indian bioresources or Indian system of medicine based on traditional knowledge. It is difficult to deny that we were caught almost unaware when some multinational companies secured one after the other patent on various products which were based on Indian Traditional Knowledge (ITK). The US patents obtained by US Department

of Agriculture and a pharma company W.R.Grace, on a technique to take out neem extract having outstanding fungicidal and insecticidal properties and by University of Mississippi Medical Center on wound healing properties of turmeric, known in India since thousands of years and by Rice Tech of Texas on aromatic basmati rice traditionally grown only in Punjab, Haryana and Uttar Pradesh were challenged and got revoked by the Research Foundation for Science, Technology and Ecology (RFSTE) and Council of Scientific and Industrial Research (CSIR), New Delhi.

Unfortunately, the malpractice is being continued with impunity. Patents issued by European Patent Office (EPO) to MNC Monsanto on a wheat

variety using a traditional Indian variety and by US Patent and Trademark Office (USPTO) on brinjal, guar, blackberry (Jamun), bitter guard (Karela) for antidiabetic properties, the fact that is known in India since centuries, are glaring examples. Recently, a biopiratic bid by Clarks Aps (a Danish company) to secure patent on fat burning properties of ginger, cumin, onion and turmeric has been contested and averted by CSIR, proving that it is already well known and old practice in India. It is not only unethical but blatant infringement of International agreements like Convention on Biological Diversity (CBD) International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and FAO and UN Law of Seas which affirm sovereign right of the nations over their genetic resources and emphasize that access to these resources and associated traditional knowledge should be subjected to national legislation and their use by another party should be based on PIC and MAT i.e. Prior Information Consent and Mutually Agreed Terms. To nail the malpractice, it should be mandatory that all the applications seeking patent under IPR must disclose the source of origin of material and associated knowledge.

What steps are necessary to enhance Intellectual Property Rights (IPR) and Patent Literacy in India?

We are in fact suffering from patent ignorance. Patent literacy is completely missing even though there is much enclosed in IPR for India. There need to create awareness and inculcate patent culture by introducing teaching courses on TRIPS at least in tertiary and higher education particularly in law, agriculture, engineering, trade, commerce and social sciences. Half-hearted approach is not sufficient. There is need to establish strong and functional units in colleges and universities. Building capability to generate new intellectual property is important. Generating patent urge through awareness will be most appropriate to better fight patent colonialism.

Traditional knowledge in India is another aspect in focus. What is

important to check its piracy by other countries?

Indian Traditional Knowledge associated with biological resources is inseparable component of knowledge, skill and techniques itself. It is usually orally transmitted and are not recorded. But its proper documentation can help to check biopiracy by making it available to patent examiners who demand written proof of its existence and prior use. Documentation of ITK is also necessary to revitalize knowledge, skill and techniques as well as priority setting for resources under threat of extinction and sharing such knowledge amongst different communities for mutual benefit.

To meet this necessity, CSIR has initiated much needed documentation of ITK which is essential to counter biopiratic offences. The Indian Traditional Knowledge Digital Library (TKDL) of CSIR has scientifically converted information available in Indian languages into English, Japanese, German, French and Spanish for making western patent examiners to understand the existence of ITK. To further accelerate these efforts it will be worthwhile to collect information and maintain TK registers in rural, particularly hitherto unexplored tribal areas. Grass root level interventions will greatly contribute to broaden the scope of the TKDL. Maintaining community Biodiversity Registers approach should be widely adopted. Such initiatives will consolidate knowledge economy as well as supplement greatly achieving the three objective of CBD like conservation of biological diversity, sustainable use of its components and fair and equitable sharing of benefits from genetic resources.

How Access and Benefit Sharing is important. How best should it be pursued by India?

The developed nations like US, have advanced technology, whereas many developing nations like India have large biodiversity. India, like other developing countries insists for pushing up Access and Benefit Sharing (ABS) provided under CBD. But it is intriguing

why US shrinks to support India's intention on ABS and is shy of CBD. But clearly the tide is against it with growing discontent and insistence for ABS from more and more nations. Moreover, of all the three objectives of CBD, the third related to benefit sharing is almost completely non-implemented so far. Hence, this is an important agenda for the tenth conference of parties to the CBD scheduled to be held this year from 18-29 October at Nagoya, Japan. Access to



benefit sharing of biological resources should indeed be insisted upon for legal binding by the countries with mega biodiversity. If adopted it will be sound document and instrumental to put this objective of CBD into practice in favour of the countries belonging to 'global south'.

India must attach high significance to the expected negotiations at Nagoya in view of ever increasing cases of biopiracy of its resources. India, along with other mega biodiversity countries must stick to ground to achieve favourable results unlike Copenhagen Conference on Environment 2009 when the outcome was much below expectations but like Doha Conference, 2001 where persistence proved useful to resolve that "TRIPS shall not prevent members from taking measures to protect public health" clearly in favour of developing countries to have open access to cheaper generic drugs. Besides, at home it is highly desirable to promote technological capabilities and establish a sound national ABS framework as well.

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Issues and Emerging Challenges of Agricultural Marketing Extension and Export Policy

The supply pool for agricultural commodities is no more confined to domestic production alone. The countries having competitive edge in the cost of production are looking for opportunities to dump their output anywhere in the world looking the commercialization era. Despite our complex and diversified agriculture, it is yet to pass the test for comparative advantage in terms of cost effectiveness for may important commodities. Unless, we succeed in inducing cost effectiveness having locational advantage, it may not be possible for us to harness the benefits of WTO through export of agricultural commodities. Besides, we have to face a number of emerging threats including unrealized opportunities in agricultural marketing; unwarranted imports by other countries; under exploited export opportunities for Indian products and distortion in domestic markets. Since India has entered in global market and signed WTO, it is necessary to change our outlook on agricultural marketing system, especially in view of the Exim-policy and the existing dynamics in domestic markets and the new agricultural policy. Market-oriented agricultural extension is the need of the time, which is the real challenge for our public sector dominated by agricultural extension system.

1. COMPONENTS FOR A SOUND AGRICULTURAL MARKETING EXTENSION

(i) **Farmer- Agro- Industry- Consumer Linkages:** There is a need to have strong and continuous linkage between agricultural marketing and agricultural production system as 'what to produce', how much to produce', 'how to produce' and 'for whom to produce'.

Agricultural production system

What to produce

How much to produce

How to produce

For whom to produce

(ii) Shift in Physical Output Value

Realization: Ensuing shift in the approach from increased physical output to increased value realization by the producers in the need of the time.

(iii) Agro- Processing and Value Addition of Agricultural Products:

India has great potential for expanding its export of processed products in view of the increasing production of fruits and vegetables, dairy products, meat and marine products, etc. The practice of contract farming is coming up around such processing centers. More and more processing facilities for such commodities need to be augmented.

(iv) **Grading and Packaging:** In view of tremendous potential for export of fruits and vegetables, it is necessary to give greater attention to grading and packaging of these commodities by creating required infrastructural support.

(v) **Diversification of Agriculture:** India has enormous inherent potentials for diversification and scope to introduce new areas in agricultural production such as hi-tech horticulture, precision farming, organic farming, etc.

(vi) **Augmented Infrastructural Facilities:** A strong infrastructural support has to be developed in terms of cold storage chains, transport, credit support, market information and insurance to fully exploit opportunities for export.

(vii) **Cost Effectiveness:** The country's agriculture has to become more cost effective to meet the growing challenges and opportunities arising out of WTO agreements and the consequent globalization impacts. For



Prof. (Dr.) Ram Pratap Singh

this, future growth of agriculture has not only be yield based but should be titled towards ensured demand in the national and international markets.

(viii) **Global Market Research and Information Center:** An apex center at the national level for market research, international price analysis, global demand, availability and also to pass on this information to the concerning authorities is very much required.

(ix) **Involvement of Private Sector:** Efforts should be made to involve private sector in creating necessary marketing infrastructures.

(x) **Marketing Information Network:** Easy access to timely and relevant information to farmers, traders, policy planners and other marketing agencies so as to enable them to take proper marketing decisions.

(xi) **Marketing of Agro-Inputs:** For the marketing agro-inputs like seeds, it is necessary to streamline and simplify seed certification procedures, modify the Seed Act and enforce it strictly. Greater participation of private sector, co-operatives and NGOs in the production and distribution of seeds and planting materials is required.

2. NEWLY EMERGING AREAS IN AGRICULTURE FOR EXPORT

There are several global issues and global dimensions which the Indian agricultural sector has to confront as a consequence of globalization and liberalized trade regime. It is a reality that our gains through export of

agricultural commodities depend on the promotion of those commodities for which we have a comparative advantage in terms of cost of production and quality aspects. Some of the new areas for the strong extension system to mould itself to perform in an effective manner are listed below:

(i) Green Food Production: It refers to organically grown crops which are not exposed to any chemicals right from the stage of seed treatment to the final post harvest handling and processing.

(ii) Hi-Tech Horticulture: It is the deployment of any technology which is modern, less environment dependent, capital intensive and has the capacity to improve the productivity and quality of horticultural and vegetables crops.

(iii) Precision Farming: It implies to the application of technologies and principles to manage special and temporal variability associated with all the aspects of production and improving crop performance and environmental quality.

(iv) Sustainable Agriculture: It is the aspect of agriculture which encompasses the use of natural resources-land, water and genetic endowment-in such a manner that is technically feasible, economically viable, environmentally non-degrading and socially acceptable.

(v) Farming System Approach: The farming system refers to the activity mix of food crops, oil seeds, fodder crop, horticulture crops, livestock and other high value commodities that would increase farm income while ensuring the goals of stability, sustainability, diversification and commercialization of agriculture.

(vi) Protected Cultivation: It is the method of harvesting the natural re-

sources through the creation of an environment to enhance crop productivity by checking the vagaries of nature as weather variation often tend to have adverse effect on the yield and production of the crop.

(vii) Cold Storage/Cool Chain: It refers to the application of refrigeration technique in the preservation and storage of perishable agricultural products like fruits, vegetables and flowers to facilitate marketing system and to ensure higher return.

(viii) Micro-Propagation: It is a demonstrated technology of producing millions of identical plants under controlled and uniform condition, independent of seasonal constraints. It ensures economy in time and space and also gives greater output.

There are numerous other newly emerging concepts and techniques of crop production. The extension system will have to resolve these problems through its network in the years to come.

3. AGRICULTURE EXPORT POLICY ISSUES AND EMERGING CHALLENGES

There is a felt need to orient our agricultural production systems for enhanced export promotion by considering followings:

(i) Promoting of environmental inputs, precision agricultural practices and managements, participatory technology development for sustainable increase in productivity and production. In order to increase the exportable surplus.

(ii) Exploit the agro-ecological diversity of the country, for production! Export of agricultural products from different potentials regions during the off-seasons to importing countries.

The APEDA and SAD's can work on this and the State Departments of Agriculture, Horticulture, Agricultural Marketing and State Agricultural Marketing Boards can put into practice.

(iii) Promote and enhance the competitiveness among the Indian agricultural producers in order to insured; cost of production desires to be brought down by increasing yield gaps and potentials per unit of inputs through facilitating adop-

tion of latest technology, practices and managements.

(iv) Training must be given to the farmers on hi-tech modules, pre-harvest management and post-harvest handling of produce to match the standards requirements of importing country.

(v) Agriculture must be treated as agri-business and all incentives must be extended for its promotion and value added products from agricultural commodities in general and dry land crops in particular.

(vi) Credit availability must be insured and all technical bottlenecks required to remove from the institutional lending, besides, creating awareness among farmers to use latest crop insurance programs and facilities available.

(vii) Harness benefits of new scientific advances such as bio-technology, cloning, remote sensing, modeling, advertising, information and communication for farmers and rural communities through Internet aided extension networks have to be materialized that too in local language.

(viii) Farm Science Centers (KVKs) should be strengthened as nerve centre for dissemination of latest know-how and promoting the market/ export oriented quality produce of the commodity.

(ix) Formation of commodity specific extension kiosk on indigenous food, horticultural crops, livestock, poultry, bee keeping, mushroom, medicinal and aromatic plants, sericulture, tea and other value addition enterprises.

(x) Distance education for farmers and small agri-entrepreneurs needs to be explored and strengthened through television, interactive audio and video system, besides, print and learning materials which would be the distinguishing feature of extension teaching and learning process.

(xi) The knowledge on freely exportable and importable commodities, restricted as well as non-exportable/ importable and various levels as it has implications on the marketing of agricultural products which needs application of Exim- policy.



4. HRD IN EXTENSION

There is a need to train the farmers in many areas like product planning, marketing information, preparation of produce for marketing, improved marketing practices, rules and regulations, input marketing, etc. We have strong network of Extension in the form of ICAR extension system comprising of SAUs, Extension system of ministry of Rural Development and extension work by the Non- Government Organizations (NGOs), business houses and voluntary agencies. The rapid advancements in the technological front necessitate that these should reach to the extension scientists in time so that they in turn could disseminate it among the farming community. The transfer of technology being a complex and continuous process, there is no alternative but to develop human resources to achieve desired goal. The first line as well as development extension agencies, both at center and in the states, involved in Extension Education activities is required to pay added attention to the following aspects of HRD to meet the challenges in the future.

(i) Professionalism in extension has to be brought about by augmenting subject matter training with training in extension education.

(ii) The extension education programme has to focus still greater attention in future on small and poor farmers.

(iii) Indigenous knowledge system and farmers' traditional practices need to be integrated with formal R&D by approaches, which have system' perspective and participatory orientation.

(iv) The public sector extension should hold, besides technology transfer, other roles like human resource development, broad basing and farming system perspective and gender differentiated strategies.

(v) The participation in agricultural technology development and dissemination process should also allow the local groups to exert demand-pull on research and extension system.

(vi) A significant training effect is needed to upgrade the technical, managerial and organizational skills, knowledge and qualifications of field

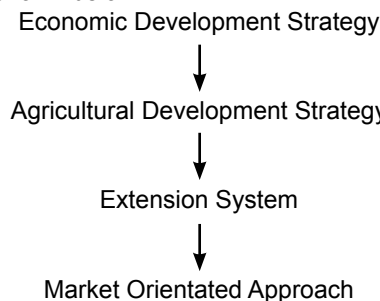
and junior extension personnel.

(vii) The extension efforts must concentrate more on group approach in the form of "self help group" which have proved more effective than the individual approach due to several limitations.

(viii) The subject matter extension specialists/scientists should be trained in the areas of information and communication management. Similarly the extension qualified experts need skill training to enhance their knowledge of subject matter modules.

5. SUGGESTED MODEL OF AGRICULTURAL EXTENSION

It is beyond the capability of any extension system to come out with a unified model to resolve all the problems of such a complex and diversified agricultural system prevalent in the country. It is recognized that approaches like farmer's participation, institutional linkages; system management approach, policy reforms, capacity building, empowerment of farmers and farm women, use of media and information technology and a host of other suggestive approaches may go a long way in making our extension system more vibrant. We can perceive the market oriented extension system as a sub-set of overall economic development strategy as shown below:



The agricultural extension strategy initiated to achieve self-reliance in agriculture has to be re-oriented and made market centered. Such a shift in extension strategy has become inevitable owing mainly to strong backward linkage that agricultural marketing has with agricultural production. as 'what to produce' and how much to produce, ensuing shift in the approach from increased physical output to increased value realization by the producers;

changes in agro-processing and value addition for agricultural products; potentials for diversification and new areas in agricultural production such as hi-tech horticulture, precision farming organic farming etc; emergence of glut in market in the wake of surplus production certain agricultural commodities; complex clauses on WTO agreement; declared EXIM policy (2002-07) by the Government of India listing freely exportable and importable commodities (restricted as well as non-exportable/importable commodities) and lack of accessibility to Information Technologies due to vast area, illiteracy and the like.

Research and Extension linkage has been considered as an intrinsic aspect for the development of agriculture in the country. It is well recognized that research and extension personnel have complementary roles in agricultural development the success of each group is determined largely by the effectiveness of linkage activities. Efforts should be directed to improve the existing linkage between research extension-farmers. Technology transfer will be more effective if all of them show more commitment on their respective fields and more coordination among them. Involvement of the farmers at planning level may help in better execution of the extension activities.

Friends, in a competitive environment of today and in the wake of missing expectations from the consumers, the hall-mark of coming decades will quality, innovations and efficiency in every sphere of business activity. By setting standards and enforcing commercial laws, government has fostered economic growth and provided the framework within which a modern economy can function. It is high time that we take stock of the existing situation, improve upon it, adopt and adapt it according to the exigencies of the circumstances. We are running a race and we must run faster in order to improve our relative position in the right path for meeting the global competitiveness in the agricultural sector.

**Former Vice-Chancellor, MPUAT,
Udaipur, Rajasthan
& Chairman, (NIDAR, Lucknow)**

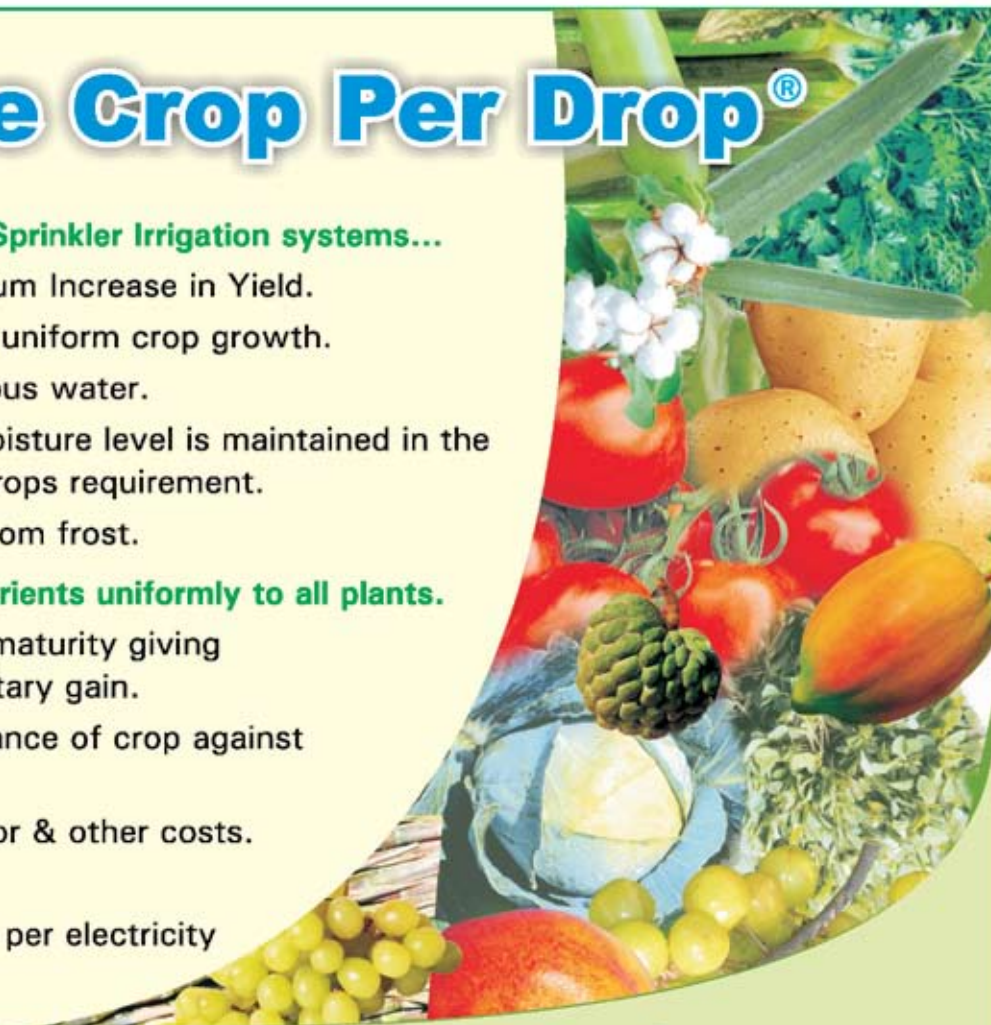
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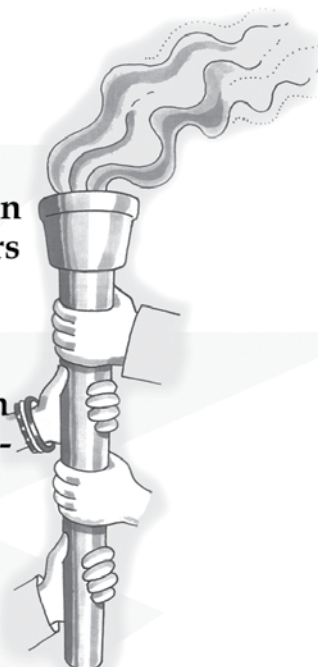
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Vision

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Future outlook

Noni – Future Fruit for Health and Wellness

Prof. P I Peter, Dr Kirti Singh, Dr. T Marimuthu and Dr. K V Peter

In this era of plants diversification and fast growing research, the aim of every research being carried out is to bring out all the positive benefits which any natural source can produce so that we can find out better ways to heal & increase the economy of the country by natural ways.

Noni (*Morinda citrifolia* L.) native to South East Asia domesticated & cultivated by Polynesians, first in Tahiti & the Marquesas and eventually in the farthest output of their country, Hawaii. It is one of the fruit which proves to finances our future in the next coming decade. Noni (*Morinda*, Indian Mulberry, ach, achhu, aal)) is a cherished fruit of the tribals in Pacific islands. Known as Hai ba ji and Wu ning (Singapore), Luo ling (Singapore and Taiwan) in Chinese; Canary wood (Australia), Noni fruit, Noni plant, Nonu (Samoa) and Pain killer tree (Caribbean islands) in English; Nono (Tahiti) in French etc., the fruits are used in fruit drink, in medicines and to make dyes. It was used as famine food, food supplement and traditional medicine in India and Indo-Pacific Island countries. In India, they are mainly grown in coastal Kerala, Karnataka, Tamil Nadu, Orissa, Andaman and Nicobar Islands and Laccadives.

Noni belongs to coffee family, Rubiaceae and can be grown in all places except in frost and snowfall prone areas. It is an evergreen tree which flowers and fruits throughout the year and naturally spreads in the tropical regions of the world. Noni, often found growing along lava flows, is an underutilized plant and unknown to many people including botanists in spite of the, is an underutilized plant and unknown to many people including botanists in spite of the fact that the fruit juice contains more than 160

nutraceuticals useful to health and wellness of people.

Morinda citrifolia is a small tree which grows up to 10 meters in height, with an irregular, open crown and shiny, dark green leaves. The tree fruits several times annually, producing oblong fruits with circular scars, which are green when unripe and yellowish-white when fully ripe. The fruits have a soft, watery flesh, and a cheesy aroma which becomes increasingly pungent during ripening.

The Fruit

Noni has antibacterial, antiviral, antifungal, anti-tumour, anti-diabetic, anti-inflammatory and immunity enhancing properties. The fruit is rich in natural antioxidants. Noni boosts immunity in human body and this has been proved in a clinical trial in Nagaland where the health status of 6 HIV patients was improved after being administered with noni juice. Clinical trials conducted on patients in several parts of India also confirmed many biological properties of noni like antimicrobial, anti-tumour, anti-inflammatory and wound healing



properties. “Your food is your Medicine”, Hippocrates declared centuries ago. So there is a need to shift our focus to wellness and freedom from diseases and disorders.

Propagation

Propagated through seeds and seedlings, noni can be grown in all types of soil, sandy clay loam being the ideal. It tolerates alkalinity up to pH 9 and saline water can be used for irrigation. The tree is free from major pests and diseases. It can be grown in tsunami affected coastal areas. In collaboration with Chennai based World Noni Research Foundation(WNRF), Government of Andaman and Nicobar Islands and Central Agricultural Research Institute(CARI,ICAR) are promoting cultivation of noni with an assured buy back arrangement(Rs.8/kg). The tree comes up well in open coastal regions at sea level and above. The tree bears fruits 2-3 years after transplanting. Propagation through vegetative means especially cutting is not encouraged as it has adventitious root system and trees may fall down during hurricane and heavy winds. A research project funded by AYUSH has developed protocols for micro propagation.

Seed dormancy can be broken by dipping them in hot water for 24 hours prior to sowing. Noni yields 50-150 fruits/tree, weighing 5-15 kg. At current price of Rs.5/kg at other locations, noni yields an income of around Rs.22,500/ha. Ripe fruits can be stored up to 9 days and juice can be extracted before 9 days. Concentrates can also be made. There are over 200 value added products from Noni. Ready To Serve(RTS) drinks are becoming popular. Plant Care Products against major pests and diseases, Bio-manures from noni fruit rinds, disinfectants for human body care etc. are being marketed. Pineapple-Noni Ready to serve drink is in much demand. Pineapple can be raised as an intercrop in Noni orchards. Fruit juices from guava, apple, orange, litchi, kiwi etc are also mixed with Noni juice to prepare RTS.

What's in noni fruit?

Noni fruit has gained popularity in today's herbal market. Either dried and crushed, juiced and bottled, or freeze-dried, noni fruit is being touted as a veritable cure-all, useful in mitigating diabe-

tes, cardiovascular disease, cancer, headaches, arthritis, and a host of degenerative diseases. According to investigations of noni fruit conducted over the past few years constituents found in ripe noni fruit demonstrate a plethora of biological activities. The following information focuses on primary constituents in ripe noni fruit, and some of their known biological activities. These primary constituents and their uses concern cleansing, antiinflammatory activity, immune enhancement and tumor-inhibition.

Antiinflammatory activity – Anecdotal accounts of anti-inflammatory effects resulting from noni fruit consumption are too numerous to dismiss. The anti-inflammatory effects of asperuloside, eugenol and scopoletin present in ripe noni fruit would support such a claim. Other agents in noni fruit may possess additional anti-inflammatory activity.

Immunomodulatory and Antitumor activity – Japanese researchers have described the activity of a polysaccharide-rich substance from the fruit juice of noni, noni-ppt. In studies, noni-ppt demonstrated immunomodulatory and antitumor activity. The authors suggested that noni-ppt may be a valuable supplementary agent in cancer treatment. Okadaic acid in noni fruit has been determined to increase the synthesis of tumor necrosis factor.

Noni studies

Noni's Bright Future

Considering the positive discoveries made with noni fruit thus far, there

is excellent reason to anticipate that further studies will prove the fruit and its preparations beneficial to health in numerous ways. Noni is a valuable medicinal plant. And it is likely to become an increasingly sought-after



dietary supplement. Further investigations into noni will likely lead to the discovery of other compounds. Additional biological activity studies will provide better information about how these agents work in living organisms. At some point human clinical studies will shed additional light on the specific activities of noni in the body.

Noni, *Morinda citrifolia*, is a highly regarded folk remedy which appears to be genuinely beneficial to health in numerous ways. Stripped of hype and mumbo-jumbo, and approached with intelligence and good science, noni may prove to be one of the more diversely valuable agents in nature's medicine chest, and an enduring dietary supplement that serves the health needs of many.

Summary

Noni is expected to play a significant role in wellness of mankind. The Chennai based World Noni Research Foundation was established to promote noni cultivation in India and abroad. **Noni cultivation has immense prospects in North East including Manipur where there is no incidence of frost.**

**World Noni Research Foundation,
Chennai**

Population explosion and Food Security Concerns

Population growth, global warming and climate change pose challenge for food security; which might have serious consequences threatening peace, disintegration of societies, national sovereignty and economy. Food Security and safety have become important globally in recent decades. Nutritional security has also surfaced as one of the outcome of excessive mining of soil nutrients in green revolution lead intensive agriculture. Every sixth person in the world (1.2 Billion) suffers from hunger and malnutrition. India with a population of 1.02 billion is the second most populated nation after China. By the year 2030, India will have the largest population surpassing China if the present growth rate is not reduced. Global human population at the end of 2009 was about 6.8 billions. Rate of global population growth is 2.8%. However, the population rise in developing countries is 3% against 1.6% in the developed countries. While population rise is highest in African countries (+5%), with Zambia at the top of the list, Italy has minimum population growth rate (1.2%) in the world. Population density in India which was 345 per square kilometer during 2005, is expected to become 440 in 2025. For keeping population constant, average woman should have 2.1 children. In the National Population Policy, 2000, it was envisaged to stabilize the population by 2010 by achieving 2.01 growth rate. Though 14 States in the country have achieved this target, the national average is higher due to lagging behind of some of the larger States including Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Haryana and Punjab having population growth plus 3%.

To feed the ever growing population by the year 2050, India should pro-

duce 494 million tons of food grains as against the highest record production of 234.47 million tons achieved during 2009-10. Post-independence India has witnessed spectacular growth in agriculture to the extent that the famines have vanished into the history of gone days. Since 1950 onward, various food commodities have grown between 4 to 27%, eg. cereals (4 times), milk (6 times), eggs (27 times), and fish (9 times). Though India produces 12% of wheat, 21% of rice, 25% of pulses, 22% of sugarcane, 16% of milk and 10% of fruits in the world; at the same time it sustains 18% of global human population and 16% livestock population, with meager natural resources comprising of 2.3% of global land and 4.2% of global water resources. Obviously, there is too much pressure on natural agricultural resources in India to feed its large population. Increased life expectancy after independence has further boosted up population figures. After the success of Green Revolution during 1960's to 1980's, the agricultural productivity in India, particularly in case of food crops (wheat and rice) has stagnated and even declined, thus fading out the gains of green revolution due to several factors resulting in soil health deterioration and fatigue as a result of excessive mining of nutrients and use of pesticides, insecticides, chemical fertilizers and other chemical inputs used along with improved seeds, as well as excessive use of groundwater to cover more area under irrigation. Thus, there is a risk to food security to our population which need to be addressed continuously in a sustainable and eco-friendly manner without deteriorating the environment and soil fertility, animal and human health. Food and Nutritional Security, growing global population, greenhouse gases, Global Warming,



Prof. (Dr) M.P. Yadav

Climate Change, Bio-fuels; green technologies, green energy and enterprises; environmental pollution and protection, poverty alleviation, gender empowerment, urbanization and feminization of agriculture due to migration of agriculture workforce from rural areas to cities in search of employment are some of the burning issues of today in the world.

Besides food and nutritional security, we should also assess the risk to food production on account of climatic and other natural factors such as floods, drought, cyclones, diseases and pests, water logging, soil erosion and tsunamis. To cite an example, the threat of UG 99, the deadly stem rust causing fungus, can cause havoc to wheat production. Originating from Uganda, it has marched eastward, affecting so far 12 countries including Yemen (2006), which is a gateway to middle-east and Asia. Other affected countries are Kenya, Ethiopia, Iran (2007) and South Africa (2010). Scientists across the globe are trying to find ways to stop its advance to major wheat growing countries, viz. India, China, Australia and Pakistan. Fears are that UG 99 may reach Punjab, which is South-Asia's most important wheat growing area. Release of billions of spores of the stem rust fungus from the infected plant has the potential to spread to new areas through air. Thus, a single disease like UG 99 is capable of jeopardizing food security in India and abroad. So

far, seven new variants of the fungus have been detected. It is a matter of satisfaction that scientists are working hard to evolve wheat varieties having resistance against UG 99. India is fortunate to have identified at least 22 varieties having resistance against it. The Generation Challenge Program of CGIAR supported by Bill Gates and Melinda Foundation will spend 12 million US dollars (60 crores rupees) over five years period for enhancing food production.

The agriculture sector employs about 52% work force in the country. A goal of 4% plus growth rate in agriculture has been envisaged in National Agriculture Policy to ensure a sustainable household food security. However, 4% growth rate in crop agriculture has always remained a dream. The main reason seems to be the decline in investment in agriculture over the years by public sector and lack of interest by the private sector in agriculture sector. This is in spite of the fact that despite tough competition from the growing manufacturing and service sectors in the post-liberalization era beginning around 1991, the agriculture sector still contributes about 18% of the national GDP.

Milk production is growing annually in India by 2.5 million tons. It needs to grow by another 2.5 million tons per year for meeting the minimum demand. Similarly, for feeding the growing population, India needs to grow

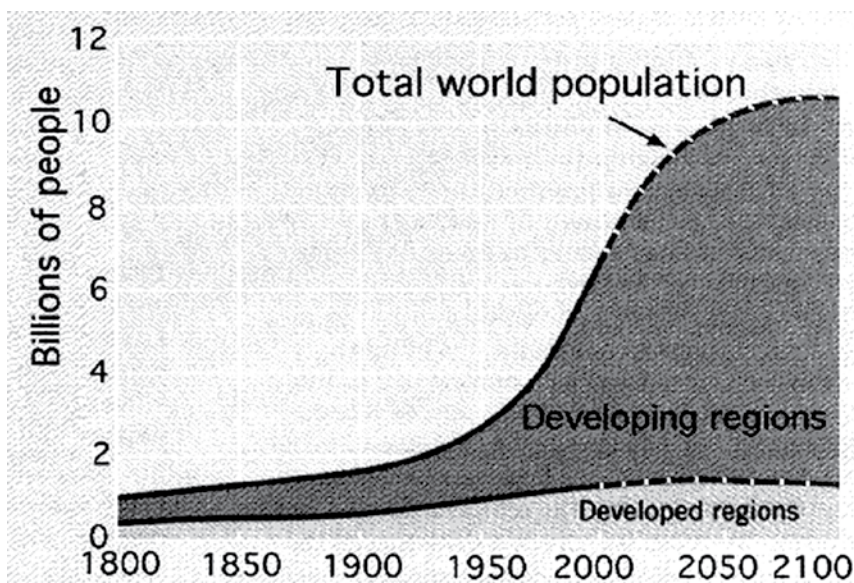
another 5 million tons of food grains every year. On an average, a person requires about 60 gram protein (1 g / kg body weight) per day of which at least 25g should be of animal origin, having high biological value due to essential amino acids in it. However, in spite of producing 110 million tons of milk (No. 1 in world), 56 billion eggs (3rd in world), 7.6 million tons of fish (3rd in world) and 3.8 million tons of meat, we are able to provide only about 11g of animal protein per person per day. Thus, production of milk, meat and fish need to be doubled to ensure nutritional security of our people.

By 2030, food demand in India is expected to rise about 60% over the year 2010. Horizontal expansion of cultivable land, which stands around 142 million hectares since decades, is not possible as more and more fertile land is being diverted for other developmental works like railway tracks, roads, highways, express ways, industry, housing, airports, educational institutions, offices etc. Other options left for increasing food production have to focus on enhancing the present irrigation facilities, covering 79 million (38% of the cultivable land) hectares, to cover entire 140 million hectares; improvement of the 120 million hectare degraded land in the country for growing crops, grasses, agro-forestry and as pastures for the livestock; enhancing per

unit production of food by roping in modern sciences of biotechnology and nano-technology along with relevant good agricultural practices and better risk management. In India, 800 million (80 crores) people earn less than Rs. 100 per day and out of these, 30 crores have been classified as BPL (below poverty line). Unless their purchase capacity is improved through better income, they will continue to be malnourished and underfed. Since burgeoning population is one of the major concern as well as cause in relation to food security, nutritional security, global warming, climate change, environmental pollution, degradation of natural resources, emissions, moral turpitudes and corruption, inefficient governance, malnutrition, hunger and employment; population growth itself also need to be addressed on priority, initially to be stabilized followed by further reduction.

Reduction of the post-harvest losses of food commodities by appropriate processing and value addition will go a long way in strengthening food security. At present, there are about 35% post-harvest losses amounting to about Rs. 80,000 crores annually in perishable commodities including fruits, vegetables, milk, egg, fish, meat and grains. Even there is problem of adequate storage and cold-chain transport of these commodities. According to an estimate, about Rs. 65,000 crore investment is needed to develop necessary infrastructure for food processing. Presently, food processing and value-addition in India is done hardly for 2% and 7% of the produce, respectively.

Precision farming such as laser leveling of land for saving on water, seed and fertilizer use; ridge and furrow sowing for better yields, diversification and water saving; zero till for saving energy (diesel and petrol) and water (irrigation for preparing the fields); mulching, drip and sprinkler irrigation (for saving water and higher yields) need to be adopted on wider scale to reduce global warming and climate change. With the modern techniques, water and nutrient efficiency can be enhanced by 30 to



60%. In the context of above facts, most of the nations now believe in the ill-effects of global warming and climate change and are busy in dialogue under WTO to reduce or cap the emissions without affecting the availability of energy required for development. Some of the instruments / measures under consideration in this regard, include reduction in the use of fossil fuels by saving on energy use, using renewable alternate source of green energy (solar energy, wind energy, geo-thermal energy, nuclear energy, tidal energy), biofuels; development of green technologies for green manufacturing, green buildings and green events; tree plantation, expanding forest covers for carbon sequestration, carbon credits, carbon foot-prints assessment and last but not the least, reduction of population itself. Ideally, two children per family should be the norm. The Government is not willing to adopt legislative measures to control the population growth. Recently, it is considering to achieve population control to desirable level by providing incentives and disincentives. Preference to male child over the girl child in India and some other developing countries due to dowry system and social custom of girl child joining her in-laws family forever after marriage, may be responsible for this social evil. Suitable laws for equal rights of property inheritance for male and female children, safe contraceptives for males, reversible contraceptives with easy availability at affordable prices along with education and awareness will go a long way to address this problem. There is also need for urgent scientific and social research in this area. Perhaps, this area has remained neglected as population explosion is not a problem of developed countries. There should be attractive incentives for those couples having less than two children and disincentives for couples having more than two children. Climate change which is the result of global warming has relationship with population explosion. More population means more pressure on natural resources including land, water, air;

more requirement for energy for agriculture, industry, transport, lighting, construction etc., leading to use of more fossil fuels (coal, diesel, petrol, and gasoline) and consequently production of more greenhouse gases (GHGs) into the atmosphere which are responsible for global warming by trapping more of sun's energy and heat. As a result of industrialization and modern agriculture, the GHGs in atmosphere have reached to about 485 PPMV (parts per million volume)



in 2009, as compared to about 286 in 1860, preindustrial era. More GHGs (above 300 PPMV) means more global warming and more climate change, which will have all over negative effect on agriculture production due to higher ambient temperatures interfering with seed germination, crop growth, grain setting, grain size; higher incidence and expansion of insects-pests due to high humidity and increase in temperature, lower animal production and reproduction due to enhanced abiotic (high and low temperatures, humidity & cyclones) and biotic (microbial) stress factors.

More population also needs more houses, roads, and other infrastructure as well as migration to cities, thus escalating energy requirement and production of GHGs. According to an estimate, globally every day 20,000 new houses are constructed and 250 km new roads are made. About 44 million (4.4 crore) people move to the cities world over every year. Migration of more people to cities will require more transport of food, fruits, vegetables, milk, eggs,

etc (mainly produced in rural and peri-urban areas) to the cities and at the same time for taking away the city's waste for disposal to rural sites. At present, about 1,20,000 million tons (mt) of urban waste is produced per day in India. Mumbai alone produces about 6,500 mt of waste per day. Thus, enhanced transport for people, goods and food etc. will burn more fossil fuels leading to higher GHGs emissions. Presently, CO₂ concentration in the atmosphere is 40% more as compared to the pre-industrial era. More population will result in more industrialization and automobiles and machines.

The concern of food security under the pressure of rising global population, global warming, climate change and widening income gaps between the haves and have nots, has been realized at international level. Some of the richest, headed by Bill Gates of US, are proposing that millionaires should provide their 50% wealth for charity. In fact, Bill Gates & Melinda Foundation is supporting programs in agriculture and health sector for ensuring food security by enhancing agricultural production through scientific inputs, including biotechnology and nano-technology for value-addition and enhanced productivity of food grains, feed and fodder, besides input use efficiency of fertilizers, water, seed and soil. Against the targeted growth of 4%, growth rate in agriculture in India is 1.2%. As a result of enhanced investment by the Govt. in recent years under National Food Security Mission, National Horticulture Mission, Rashtriya Krishi Vikas Yojana (RKVV) and MNREGA etc., the growth rate in agriculture during first 3 years of 11th Plan (2007-10) has become 2.2%. Stabilization of population is must for attaining food security. It can be achieved, provided there is political will and proper policies are framed and adopted by Central and State Governments.

**Ex Vice-Chancellor, SVP University of Agriculture & Technology, Meerut
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Building a climate resilient Agriculture Sector

Etali Sarmah and Bedanga Bordoloi

Agriculture being highly reliant on nature is most vulnerable to climate change. Climate change is threatening food production systems and thus the livelihoods and food security of billions of people of the world is in danger. Today, when the whole world is concerned about the effect of climate change on environment due to human interferences, agriculture has a major responsibility to shoulder to counter this threat. En-

acting measures to build agricultural resilience requires an understanding of strategies to reduce vulnerability and at the same time sustain the farm income and reduce poverty.

Agriculture is both an emitter of and a sink for greenhouse gases. Asia and the Pacific region accounts for 37% of the world's total emissions from agricultural pro-

duction. The agriculture sector in India emitted 334.41 million tons of CO₂ eq in 2007 (MOEF). Enteric fermentation in livestock constituted 63.4% of the total GHG emissions (CO₂ eq) from agriculture sector in India releasing 212.10 million tons of CO₂ eq (10.1 million tons of CH₄). GHG Emissions from rice field accounted for 20.9 % of the total GHG emissions releasing 69.87 million tons of CO₂ equivalent or 3.27 million tons of CH₄. Agricultural soils, a source of N₂O, mainly due to application of nitrogenous fertilizers in the soils accounted for 13% of the total GHG emissions, while,

burning of crop residues accounted for 2 % and manure management accounted for 0.7% of the total GHG emissions by the Agriculture Sector in India. The LULUCF sector in 2007 was a net sink. It sequestered 177.03 million tons of CO₂ (excluding wet lands). The estimates from LULUCF sector include emission by sources and or removal by sinks from changes in forestland, cropland, grassland, and settlements.

designing carbon sequestration policies. For example, reduced tillage usually reduces soil erosion and nutrient runoff, but it may increase the use of herbicides for controlling perennial weeds and thus may ultimately increase herbicide runoff. Conversion of cropland to perennial grasses may improve wildlife habitats and increase species diversity. On the other hand policy measures that are designed for addressing water qual-

ity, such as establishment of green set-asides and buffer strips can contribute to carbon sequestration.

Agriculture can participate in or be influenced by GHG mitigation efforts by ways of reduction of emissions from agricultural production; by creating or expanding sinks; Provi-

sion of products which can substitute emission intensive products and participating in Greenhouse gas mitigation policies on agricultural input and output prices (Mc Carl and Schneider, 2000). GHG emissions mitigation options in the livestock sector include improving grassland and pasture management; reduction of methane emissions of livestock through better diets and genetics, better manure management; and by reduction of nitrous oxide emissions through altered diet and improve manure storage and applications methods.

In addition to the above efforts all on-



Carbon sequestration options for cropland includes afforestation, conversion of cropland to perennial grasses, switching from conventional tillage (moldboard plough tillage) to reduced tillage or no-till. Options with lower carbon-storing potential include changing crop rotations, elimination of summer fallow, expanding the use of winter cover crops, and improved management of fertilizer, manure and irrigation (Antle 2009, Lewandrowski et al. 2004). Many of the carbon sequestration activities or mechanisms have ancillary benefits and costs that need to be taken into account when

going development initiatives need to be strengthened to reduce vulnerability of the agriculture sector to climate change. These initiatives includes developing agricultural markets, reducing distortions and subsidies in agricultural policies, continuing trade liberalization policies, enhancing social protection and microfinance, preparing for disasters and, critically, mainstreaming climate change in agricultural policies. However adaptation will require improvements that take existing development policies above and beyond their current capacity.

Innovative policies interventions include:

- (i) Changing investment allocation within and across sectors,
- (ii) Increasing the focus on risk-sharing and risk-reducing investments,
- (iii) Improving spatial targeting of investments,
- (iv) Eliminating existing detrimental policies that will aggravate climate change impacts, and
- (v) Reducing greenhouse gas (GHG) emissions from agriculture and increasing the value of sustainable farming practices through

the valuation of carbon and other forms of agricultural ecosystem services such as water purification and biodiversity.

Key components of new and innovative adaptation measures to climate change include

- (i) Changes in agricultural practices to improve soil fertility and enhance carbon sequestration;
- (ii) Changes in agricultural water management for more efficient water use;
- (iii) Agricultural diversification toward enhanced climate resilience;
- (iv) Agricultural science and technology development, agricultural advisory services, and information systems; and
- (v) Risk management and crop insurance

Agriculture should adopt environmental friendly technologies to move towards a climate resilient agriculture. The gains already made in the green revolution areas have to be sustained by means of management of soil health, water conservation and preservation of biodiversity. Reduction of use of fertilizers and other agricultural chemicals can reduce ener-

gy demand of agriculture sector. This calls for use of practices like Integrated Pest Management, Integrated Nutrient management, Conservation agriculture, Organic farming, newer and better methods of cultivation like System of Rice Intensification (SRI), System of Wheat Intensification (SWI) and also interventions at the genetic levels of crops. Use of renewable energy in agriculture needs further research, as there is tremendous potential. Use of Photovoltaics in agriculture and development of machineries based on solar and wind power like solar water pumps, solar farm fences etc. have and can be developed further. This can be streamlined with the pursuance of Government's resolve to implement the National Solar Mission. Proper use of biomass can also produce energy. Finally, effective implementation of an agenda for climate change adaptation will require mainstreaming climate change and adaptation into development planning, reforming climate-related governance and institutions, and undertaking new investments in agriculture to combat climate change.

TERI, New Delhi

कृषि टुडे

ग्रामीण भारत की सम्पूर्ण पत्रिका

पत्रिका को मंगाने हेतु

सदस्यता शुल्क

अवधि संस्था हेतु कंपनी व्यक्तिगत

एक वर्ष रु.400 रु.300 रु.240

पत्रिका की सदस्यता हेतु कृपया अपना ड्राफ्ट, 'कृषि टुडे' के पक्ष में निम्न पते पर भेजें।

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A Thought

Science With Compassion For A Hunger-Free World

It has been repeatedly proving that science & technology that is close and in harmony with nature is proving winner in the long run. If the past 60 years led to the Green Revolution in agriculture which often became Greed Revolution, the next 60 years should be the emergence of love for nature, diversity and Sustainable Green Revolution. The two goals- Sustainability and Productivity are inter-related as pointed out by Mahatma Gandhi many years back: "How can we be non-violent to nature, if we are going to be violent to each other?".

As said in the book, 'Revenge of Gaia' (James Lovelock), the main difference between the past and today is that our problems are truly global. We are also aware that globally and nationally the rich-poor divide is growing and though world produces enough food, nearly 800 million people remain good insecure. Among 8 millennium goals, eradication of poverty and hunger and environmental sustainability are perhaps the most prominent and

complimentary.

Soil Quality & Food Security

The Mother Earth Day is celebrated every year on 22nd April worldwide for creating awareness about the challenges of land degradation, soil and water problem and climate change. There is year by year a net depletion of nutrients in the soils. A decline in Organic Carbon content (SOM) of soils in a state likes Punjab (and many others) due to continuous cultivation of cereal based cropping system- for instance Rice-Wheat, Rice-Rice, etc. The continuous depletion of nutrients is a severe threat to soil health (SH), together with poor quality water and low vegetative inputs in to the soils.

The SOM (Soil Organic Matter) consists of living organisms (bacteria, fungi, earthworms, humus etc). The sources of SOM and humus serve as reservoirs of living organisms, which participate in the mobilization of plant nutrients and many more advantages to the soil health. Organic Car-



Dr. MH Mehta*

bon (SOC) is the energy source for soil organism and increasing SOC in tropical climate can be by continuous applications of lignocellulotic crop residues, Farm Yard Manure, biofertilizers, etc. The following Table-1 gives some typical data.

SOM is extremely important for crop productivity and particularly for poor soils of arid semi-arid and coastal areas. Its direct contribution to Nitrogen and Sulphur nutrition of crops and supporting soil biota responsible for creating pores through which water and air cannot be ignored. SOM plays a major role in the retention of cationic nutrients by dominant soils of these areas with weak ability to hold nutrient cations.

Africa and Asia are the two continents to watch for agricultural development. African farmland is losing fertility at an alarming rate. Their soils do require replenishments. African farmers pay 2 to 6 times the average world price for chemical fertilizers and most cannot afford.

Nature's way of making Nitrogen available for life relies on the action of a small group of bacteria that can break the triple bond between those two N atoms- a process called Nitrogen Fixation.

Agri Input Scenario – Alternative Model

Farmers worldwide are greatly con-

TABLE-1: Post harvest buildup of SOC by use of different Organic residues under different cropping sequences

Land use systems	Material added	Organic Carbon (%)
Ragi-cowpea-maize (3 yrs)	Control	0.30
	Farm yard manure	0.64
Rice-rice (10 yrs)	Control	0.43
	50% from inorganic + 50% through green manuring (Sesbania aculeate)	0.90
Rice-wheat (3 yrs)	Control	0.44
	Farm yard manure	0.54
Rice-wheat (7 yrs)	Fellow	0.23
	Green manuring (Sesbania aculeate)	0.37

Table 2: Bt Cotton & Superlife
Superlife: A Novel Microbial Consortia Formulation for Nutrition & Disease Control

Treatment	% Fungal Diseases	Yield Q/Ha
Bt Cotton	23.50	15.20
Bt Cotton Chem. Fungicide	15.00	16.72
Bt Cotton Superlife	10.50	20.35
Bt Cotton Chem. + Superlife	9.80	21.54



cerned about the high input costs for fertilizers, pesticides, seeds, etc. Indian farmers spend more than 20 lac million Rupees on these inputs, in spite of the fact that more than Rs.5 lac million goes for fertilizer subsidy. Fertilizer use efficiency is drastically declining for the reasons discussed earlier. As regards pesticides, the scenario is changing drastically. The European Council last year passed a directive banning more than 40% chemical pesticides and many Government (like Sweden) have started making a black-list of a number of toxic herbicides, fungicides and insecticides. This, coupled with new advancements in biopesticide industries, technology of organic movement is already bringing a major change taking this industry to 1 billion shortly. Next month, the European Parliament plenary will vote on proposed legislation to subject biopesticides to a quicker approval process than conventional pesticides.

Agri Bio Inputs (ABI) & 20: 20 Model

Scientific understanding of multi-microbial consortia technology for applications in biofertilizers and biocomposts, microbial and botanical biopesticides, bio-growth enhancers etc. has considerably increased. It has been demonstrated that a 20: 20 Model can be advantageously applied to a number of crops in a variety of situations in different countries. The model helps improve the farm productivity and at the same time lower the input costs through the use

of agri bio products. The range of multi-microbial products- as Biofertilizers, Biopesticides, Biocomposts etc. play a key role in these new generation inputs.

To Bt or not to Bt?

Science and technology is making tremendous changes to the extent that new discoveries happening in 5 years will be more than the past 50 years. When such changes are happening in all fields of science, we can not expect Agriculture to be free or



Table-3: The Science Ashram - GLS Farm, Chapad

Vegetables	Eggplant, Brinjal
Agribio inputs	Biocompost (Cow dung treated with wonderlife 1-2-3) & Pragati+ (DOC treated with Wonderlife 1-2-3)
Soil Application	Superlife, Tricholife, WL-g, Beaulife
Foliar Spray	MONOSHOT, NEEM-A-LIFE, NPV, BIOLIFE, GLS AMINOMIX, GLS KELP EXTRACT & GLS HOT FAVOURITE



less affected. But what is often not realized is that new developments are not only Genetically Modified (GM) or Atomic Modified Seeds, or Golden Rice. Comparatively simple looking innovations like drip irrigation, composting, multi-microbial biofertilizers or biopesticides have been playing heroic roles in our agricultural developments.

In a very interesting study about Bt-Cotton and Self-Identified Organic Cotton Farmers in Gujarat by Roy found that a large number of "organic" farmers consider Bt-Cotton to be organic. As a close witness to the debate on Bt-Cotton in India, particularly Gujarat in 2000-2002- as I look back at the scenario, where productivity has drastically improved and the amount of chemical pesticide use has substantially reduced, the major emphasis from farmers point of view shifts elsewhere. In the interaction with farmers, it also became clear that need for a special product like Bt-Special multi-microbial Super life helped the productivity and control of fungal diseases (which may become critical many times) as shown in following Table-2.

Another interesting debate is Bt-Brinjal. Farmers of Padra, District-Vadodara grow vegetables including Brinjal in a big way and usually resort to heavy doses of chemical pesticides up to 16 or 17 sprays. During our discussions, the farmers refused to believe that such high sprays (of costly and hazardous pesticides) can be avoided.

The best way therefore was to demonstrate and prove by field trials.

Farm : The Science Ashram – GLS Farm, Chapad village, Distt. Vadodara.

Area : About 1 acre reserved for Brinjal (Eco-friendly Brinjal Experiment).

We have been getting more than 20% higher production than the conventional farms nearby using heavy doses of chemical spray. Further our input cost was lower by nearly 25% (as our natural and biological products are available at much lower cost than the chemical input cost).

From the point of view of an average farmer, the priority is on a model, which gives good productivity and reduces input costs. Technology, which is sustainable and of long term benefit will be intelligently accepted by a farmer and his judgment is usually the final test. It is thus time to view such matters from the practical field conditions compared to the energy and times spent in several debates.

CONCLUSIONS

(1) As pointed out by Jan Tinbergen ('Beyond the Limits') : Two things are unlimited; the number of generations we should feel responsible for and our inventiveness.

(2) "Each 1 percent increase in agricultural productivity reduces poverty by 0.6 percent." A yield increase of 1 percent decreases the number of

people living with less than US\$ 1/ day by 6 million. Agricultural progress represents the best safety net against hunger and the greatest good it confers on the largest number of people.

(3) Ecologically improved technologies can lead to higher productivity without adverse impact on the natural resources and environment. Blending traditional and frontier technologies lead to give combined strength to Economics, Energy, Equity and Sustainability.

(4) Translating ecofriendly technologies in to action means improving productivity of small (and big) farms and well-being of people. One of the most important need of the world is developing a model to improve farm productivity at lower input costs in a sustainable manner.

(5) A hunger-free and nutrition secure world is possible. There is a vast untapped potential. We can support all the world's people adequately and sustainably long in to the future. We need to act and there are ways.

The great power of science can benefit the world when we know to temper it with compassion and love.

As said by Vivekanand : "We want today the bright sun of intellectuality joined with the heart of Budha."

**Chairman - The Science Ashram
Gujarat Life Sciences**

From Where Our Food Will Come

Vijay Jawandhia is a farmer in Vidarbha, the region which brought home to us the crisis that is compelling farmers to kill themselves.

He is also a leader of farmers. Recently, he spoke of new challenges: "In my village we are hiring vehicles and bringing people from cities to work in the field." Sounds bizarre but news stories from across farming regions suggest a similar trend.

What does this mean for food security? The fact is labour shortage, in part, is about the wages farmers can pay. It is for this reason the National Rural Employment Guarantee Scheme has often been accused of taking away labourers from farms. But the scheme pays a subsistence wage at best for the hard work of digging ponds and breaking stones. Nonetheless, it provides alternative work, thus, improving the bargaining power of farm labourers for wages.

Furthermore, if the assets-ponds, check dams, soil conservation structures and roads-being built under the scheme are indeed built, they will improve farm productivity and incomes. It is another matter that as yet the quality of rural assets is poor because the scheme focuses on jobs, not work.

The reasons for the growing shortage of farm labourers are not understood adequately but implications are obvious: there will be higher prices for farm work. As market economists will tell you this is good news, for it will increase the income and purchasing power of the poorest in the country.

Along with the increasing prices of other inputs, like seeds, fertilizers and water, higher wages will make growing food more expensive. Market economists will also tell you that this will place more money in the hands of poor farmers, themselves consumers of food. So everyone will grow richer. This is begging the question.

The bulk of Indian farming-over 60 per cent-is rainfed. Farmers have no option but to depend on an increas-

ingly erratic rainfall. They grow crops for subsistence; their very existence is threatened. One poor rain or flood can push them down the vicious spiral of poverty and destitution. They cannot afford expensive food.

So, there is no easy way ahead. It is time policy-makers recognized two critical facts. One, that growing food will cost money and two, that we cannot afford expensive ways of growing food. If the western world has flooded the food market, it is not because their ways of farming are more efficient or their farmers are more learned, but because their governments pay obscene amounts as subsidy to underwrite the costs of growing food. The European Union doles out US \$51 billion each year to its farmers to keep them in the market. European sugar farmers-whose produce our government imports often- are paid four times the world market price. Then the surplus is dumped in world market using an additional US \$1 billion in export subsidy, which depresses global prices. The situation in the corporate-run US farms is similar.

In India, policy must be designed to increase the minimum support price so that farmers are paid for the costs they incur. Today farmers invest large amounts of private capital into building the infrastructure for their operations unlike any private company or industry. They pay for building irrigation facilities-more than half the irrigated land is groundwater-irrigated. Some 19 million wells and tubewells have been built with private capital. This cost must also be accounted for in the food bill.

But as yet, policy has been caught between a rock and a hard place. On one side are poor farmers who need to be paid for growing food. On the other side are vast numbers (also farmers) who cannot afford the price of that food. As yet, the policy has been to subsidise food, not pay farmers. The public distribution system is designed to buy vast quantities of food grain and supply it to people. It



Sunita Narain

depends on keeping the price of procurement as low as possible. That's what the minimum support price is all about.

This will not work in the future. India will have to design policies to pay farmers the real cost of growing food, and to pay them directly. This means revamping the fertilizer subsidy, which pays companies to make fertilizers, not farmers to buy it. The challenge of reaching cheap food to vast numbers still remains. That's why the policy must recognize the need to cut the cost of growing food as well. We are obsessed with crop yields, not realizing that high-input farming is based on just one principle: increased cost of production. This can work where consumers are affluent enough to pay the price or governments are rich enough to subsidise farmers. It will not work in India.

India has to find ways of valuing agriculture, which is low-input but gives relatively low yields. It is here that policy must be innovative. We must invest big time in marginal agriculture. This means doing watershed development to recharge groundwater and decentralized water harvesting to improve irrigation. This also means better seeds and procurement of locally grown food at good prices for food distribution programmes. This will build local food sufficiency. These are game changer steps. Let's try them for once.

Director, Centre for Science and Environment, New Delhi

INTERNATIONAL AGRICULTURE CONSULTING GROUP

Indian initiative towards food and agriculture solutions

Vision

Our vision is to be a leading provider of Indian regional expertise in food and agriculture and to outstand as key advisory partners on food security concerns, policy planning and strategy framework for sustainable development through agriculture.

Mission

Our mission is to initiate and support micro and macro level changes in agriculture by providing Indian expertise and solutions for research, extension, education, training, institutional frame, policy planning, agribusiness and project consulting so as to address their major agricultural concerns relating to farm production, food security, environment sustainability, rural employment, economic growth and human resource development.



Objectives

1. Provide Indian expertise to deliver solutions to agricultural issues and concerns through formulation of agro and rural development projects, farming solutions, micro and macro level national agriculture planning, policy support, organized research, extension infrastructure and institutional set-ups, value addition and market linkage services.
2. Manage short terms management programs, training and entrepreneurship course for farmers, research & extension personnel, officials and professionals of various countries while recognizing and understanding ecological, technological, social and economic concerns related to their food and agriculture sector.
3. Facilitating students from different countries in enrolling in food and agricultural degree programs; management and entrepreneurship courses offered by various institutes and recognized universities of India, so as to help various countries in developing human resource for creative and productive change at ground level.
4. Organizing delegation level visits from India to various countries and of different countries to India for participation in agri and business summits, learning and exposure at technology institutions, agri universities, model farms etc., and discussing possibilities for joint ventures, collaborations and promoting better understanding in agriculture and agribusiness.
5. Facilitating Governments, Corporates or Institutions to venture globally and act as total solutions providers in implementation of foreign agriculture projects by providing research structure, technical assistance and investment planning in food, farming, agribusiness or agriculture development programs.



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