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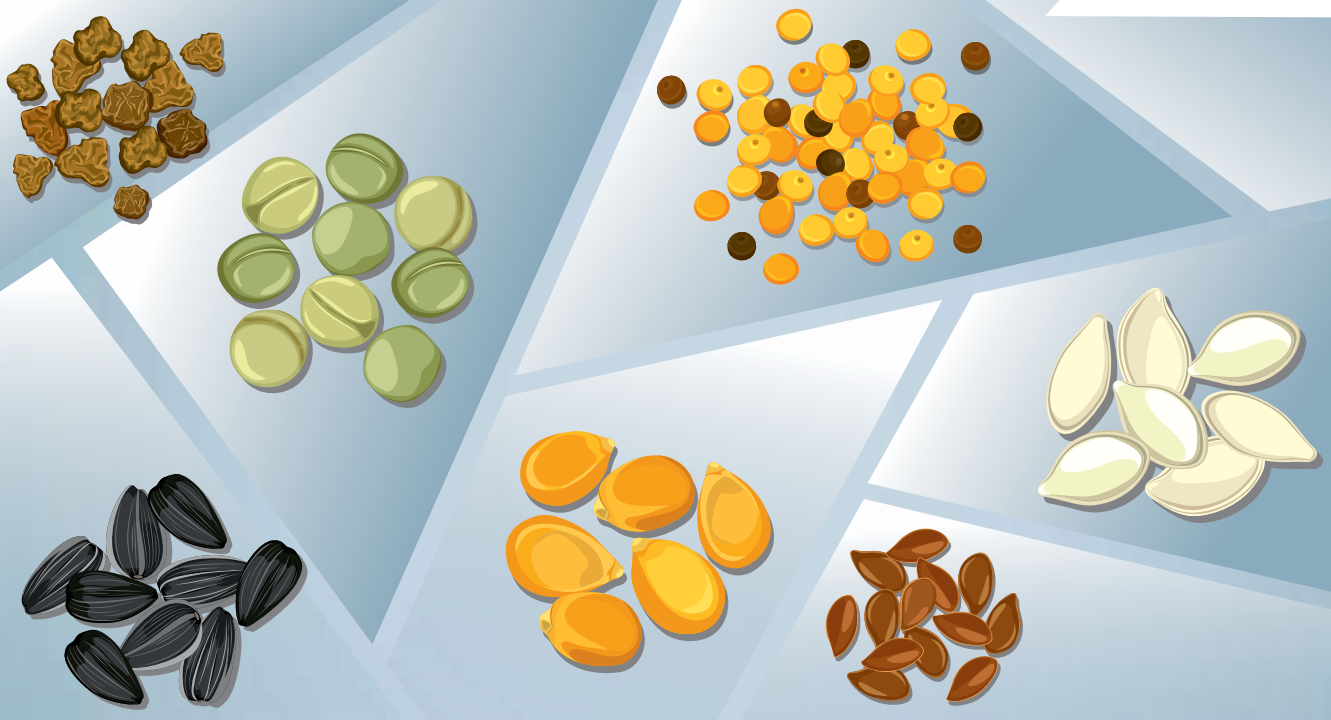

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STRENGTHEN AGRI R&D SECTOR

Economic Survey 2021-22 observed that Research and Development in agriculture & allied sectors can play a major role in realisation of sustainable agriculture practice that efficiently meets the objectives of nutritional security and improvement in farm income. Research shows that every rupee spent on agricultural research and development, yields better returns compared to returns on money spent on subsidies or other expenditures on inputs. The increase in agriculture R & D therefore may improve productivity in the crop and allied sectors.

It is an overlooked observation as we have seen hardly any traction on investments in agri R&D. As a percentage of Agricultural GDP, India spent 0.5% of its Ag GDP on agricultural research in 2011, which was lesser than the share invested by China (0.62%) and Brazil (2.6%). It should be noted that India's agriculture fortunes were changed with R&D. We could usher in green revolution and hence could prevent a complete collapse of the food stocks.

Today we are faced with bigger threats of climate change, dwindling resources, loss of biodiversity, urban expansion and many more and, to fully commit our faith in R&D. While we should be investing massively in developing varieties that can withstand climate variables, we are spending on subsidies. While we need to think about scaling production without increasing area, we are promoting unscientific practices.

It is also to be pondered upon whether the work done by researchers are reaching the farmers. The Committee on Doubling of Farmers' Income or popularly known as the Dalwai Committee once questioned the extent of penetration of research at the grass root level. More than 50,000 dedicated agricultural scientists are working to address field level problems and to evolve technological solutions. However, all the technologies developed by these scientists have not always reached all the farmers. So along with increasing public spending on agricultural R&D, our extension machinery need to be strengthened.

The research outputs developed should strictly adhere to economic considerations as well. We are a country of small and marginal farmers. So the research outputs should consider scalability and should be gender inclusive.

Our research priorities should mirror the ground realities. The research sector should be strengthened by incentives and offer motivation. I hope the new government would be able to grant the much needed support to Agri R&D.

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RESEARCH AND DEVELOPMENT

KEY TO SAFEGUARDING FOOD SECURITY AND NUTRITION

India's food security story is at a critical juncture. With a burgeoning population projected to reach 150 crore by 2030-32, the demand for food grains is estimated to reach a staggering 350 million tonnes. This burgeoning demand coincides with a period of environmental challenges: depleting natural resources and the ever-present threat of climate change. In this complex scenario, agricultural Research and Development (R&D) emerges as the cornerstone of securing agricultural productivity and environmental sustainability.

With the global population continuing to expand and rising temperatures placing strain on farming resources, the agricultural sector faces an uphill battle. Agricultural companies must harness the power of R&D to fortify the sector against these challenges through continuous resource enhancements and production improvements. The overarching strategy to meet escalating demand revolves around enhancing productivity while simultaneously increasing the income of farmers.

Efficient Resource Utilization

Precision agriculture, a revolutionary approach that utilizes cutting-edge technologies like drones, sensors, and satellites, offers a viable solution. By optimizing farming practices with these tools, farmers can

achieve significant gains in efficiency and sustainability.

A prime example of this approach is Direct Seeded Rice (DSR), a pioneering practice developed in India. DSR eliminates the need for puddling, a traditional method that involves saturating fields with water. This innovative technique not only conserves millions of liters of precious water but also reduces methane emissions, a potent greenhouse gas. This win-win situation for both farmers and the environment exemplifies the power of precision agriculture.

Another game-changer is drip irrigation, a technology that ensures water reaches plant roots directly, minimizing wastage. This targeted approach, alongside advancements in soil health management and the use of biofertilizers, empowers farmers to become responsible stewards of the land. These advancements, coupled with ongoing research, are crucial for building a more sustainable and resilient agricultural sector.

Varietal Enhancements

Consider the case of cotton, notorious for its water-intensive nature. Technological breakthroughs like Bt cotton have significantly reduced pesticide usage, safeguarding farmer health and environmental integrity. Similar success stories unfold in maize cultivation, where hybrid varieties and improved crop management practices have bolstered yields, rendering India self-suf-

Public investment in R&D necessitates a substantial boost.

About the **AUTHOR**

Mr Ajai Rana,
Chairman FSII, & CEO and Managing Director, Savannah Seeds Pvt Ltd

In the pursuit of sustainable agriculture, a holistic approach is essential. Beyond technological advancements, attention must be paid to social and economic factors. Empowering smallholder farmers, who constitute a significant portion of India's agricultural workforce, is crucial. Access to credit, markets, and education plays a vital role in enhancing their productivity and resilience. Furthermore, gender equity in agriculture is essential, as women make substantial contributions to farming but often face barriers in accessing resources and decision-making roles.

ficient in this vital food source. Moreover, research in farm mechanization is curbing reliance on fossil fuels, paving the way for a greener agricultural footprint.

Despite their potential, genetically modified (GM) crops remain contentious, particularly in India due to stringent regulations. However, evidence underscores their benefits. Bt cotton, for instance, has slashed insecticide dependency, leading to higher yields and increased farmer incomes. Golden Rice, fortified with Vitamin A, represents a beacon of hope in combating childhood blindness. These instances highlight the significant contributions of GM technology, subject to rigorous testing and regulation, in enhancing food security and nutritional well-being. Furthermore, the advent of gene editing tools like CRISPR promises even more precise modifications, heralding a new era of sustainable crop improvement.

Technological breakthroughs like Bt cotton have significantly reduced pesticide usage, safeguarding farmer health and environmental integrity.

Challenges Persists

While strides have been made, challenges persist. Public investment in R&D necessitates a substantial boost. Bridging the gap between research and on-farm application demands strengthened extension services and farmer education. Collaboration between public and private sectors remains imperative to expedite innovation and ensure widespread adoption of new technologies.

Environmental sustainability must also be prioritized. Climate-smart agriculture practices, such as conservation agriculture and agroforestry, mitigate climate change impacts while promoting biodiversity and soil health. Agroecological approaches, which emphasize natural processes and ecosystem services, offer viable alternatives to conventional farming methods reliant on synthetic inputs.

Collaboration for Accelerated Progress

Policy support is indispensable in driving the transition towards sustainable agriculture. Incentives for eco-friendly practices, subsidies for renewable energy adoption, and regulations to curb agrochemical misuse are essential. Moreover, investment in rural infrastructure, including irrigation systems and storage facilities, is imperative to enhance agricultural productivity and market access.

International collaboration can further accelerate progress towards sustainable agriculture. Knowledge sharing, technology transfer, and joint research initiatives enable countries to learn from each other's experiences and innovations. Global partnerships, such as the United Nations' Sustainable Development Goals and initiatives like the Climate Smart Agriculture Alliance, provide platforms for collective action and knowledge exchange.

Embracing sustainable practices, deploying genetic engineering responsibly, and fostering collaborative R&D endeavors hold the key to cultivating a future of abundance. By prioritizing innovation and sustainability, India can navigate the challenges ahead and emerge as a global leader in agricultural resilience and food security. With concerted efforts from policymakers, researchers, farmers, and stakeholders across the agricultural value chain, India can build a resilient and sustainable food system that meets the needs of present and future generations.

CONFERENCE REPORT

GENOME EDITING

Ensuring a Resilient and Sustainable Agrifood System

Speedy development and adoption of genome-edited crops with targeted traits such as enhanced water and nutrients use-efficiency, reduced greenhouse gas emissions, reduced dependence on agrochemicals and pesticides, and with inbuilt resilience to the fast-changing climate have become necessary for sustainable development of agriculture. Development of such improved crops requires discovery of target genes and alleles associated with different agronomic traits through the enhanced use of entire GenBank accessions and exploring the existing crop diversity using the current genomics and molecular approaches.

An unprecedented global revolution is shaping up due to various applications of this powerful technology in genetic improvement of crops. The genome editing technology enables the manipulation of targeted genes in a precise and efficient manner in different organisms and cell lines, including crops of agricultural importance.

The genome editing technology enables the manipulation of targeted genes in a precise and efficient manner in different organisms and cell lines, including crops of agricultural importance.

Government Support

Importantly, Government of India created an enabling environment and announced exemption of genome edited crops from biosafety assessment in the year 2022, under the Rules 1989 (EPA1986) based on scientific reasoning that the resultant crop varieties do not carry any vector or foreign, exogenously introduced DNA and remain indistinguishable from the products developed through conventional breeding.

Subsequently, guidelines and SOPs were developed to encourage researchers for using this technology within the biosafety framework as described in the SOPs (https://dbtindia.gov.in/sites/default/files/SOPs%20on%20Genome%20Edited%20Plants_0.pdf). This has provided the much-needed impetus to leverage the technology for addressing the key issues related tothe climate crisis that is looming large, and for ensuring food security, environmental sustainability and the much-needed self-sufficiency in edible oilseeds and pulses production. Another decision by

About the **AUTHORS**

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Viswanathan Chinnusamy,
Joint Director (Research), ICAR-Indian Agricultural Research Institute (IARI), Pusa, New Delhi

These two recent positive developments motivated us to organize these conferences focusing on both GM technology and genome editing, and the young researchers around the country who participated in large numbers in these conferences to take up research and development for enhancing food production using the new genetic technologies. Further, these recent developments have opened avenues for integrating the use of crop diversity with the advanced gene-based technologies for efficient product development, and ensuring a resilient and sustainable agrifood system.

The Chief Guest, Dr. Trilochan Mohapatra, Chairperson, PPVFRA, Govt. of India addressing the conference participants; February 16, 2024, NASC, Pusa, New Delhi.

the Government of India in the same year (2022) resulted in the environmental release of a gene technology for developing high yielding GM mustard hybrids.

Recommendations that Emerged from the Conferences

- Speedy development of crops with inbuilt climate resilience combined with efficient use of water and nutrients, high nutritional density yield is a must.
- Undertake 'on priority' research and product development using genome editing to be self-sufficient in pulses and edible oilseeds production.
- Enhance utilization of entire GenBank accessions and the available genetic diversity for discovering target genes and alleles associated with climate resilience, desired plant type and domestication of wild crop species and relatives.
- Undertake focused research on functional genomics using CRISPR-Cas system for identification of target genes for desired traits for product development.
- Major emphasis is needed to develop:(a) functional transformation protocols in prioritized elite crop varieties, (b) easy and efficient methods for CRISPR reagents delivery, and (c) an efficient DNA-free, RNP-based gene editing systems in vegetatively propagated crops.

Genetic engineering technology for developing GM crops is complementary to genome editing and otherbreeding technologies

- Identify and validate diverse RNA-guided DNA nucleases (other than Cas9) for index creation in plants.
- To overcome the low efficiency of HDR-based SDN2 in plants, use base editing and prime editing for diverse biological applications including crop improvement.
- Develop indigenous novel gene editing tools so as to enjoy "Freedom to operate (FTO)". Simultaneously, address the CRISPR-Cas technology related IPR issues for timely and effectively utilizing these technologies for the benefit of agriculture and allied sectors.
- Develop viable partnership between public and private laboratories,and networking with international laboratories.
- Organize capacity building workshops for young researchers and plant breeders, and conduct educational, awareness programmes for the public at large for taking the science to society, including the regulators and legislators.

General remarks

- Effective use of genome editing and genomics technologies are necessary for globally competitive agriculture, and for achieving the United Nations Sustainable Development Goals (SDGs-2030) and beyond.
- More funding for infrastructure and HRD is required for wider adoption of genomics assisted breeding, and genome editing technologies.
- Genetic engineering technology for developing GM crops is complementary to genome editing and other breeding technologies. Hence, it should not be ignored as many traits such as insect resistance, production of novel molecules, synthetic biology, etc. can be developed with the best use of genetic engineering alone. Hence, continuous support in terms of funding and policy execution are necessary for developing and timely commercial release of GM crops.

Prof. Bansal delivered the valedictory address and motivated the young researchers for searching innovative and scientific but nature-based solutions to the current burning problems facing agriculture. He stressed upon applying the frontier, molecular science-based technologies, including genetic engineering and genome editing for ensuring a resilient, sustainable and food secure world for all.

INVESTING IN RESEARCH

Australia ranks fourth in the world behind Brazil, Argentina and the Netherlands as a net exporter of agricultural products.

Australia typically exports 60 to 70 per cent of its agricultural products, hence helping meet the food requirements of Australia's 25 million people, plus another 60 million overseas. In addition to this, a conservative estimate suggests that Australia helps feed between 400 and 500 million people in developing countries as a result of leading or participating in agricultural education, training, development, knowledge and technology transfer in partnership with developing countries and International Agricultural Research Centres (IARC).

Dwindling Resources and Spiralling Demand

We must remember that the world's population just surpassed 7.7 billion and is on track to add yet another billion in the next decade. Modern society can't thrive without access to a high level of quality food, produced sustainably and economically, and the challenge is to find solutions to declining natural resources and inclining human population.

Feeding the growing population will require renewed and vigorous efforts to enhance agricultural productivity, utilising all the advantages modern science (including socioeconomics) and technology bring.

Using a wide range of indicators, including water, fertiliser and energy use efficiency and rate of adoption of technologies such as new varieties and production practices (e.g. zero tillage, crop rotations and precision agriculture), Australian agriculture leads the world. Continued long-term improvements in world food production are fundamental to world security. Feeding the growing population will require renewed and vigorous efforts to enhance agricultural productivity, utilising all the advantages

About the **AUTHOR**

Professor Kadambot Siddique is the Hackett Chair of Agriculture and Director of the UWA Institute of Agriculture, The University of Western Australia.

modern science (including socioeconomics) and technology bring.

Declining Productivity

The productivity growth in Australian agriculture has slowed during recent years. However, international competitors have been making rapid advancements. With the reduction in cost of production and improvements in supply chain efficiencies, competitors such as the Black Sea countries may erode Australia's market share especially wheat in key international markets. As global demand increases, there are emerging opportunities for Australia to capitalise on.

A general challenge the Australian agricultural sector faces is to develop the production systems we need to supply. The potentially significant increase in demand in new markets require this in order to avoid damaging the landscape and increasing substantially our environmental footprint.

Advancements in Dryland Food Production

The past 50 years have seen tremendous advances in dryland food production systems and, in this field, we are on the frontier of global practice. This is entirely the result of decades of diligent research and development, and honing the mechanisms to share findings and see them translated to our innovative farmers and the industry.

Western Australia has recently set a plan to double agricultural production in the state by 2030. In order to achieve the above target WA should focus on:

- An increasingly variable climate will require close monitoring, innovative research, development and continued adaptation of predominantly dryland farming systems in Australia.
- Versatility in our systems to manage risks associated with markets and climate. We need systems that enable producers to cope with 'poor' seasons and capitalise on 'good' ones, which will depend on scientific innovation as well as innovation and leadership in business and the partnerships across the industry supply chain and end-markets.

The new digital technologies now available promise a new era of agricultural science and research.

Two-and-a-half billion people globally now depend on dryland farming for food and livelihood. Drylands cover more than 40 per cent of the world's land area and are home to one-third of the world's population. The effects of climate change will lead to even more water scarcity and declining crop yields, leaving the people of these regions acutely vulnerable in the absence of appropriate risk management strategies. The inherent complexity of the drylands requires an integrated systems approach. The immense diversity and magnitude of the issues and challenges call for a strategic approach with realistic prioritisation for steady impact. Improved adaptation and resilience in agricultural production and food supply are a high priority.

New Era of Research Unfolds

The new digital technologies now available promise a new era of agricultural science and research. The application of these technologies – drones, sensing equipment, data collection techniques – offer the means of achieving even better outcomes. New areas and methods of agricultural research – crop simulation models, smart genetics, ecosystem management and the improvement of farm-level decision-making through digital support – are the new frontiers.

INNOVATIONS & RESEARCH IN CROP PROTECTION

Crop protection stands as a cornerstone of modern agriculture, vital for ensuring crop health and productivity while minimizing environmental harm. Amidst the escalating challenges posed by climate change, evolving pest resistance, and the imperative for sustainable agricultural practices, continuous innovation in crop protection becomes imperative. Technological advancements have catalyzed a significant transformation in the agricultural landscape, with the integration of robotics emerging as a particularly promising avenue.

However, before exploring these innovative solutions, it's essential to grasp the pressing challenges confronting the crop protection industry. Conventional methods often rely heavily on chemical pesticides, which not only contribute to environmental pollution but also harm non-target organisms and foster pest resistance. Moreover, the escalating impacts of climate change introduce new pressures in terms of pest and disease dynamics, underscoring the urgent need for innovative technologies, practices, and strategies.

Virtual screening offers a powerful tool for accelerating molecule discovery and unlocking new avenues for crop protection.

Early Detection and Prevention in Crop Protection

The integration of remote sensing, IoT, precision agriculture, hyperspectral imaging, and molecular diagnostics has revolutionized early detection and prevention in crop protection. These technologies enable farmers to monitor crop health in real-time, identify po-

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CRISPR-Cas technology enables precise gene editing in crops, facilitating the development of traits such as disease resistance and improved nutritional content. Biofortified crops, engineered to contain higher levels of essential nutrients, address malnutrition and enhance food security, showcasing the diverse applications and benefits of biotechnological advancements in crop protection and agricultural development.

tential threats, and implement targeted interventions, reducing the reliance on chemical inputs and promoting sustainable farming practices. By leveraging these innovative tools, farmers can enhance crop productivity, mitigate risks, and ensure the long-term viability of agricultural production in an ever-changing environment.

Remote sensing technologies, including drones and satellite imagery, provide farmers with comprehensive insights into their fields, allowing for early detection of crop stress, nutrient deficiencies, and disease outbreaks. Additionally, sensor networks and IoT devices offer real-time monitoring of environmental conditions, facilitating proactive decision-making in irrigation scheduling, pest management, and crop protection measures. Precision agriculture technologies optimize input use and minimize resource waste, while hyperspectral imaging and molecular diagnostics provide detailed information on crop health status, enabling targeted intervention strategies.

Accelerating Molecule Discovery by Virtual Screening in Crop Protection

Virtual screening offers a powerful tool for accelerating molecule discovery and unlocking new avenues for crop protection. By harnessing the power of computational algorithms and predictive models, researchers can identify promising lead compounds, optimize their properties, and expedite the development of next-generation crop protection products. Numerous success stories in the field of crop protection attest to the transformative power of virtual screening.

From the discovery of novel insecticides to the development of innovative fungicides, virtual screening has enabled researchers to identify potent molecules with unprecedented speed and precision. By leveraging computational tools and predictive models, companies and research institutions are revolutionizing the way we approach molecule discovery, paving the way for a more sustainable and resilient agricultural future. As virtual screening techniques continue to evolve and improve, we can look forward to a future where agriculture is more resilient, sustainable, and productive than ever before.

Biotechnology solutions including CRISPR-Cas technology, have revolutionized crop protection, offering sustainable solutions to enhance plant resilience and reduce reliance on chemical pesticides.

Biotechnological Solutions

Biotechnology solutions including CRISPR-Cas technology, have revolutionized crop protection, offering sustainable solutions to enhance plant resilience and reduce reliance on chemical pesticides. Through genetic engineering techniques, researchers can develop crop varieties with enhanced resistance to pathogens, pests, and abiotic stresses, reducing the need for chemical inputs and promoting sustainable farming practices.

Biotechnological innovations such as Bt crops, engineered to produce insecticidal proteins, and RNA interference technology, which silences specific genes in pests or pathogens, have demonstrated remarkable success in controlling insect pests and diseases while minimizing environmental impact. Additionally, the development of biopesticides and biostimulants derived from natural sources, facilitated by biotechnology, provides environmentally friendly alternatives to synthetic chemicals for crop protection and growth enhancement. Herbicide-tolerant crops and disease-resistant varieties developed through biotechnology empower farmers to manage weeds and combat

plant diseases effectively, contributing to improved yields and agricultural sustainability.

Nanotechnology

Nano-technology holds immense promise in revolutionizing plant protection strategies by enabling targeted delivery of pesticides, enhancing their efficacy while reducing environmental impact. Nanopesticides, formulated using nanoparticles, exhibit improved penetration, adhesion, and controlled release properties, leading to lower application rates and reduced off-target effects.

By leveraging nanomaterials such as nanoparticles, nanotubes, and nanofibers, researchers can develop novel formulations for targeted delivery of pesticides and biopesticides, enhancing their efficacy while reducing environmental impact. Nano-enabled formulations exhibit improved properties such as increased stability, controlled release, and enhanced penetration, enabling more precise and efficient pest management. Additionally, nanosensors and nanomaterial-based diagnostic tools facilitate early detection of plant diseases and nutrient deficiencies, enabling timely intervention and precise monitoring of crop health.

Data-Driven Decision Making

In the digital age, data is king. By collecting and analyzing vast amounts of information about soil health, weather patterns, and pest populations, farmers can gain valuable insights into the dynamics of their fields and make data-driven decisions about crop protection strategies. Machine learning algorithms can crunch this data in real-time, providing farmers with personalized recommendations for pest control measures tailored to their specific needs.

Remote Monitoring and Control of Farms

One of the most exciting developments in digital agriculture is the ability to remotely monitor and control crop protection measures. Through the use of IoT-enabled devices and cloud-based platforms, farmers can now monitor their fields from anywhere in the world, receiving alerts about pest outbreaks or environmental conditions that require immediate attention. Automated systems can even take action on behalf of the farmer, deploying drones to spray pesticides or adjust irrigation systems as needed.

Implementation to Make an Impact

To translate these innovations/technologies/practices into tangible benefits for farmers and ecosystems, collaboration among stakeholders is crucial. Governments, research institutions, industry players, and farmers need to work together to foster research, develop appropriate regulatory frameworks, and promote adoption of sustainable crop protection practices.

- **Research Collaboration:** Encourage collaboration among researchers, academia, and industry to accelerate innovation in crop protection. Funding initiatives and grants should prioritize interdisciplinary research projects addressing key challenges in sustainable pest management.
- **Technology Transfer and Extension Services:** Establish extension programs to disseminate knowledge and best practices in crop protection to farmers. Utilize digital platforms, demonstration plots, and farmer field schools to promote adoption of innovative technologies and sustainable practices.
- **Policy Support:** Develop policies and regulations that incentivize the adoption of sustainable crop protection practices while ensuring safety and efficacy. Support initiatives promoting integrated pest management, organic farming, and reduced pesticide usage through subsidies, tax incentives, and certification programs.
- **Capacity Building:** Invest in training programs and capacity building initiatives to empower farmers with the skills and knowledge needed to implement integrated pest management practices effectively. Provide access to extension services, training workshops, and educational materials tailored to local contexts.
- **Monitoring and Evaluation:** Establish robust monitoring and evaluation mechanisms to assess the impact of innovative crop protection strategies on agricultural productivity, environmental sustainability, and farmer livelihoods. Use feedback mechanisms to refine interventions and improve their effectiveness over time.

Innovation in crop protection is essential for ensuring food security, environmental sustainability, and the resilience of agricultural systems in the face of emerging challenges. By leveraging advancements in technology, sustainable practices, and integrated pest management, we can develop holistic solutions that promote productivity while minimizing environmental impact. Through collaboration, policy support, and capacity building efforts, we can translate these innovations into actionable strategies that benefit farmers, ecosystems, and society as a whole and resilience.

INDIA COUNCIL OF GRAINS AND PULSES LAUNCH

India Grains and Pulses Council under the aegis of Indian Chamber of Food and Agriculture (ICFA) was launched on 12th April 2024 at The Park Hotel, New Delhi, marking a strategic initiative to tackle challenges, leverage emerging opportunities, and propel the growth and prosperity of the pulses and grains sector in India.

Dr MJ Khan, Chairman; Prof. Ramesh Chand, Hon'ble Member, Niti Aayog; Shri RK Tiwari, Chairman IGPC Steering Committee, Ex Chief Secretary, UP; Mr. Deepak Pareek, Convener IGPC; Mr. Tarun Bajaj, Director, BEDF, APEDA; H.E. Dr. Manoj Nardeo singh, Secretary General, AARDO; H.E. Mr. Moe Kyaw Aung, Ambassador, Embassy of Myanmar; Mr. Arnaud Petit, Executive Director, International Grains Council (IGC); Mr. Amrendra Mishra, Managing Director - India, ADM; Mr. Sanjay Sacheti, Country Head - India, Olam Agro; Mr. Dushyant K Tyagi CEO Farmgate Technologies; Sh. Samuel Praveen Kumar, Joint Secretary, Dept of Agriculture and Farmers Welfare, Govt. of India were present.

International Trade and Cooperation in Grains and Pulses

H.E. Sh. Manoj Nardeo Singh, Secretary General, AARDO stressed on the need for innovative approaches and sustainable practices in agriculture, especially in the context of changing climate patterns and evolving global trade dynamics. He underlined the importance of sharing knowledge, technology, and best practices among nations to achieve food security goals and ensure sustainable agricultural development.

H.E. Mr. Moe Kyaw Aung, Ambassador, Embassy of Myanmar highlighted the importance of technology transfer from India to Myanmar, urging Indian investors to consider opportunities in Myanmar and provide technical assistance to enhance productivity and trade collaboration. He expressed his optimism about future cooperation between India and Myanmar, particularly in enabling direct trade in rupees. He looked forward to strengthened cooperation and mutual benefit through increased trade partnerships and exchange of expertise.

H.E. Mr. Peter Hobwani, Ambassador, Embassy of Zimbabwe, emphasized the importance of strengthening bilateral trade between India and Zimbabwe and highlighted key challenges faced by Zimbabwe, such as climate change and food insecurity. Mr. Hobwani also stressed on the importance of Indian investment in manufacturing sectors across Africa. He sees this as a valuable opportunity for both countries to collaborate and contribute to economic growth and job creation in the region.

Mr. Arnaud Petit, ED, International Grains Council highlighted the trade dynamics between Africa and Asia, particularly emphasizing on India's tremendous improvement in productivity in the grains and pulses sector. Mr. Petit discussed the export-import scenario of India and underscored the significant opportunity for Asian countries to supply products to various regions, thereby fostering trade development. Regarding pricing challenges, Mr. Petit stressed the importance of having accurate yield forecasts to navigate market fluctuations effectively. He also pointed out the considerable market potential in the coming years, both in terms of trade volume and opportunities, offering valuable insights into market trends and dynamics.

Policies concerning grains and pulses production, logistics, consumption, value addition, marketing and exports

Mr. Amrendra Mishra, MD, ADM emphasized on the need for an ecosystem approach for pulses and grains systems which involves incorporating research and development (R&D) initiatives alongside establishing a niche for logistics and warehouses. He stressed on the need for collaborative efforts among industry players, government agencies, and research institutions to develop and implement strategies that harness full potential of India's pulses and grains systems.

Mr. Sanjay Sacheti, Country head, OLAM emphasized the need for conducive policies and resilience in the production part, stressing the importance of a resilient farming system. He also highlighted the necessity of investments in logistics and infrastructure to enhance competitiveness in the global market. He called for policies that prioritize value maximization and also discussed the government's role in supporting pricing systems to ensure fair returns to farmers and promote sustainable agricultural practices. He stressed the need for strategic planning and policy frameworks that encourage innovation, efficiency, and quality in agricultural production. Additionally, he emphasized the role of partnerships between the private sector and government agencies in driving positive change and fostering growth in the agriculture sector.

Mr. Tarun Bajaj, Director, BEDF, APEDA touched upon the potential for value addition and diversification within the sector, highlighting the importance of technological advancements, sustainable practices, and market intelligence in maximizing the sector's potential. He also emphasized the need for continuous dialogue, research, and policy support to ensure the long-term viability and competitiveness of India's grains and pulses industry on both domestic and international fronts.

Mr. Dushyant K Tyagi, CEO Farmgate Technology highlighted the significance of digitalization in the agricultural sector. He commended the thoughtful objectives set by the council, stressing the importance of transparency between production and availability of agricultural products. Mr. Tyagi emphasized that for the system to be successful, stakeholders must have choices and access, underlining the critical role of digitalization in both production and post-harvest trading. He further emphasized the importance of focusing on India's export and import strategies to enhance market opportunities and global competitiveness.

Sh. Samuel Praveen Kumar, Joint Secretary Dept of Agriculture and Farmers Welfare discussed the role of the private sector in assisting the government in creating the right buffers to ensure food nutrition and security. He highlighted the importance of farmer-centric approaches to pricing and efforts, emphasizing the need for strategies that prioritize the well-being and empowerment of farmers. Moreover, Sh. Kumar touched upon the pressing issues of climate change, water management, and soil health, noting the importance of

implementing buffering mechanisms to mitigate risks and ensure the resilience of the agricultural sector.

Sh RK Tiwari, Chairman IGPC Steering Committee, Ex Chief Secretary, UP highlighted the centrality of farmers in agriculture and underscored the importance of making swift decisions in the sector. He emphasized the need for agility and responsiveness in policy-making to address the evolving needs and challenges faced by farmers and the agricultural industry.

Prof. Ramesh Chand, Hon'ble Member, Niti Aayog said that "Whenever there is a global shock, it's always agriculture that provides resilience." He identified a critical issue where food production often exceeds consumption due to challenges in distribution, leading to food wastage. He predicted that institutions like IGPC would become even more important in the future, especially as plant-based foods gain prominence due to climate change concerns. Prof. Chand made an important observation regarding livestock, which primarily consumes by-products of grains and pulses such as wheat and maize. This aspect contributes to the sustainability of agriculture by utilizing resources efficiently and maintaining a balanced ecosystem. Furthermore, he discussed the importance of trade intelligence in meeting market demand, emphasizing the need for right pricing strategies based on quantity and quality to facilitate efficient trade of grains and pulses, ensuring sustainability and economic viability for farmers and traders alike.

Mr. Deepak Pareek, Convener IGPC elaborated on the specific initiatives and objectives that IGPC aims to achieve in the grains and pulses sector. Mr Pareek highlighted the council's focus on promoting technological advancements and said that these efforts aim to enhance productivity, reduce resource wastage, and improve overall efficiency in grain and pulse production. Mr. Pareek discussed IGPC's plans for capacity building and skill development among farmers and agricultural stakeholders and also highlighted the council's role in advocating farmer-friendly policies, fair pricing mechanisms, investment incentives, and trade facilitation measures that promote the growth and competitiveness of the industry.

Dr. Khan expressed gratitude to all dignitaries, participants, and attendees for their valuable contributions and support towards the successful launch of the Indian Grains and Pulses Council.

RECOMMENDATIONS

- Promote collaboration among stakeholders
- Encourage widespread adoption of technology-driven solutions
- Invest in training programs, workshops, and knowledge-sharing initiatives to build the capacity of farmers, agricultural extension workers, and rural communities
- Advocate policy reforms that support sustainable agriculture
- Launch public awareness campaigns to educate consumers about the environmental and social benefits of choosing sustainably produced food
- Promote local and organic farming practices, and encourage responsible consumption and waste reduction.

THE CHALLENGE OF BIOPESTICIDES

TACKLING REGULATORY AND ADOPTION ISSUES IN INDIA

With a shift in practices worldwide, biopesticides have emerged as a promising solution to combat the environmental issues linked to synthetic pesticides. India, being one of the leading producers globally, is on the brink of taking the lead in embracing biopesticides. However, obstacles hinder the country's acceptance of these environmentally friendly alternatives.

The Regulatory Barrier: India's Struggle

A challenge slowing down the expansion of the biopesticide sector in India is its system. The process for registering biopesticides is often intricate, as it demands data on effectiveness, safety measures and environmental impacts. This time-consuming and expensive process usually deters medium-sized businesses (SMEs) from investing in biopesticide research and development. The current regulatory framework in India does not support the growth of the biopesticide industry. The registration requirements are often similar to those for pesticides without acknowledging the differences in their nature and how they work.

In contrast, other regions have regulations for biopesticides. The European Union (EU) registration process is typically lengthy and costly, taking around 5-7 years and costing €10-15 million to bring a biopesticide to market. This regulatory environment has been criticised for not addressing the characteristics of

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CEO and Founder of Bionema Group, UK

biopesticides.

On the side of North America (NA), the United States has a more efficient and supportive regulatory process for biopesticides. The U.S. Environmental Protection Agency (EPA) runs a program for registering biopesticides to facilitate approval. Compared to the EU, registering a biopesticide in the U.S., is quicker and less expensive, with a 12 to 18 months timeline and lower registration fees.

An Example of Successful Transformation

The situation in Brazil stands out due to the country's efforts towards reforms in the biopesticide industry, resulting in impressive market expansion. The estimated value of Brazil's biopesticides market is projected to be $257.25 million by 2024, expected to grow to $408.73 million by 2029, showing an increase of 9.7% (MI, 2023). Brazil currently boasts 433 registered biopesticides as of March 2022, marking a surge of 404% over the past nine years. In contrast, in 2013, 107 biological pesticides had been registered in the country, indicating Brazil's leading role in embracing biopesticides.

The recent shifts in regulations within Brazil have impacted the biopesticide sector. Through streamlining the registration procedures and acknowledging the characteristics of biopesticides, Brazil has encouraged innovation and boosted the uptake of these environmentally friendly solutions.

Challenges and Demand

One key hurdle farmers face in India is their knowledge and understanding of the advantages offered by biopesticides. Many Indian farmers are deeply rooted in using pesticides, which they perceive as more effective and dependable. Overcoming this mindset and demonstrating the effectiveness of biopesticides is vital for increasing their acceptance.

Additionally, there is an issue with substandard biopesticides being distributed to farmers without research or approval, leading to a lack of trust within the market. Indian regulatory systems do not always align with the guidelines set by the OECD or EPPO for testing plant protection products. The lack of adherence to these standards, which include experimental procedures and replication, has led to doubts about the effectiveness of such products.

Global Biopesticide Market

The biopesticide market, covering bioinsecticides, biofungicides, bionematicides and bioherbicides, reached $6.7 billion in 2023. It is forecasted to hit $13.9 billion by 2028, with a growth rate of 15.9% (Markets and Markets 2023). Bioinsecticides hold a share of 50% globally. In India, the biopesticide market is anticipated to grow to $130.37 million at a rate of 9.3% (MI, 2023).

Brazil currently boasts 433 registered biopesticides as of March 2022, marking a surge of 404% over the past nine years

The underwhelming quality and limited range of products in the Indian market have also added to farmers' reluctance. Indian biopesticides are often dismissed due to their formulations and lack of solutions. India can draw inspiration from practices in countries like Brazil to enhance the variety and quality of biopesticides offered.

Collaboration and Coordination Critical

Firstly, there is a need to simplify and streamline the biopesticide framework in India. Given their characteristics and mechanisms of action, establishing a regulatory body or expediting the approval process specifically for biopesticides could significantly reduce registration time and costs. This would make it easier for medium enterprises (SMEs) to enter the market and encourage more investment in biopesticide research.

The process for registering biopesticides is often intricate, as it demands data on effectiveness, safety measures and environmental impacts.

Secondly, the government should introduce targeted policies and incentives to encourage farmers to adopt biopesticides. Measures such as subsidies, tax breaks or price support schemes could make these products financially viable for practitioners. Furthermore, the government needs to show its support by setting up demonstration plots and organising training programs to educate farmers on the advantages and usage of biopesticides.

Another critical aspect is the collaboration among companies, research institutions and agricultural extension services. Private firms can invest in research and development to enhance the effectiveness and reliability of products. On the other hand, research institutions can contribute to the knowledge and validation of these solutions.

Agricultural extension services can then play a role in spreading information and providing training to farmers on how to use biopesticides. By adopting an approach that involves parties, India can fully harness the potential of biopesticides and establish itself as a leading player in this rapidly expanding market. Drawing lessons from nations like Brazil, India can streamline its framework, implement supportive policies, and create an enabling environment for innovation and adoption of biopesticides.

The timing is perfect for India to seize this opportunity and pave the way for a future in agriculture, reaping both environmental benefits as well as economic rewards that widespread adoption of biopesticides can offer.

IRRI'S SPEEDFLOWER PROTOCOL REVOLUTIONIZING RICE BREEDING FOR GLOBAL FOOD SECURITY

In a major development, the International Rice Research Institute's South Asia Regional Centre (ISARC) in Varanasi, Uttar Pradesh, India, has introduced an innovative speed breeding protocol known as "SpeedFlower." This marks the world's first comprehensive speed breeding effort for rice and represents the initial successful speed breeding protocol for any crop in India. This cutting-edge protocol utilizes the state-of-the-art speed breeding facility, "SpeedBreed." The facility was established at ISARC and inaugurated by the honorable Prime Minister of India, Shri. Narendra Modi, on December 23, 2021.

PRELUDE

The inspiration for this innovative research comes from the NASA, Vegetable Production System team, which has optimized plant growth for space conditions to sustain astronauts during extended space missions. The speed breeding research conducted by the researchers of The University of Queensland, Australia for long-day plants has also contributed significantly. Together, these studies serve as catalysts for the development of SpeedFlower in rice.

About the **AUTHOR**

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IRRI Regional Breeding Lead - South Asia

Benefits

The primary objective of the Speed breeding technique is to accelerate rice research by surmounting challenges related to generation time and seasonal constraints. The SpeedFlower protocol achieves an unprecedented four to five generations of rice in a single year, sig-

nificantly reducing the traditional timeline of 1 or 2 generations under field conditions.

Protocol

The success lies in intelligent light parameter combinations, including a high red-to-blue spectrum ratio, coupled with a 24-hour long day photoperiod. Optimal growth conditions, encompassing temperature, humidity, and nutrient levels, play a crucial role. The protocol's efficiency is evident in early flowering, facilitated by a meticulous balance of day and night temperatures and light intensity.

SpeedFlower protocol was validated on all 12 rice subgroups of major cultivated rice, and the finding was published in the esteemed "Plant Biotechnology Research" journal, positioning itself as a catalyst for enhancing genetic gain and potentially nourishing half of the world's rice-dependent population.

The primary objective of the Speed breeding technique is to accelerate rice research by surmounting challenges related to generation time and seasonal constraints.

Partners

The project is part of a Department of Biotechnology (DBT), Government of India-funded initiative aimed at improving existing rice varieties and creating new ones through a haplotype-based breeding approach collaborating with National Agricultural Research Systems (NARS) partners. In this study, additional support was also received from the Ministry of Agriculture and Farmers' Welfare, Government of India and Indian Council of Agricultural Research (ICAR), Government of India. Acknowledging ISARC's leadership, the Ministry of Agriculture and Farmers' Welfare, Government of India has appointed ISARC as a member of a technical expert committee, emphasizing its pivotal role in advancing such research nationally.

Future

This research will help in the rapid development of a new generation of varieties which will add to addressing global food and nutritional security in climatic change conditions. Apart from rice; its application extends to other crops also. The ability to expedite variety development provides a crucial solution to meet the estimated yield targets necessary to feed the growing global population by 2030, amidst the challenges of climate change. This transformative approach not only expedites new varieties' development but also accelerates diverse crop research activities.

ADVANCED RESEARCH INITIATIVES

Creation of Spectral Libraries Utilizing Drone Technology

With the global population projected to reach 9.7 billion by 2050, the agricultural sector faces immense pressure to enhance productivity while minimizing environmental impacts. Traditional farming methods are increasingly viewed as insufficient, often failing to detect early signs of disease and pest infestation. This article explores the transformative impact of R& D in advanceddrone technology and spectral imaging on creating a more sustainable and profitable future in farming.

Research in drone technology and spectral imaging directly enhances farmer profitability by enabling precision agriculture.

About the **AUTHOR**

Amandeep Panwar,
Co-founder & Director,
BharatRohan

Drones - Revolutionizing Agricultural Practices

Drones, equipped with either fixed-wing or rotary systems, are revolutionizing agricultural practices. These unmanned aerial vehicles (UAVs) efficiently monitor vast expanses of farmland, providing data with precision unmatched by conventional methods. Paired with hyperspectral and multispectral cameras, these drones capture comprehensive data across multiple wavelengths, offering an in-depth analysis of crop health that is invisible to the naked eye.

The development of spectral libraries is a fundamental aspect of modern agricultural research. This process begins with drones systematically collecting multispectral and hyperspectral images over

fields. After extensive processing and normalization of the data, these images contribute to building spectral libraries that catalog unique spectral signatures associated with various crop health statuses.

R&D in Drone Technology

Research in drone technology and spectral imaging directly enhances farmer profitability by enabling precision agriculture. With insights from spectral data, farmers can perform targeted interventions at precise locations and times, significantly reducing resource waste and boosting crop yields. Early detection of potential issues allows for swift action, preventing disease spread and minimizing crop damage.

In a focused R&D initiative, drones equipped with hyperspectral imaging technology have been deployed to improve pest and disease detection in crops such as paddy and cotton. This technology specifically aims to combat major threats like the Brown Plant Hopper and Pink Bollworm in cotton, as well as rice blast and boll rot in paddy fields. The drones collect data with a high resolution of 5 cm/pixel and an accuracy rate of approximately 95%, minimizing human error and bias in data collection. Early results from this initiative suggest a potential reduction in crop losses caused by these pests and diseases by 20-30%, significantly increasing yields and benefiting farmers' profitability.

Looking ahead, the potential of R&D in spectral libraries and drone technology is vast. Innovations like integrating AI to predict crop yields and detect subtle environmental changes could further revolutionize agricultural practices. Expanding the range of crops covered by spectral libraries and enhancing the resolution of spectral data are also critical areas of focus.

Transformative Benefits for Crop Management

Increased Crop Yields

Data-driven insights enable farmers to optimize planting strategies, irrigation, and fertilization, which significantly enhances crop yields. For instance, spectral analysis can reveal nutrient deficiencies that can be corrected before they impact yield.

A spectral library stores signatures representing various environmental materials, such as different soil types, plants, and water bodies under various health conditions. These libraries are crucial for interpreting the data captured by drones, enabling farmers to quickly identify changes in plant health, often before any physical symptoms are visible. Machine learning algorithms play a crucial role in parsing through this vast amount of data, helping to identify and categorize spectral signatures effectively. This automation not only speeds up the process but also enhances the accuracy of the spectral libraries.

Innovations like integrating AI to predict crop yields and detect subtle environmental changes could further revolutionize agricultural practices.

Enhanced Pest and Disease Management

Early detection of anomalies allows for timely interventions, drastically reducing the spread of disease and pest infestation. This not only saves crops but also reduces the need for chemical treatments, promoting a healthier environment.

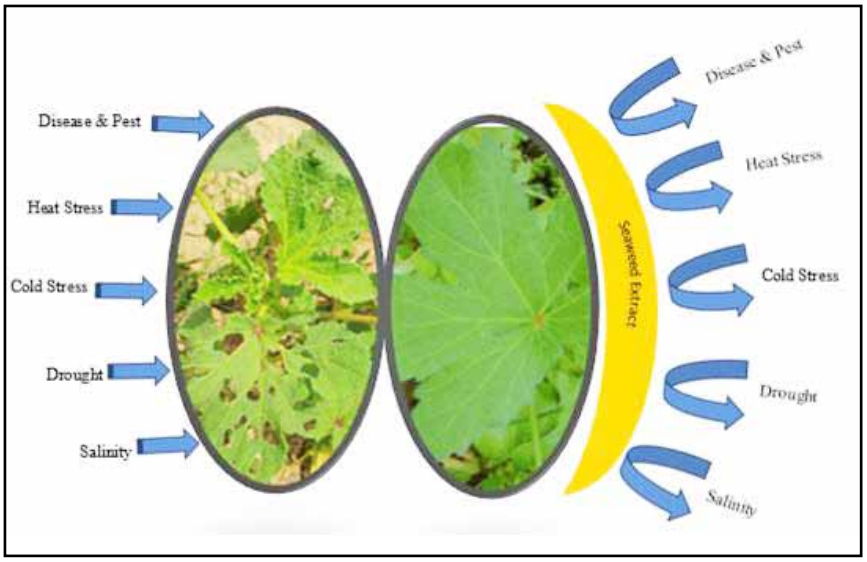
Economic Impact and Farmer Profitability

Precision agriculture reduces waste and increases efficiency, leading to substantial cost savings. For example, targeted pesticide application minimizes expenses and environmental impact. The economic benefits are clear, with farmers reporting significant increases in profitability through reduced costs and improved yields.

Through detailed and systematic R&D efforts, the application of spectral libraries using drone technology not only boosts farmer profitability but also contributes to more sustainable and efficient agricultural practices globally. These initiatives facilitate precise, data-driven decision- making, allowing farmers to implement more effective pest control, disease management, and nutrient supplementation strategies. The ability to anticipate problems before they become visually apparent minimizes potential damage and ensures consistently high production levels, leading to lower operational costs and higher market returns.

SEAWEEDS – THE NEWEST WEAPON AGAINST CROP STRESS

India offers a diverse range of climatic conditions and physico-geographical features, making it ideal for cultivating a variety of horticulture crops, including fruits, vegetables, flowers, nuts, spices, and plantation crops. Vegetables are essential to the human diet since they include the necessary fibre, vitamins, and minerals for good health. India is currently the world's second-largest producer of vegetables, and progress made in the horticulture industry is a sign that consumer demand for horticulture produce and products is rising.



Crop Stress

Crops generally experience an increasing number of abiotic and biotic stresses due to global warming and possibly associated climatic irregularities, which have a significant negative impact on their growth and output. Temperature, cold, drought, heat, salt, etc. are examples of abiotic stress, while insects, bacteria, viruses, nematodes, weeds, and fungus are examples of biotic stress. It is well recognised that abiotic stress factors like drought, extremes in temperature, and salinity have an impact on the incidence and spread of diseases, insects, and weeds. They could cause local pests to develop into future dangers. By modifying plant physiology and defence mechanisms, these stresses also have a direct impact on interactions between plants and pests. Abiotic stress circumstances, such as drought, can favour competitive interactions between weeds and crops because many weeds use water more effectively than crops.

Seaweeds are used as biofertilizers to make substitute for nutritional deficiencies in the soil.

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Seaweeds as Biofertilizer

Seaweeds are used as biofertilizers to supplement nutritional deficiencies in the soil. Regulators, plant growth hormones, carbohydrates, auxins, gibberellins, and vitamins are all included in seaweed extract (SEs), which can assist in increasing crop yield and preserve soil fertility. With the help of the SEs, it is possible to increase stress tolerance and lessen plant damage from bacterial, fungal, insect, and parasite infestations.
Understanding seaweed method of action is quite difficult because to the complexity of SEs' biological composition.

Seaweed Extract and Abiotic Stress

The primary factors limiting agricultural

development and sustainability across the world include abiotic stresses such temperature extremes (heat and cold), drought, salinity, and heavy metals. Growth and yield are significantly impacted. By addition of seaweed extract on crops, it improves the utilization of nutrients from soil as well as more production of metabolites in plants which cause more resilience from adverse abiotic conditions.

Use of seaweed extract and its bioactive compounds are successfully employed as defence agents in plants to trigger immune response against biotic stress.

Seaweed Extract and Biotic Stress

Due to environmental changes and intensive agriculture, pathogenic plant diseases are emerging more often. Although new technology, research, and products help agriculture in sustaining integrated management and farming practises, infections (mainly bacteria, viruses, and fungi) have diminished agricultural production, causing financial harm to at least 10% of the world's food supply.Plants utilise many defence mechanisms to combat the biotic factors brought on by pathogenic infestation. By enhancing the plant's molecular defence system through the use of various chemicals, organic compounds, and phytohormones, biotic stress in plants has been successfully mitigated. Use of seaweed extract and its bioactive compounds are successfully employed as defence agents in plants to trigger immune response against biotic stress.

The coastlines of oceans and seas are habitat to marine aquatic plants known as seaweeds or marine algae. These small organisms can be seen clinging to the solid surfaces of rocks, shells, and other plant matter. Only 5% of its 6000 species, which come in a wide range of sizes and shapes, are employed today. The secondary metabolites produced by seaweeds have a wide range of biological activities and are a rich source of bioactive chemicals. The vast seaweed reserve along the world's coastlines should be managed more efficiently and strategically to avoid the wastage of these essential resources because seaweed is so crucial to agriculture and human existence.

Effect of seaweed extract on abiotic stress of vegetable crops

Crop	Type of abiotic stress	Seaweed extract	Response of plant
Zucchini squash	Salt stress	*Ecklonia maxmia*	Improvement in shoot biomass, chlorophyll and nutritional content
Tomato	Water stress	*A. nodosum*	Reduction in ABA accumulation
	Heat stress		Enhancement in heat tolerance
Spinach	Heat stress	*A. nodosum*	Improved germination Percentage and seedling vigour

Effect of seaweed extract on biotic stress of vegetable crops

Crop	Disease	Seaweed extract	Response of plant
Cucumber	Powdery mildew	*Ulva armoricana*	Reduction in powdery mildew infection
Eggplant and Watermelon	Root rotting diseases	*Stokeyia indica*	Suppression of root knot nematode
Potato	Pythium leak	*S. vulgare*	Reduced rot penetration in potato
Broccoli	Clubroot	*Durvillaeapotatorum*	Decrease of plasmodia in root hairs

tête-à-tête with Anjana

Collaboration with Customers is Key

NOVUS recently named Dr. Manish Kumar Singh its new regional director for NOVUS in South Central Asia. Novus International, Inc. is the intelligent nutrition company which combine global scientific research with local insights to develop innovative, advanced technology to help protein producers around the world achieve better results. With extensive expertise about the market and the customers throughout South Central Asia, Dr. Singh has 15 years of experience working in South Asia and Asia-Pacific regions in various roles. In an interview with Anjana Nair, Group Editor, Agriculture Today Group, Dr Singh discusses the feed segment in India and puts forward some valid points.

How important a market is India for Novus?

India is extremely important to the entire agriculture industry, not just NOVUS. Over 54% of the country's land is classified as arable and half of the total labor market is in the agriculture industry. Having the world's second-highest population means producers in India need support to feed their neighbors. This is where NOVUS can help with intelligent nutrition products that allow producers to get more from their animals. And, with a growing middle class the demand for quality meat, milk and egg products is changing, making that support even more invaluable. India produces around 44 million metric tons of animal feed and is the fourth largest feed producer in the world after China, the United States and Brazil. Animal feed production in India is growing at a CAGR of 8.2%. On average the protein requirement is 1g/kg body weight. The current consumption of India for adults is 0.6 g/kg body weight, which means there is a gap of 40% that must be filled.

What is the market share of Novus in India?

For years, NOVUS has supported poultry producers throughout the country. We're the leading player in organic minerals, enzymes and organic acid segments in India. We recently began providing more resources and expertise to dairy farmers to support milk production, milk fat yield, and overall cow welfare.

Although India holds a lot of potential for the animal health and nutrition industry, the entry barriers for feed additive products are low due to lack of registration mechanisms.

There is a persistent challenge of feed scarcity in India. How can we ensure nutritious feed to our animals?

This is where technology can make a difference. Our CIBENZA® Enzyme Feed Additive helps unlock nutrients in feed, allowing producers to diversify their feedstuffs.

When quality feed is scarce, minerals also make a difference by supporting performance. Our MINTREX® Bis-Chelated Trace Minerals are shown to support layer performance, eggshell and meat quality. In dairy, MINTREX® Trace Mineral is shown to optimize reproductive performance, enhance hoof hardness and stimulate higher milk component concentration. Additionally, with the inclusion of MFP® Feed Supplement, an HMTBa-based product shown to optimize milk quality and quantity, dairy producers can support their cows.

What is meant by intelligent nutrition? What are the products of Novus in this segment?

Intelligent nutrition is the combination of experienced people, insightful perspectives and smarter solutions that allow us to put more into everything we do.

tête-à-tête with Anjana

As an international company, NOVUS has customers around the world who face similar challenges but may address them differently. We can take those experiences and share them with our customers. Our products are also Made of More™ meaning customers can expect something beyond what is typical from feed additives. For instance, our MINTREX® Bis-Chelated Trace Minerals contain methionine, our AVIMATRIX® Feed Solution is embedded in a fat matrix that allows targeted and gradual release in the entire intestinal tract to better support gut health.

How easy or difficult is introducing new products in India?

Although India holds a lot of potential for the animal health and nutrition industry, the entry barriers for feed additive products are low due to lack of registration mechanisms. Also, there's been a great improvement in the genetic potential of livestock animals and the industry has shifted towards producing nutritionally balanced diets to sustain animal performance. Due to the fragmented nature of the many segments in the industry it takes a bit of time to establish a new concept. However, any innovation that adds value to the producer's production system is welcomed by the industry.

What challenges have you faced in expanding business here?

NOVUS is known for its innovation and has been credited for establishing many new concepts in the South Asian markets like HMTBa-based methionine (ALIMET® Feed Additive, MHA® Feed Additive, MFP® Feed Supplement), HMTBa-based organic trace minerals (MINTREX® Bis-Chelated Trace Minerals), CIBENZA® Enzyme Feed Additive and AVIMATRIX® Feed Solution, to name a few. It always takes time to establish an innovative concept but when the customer realizes the value they're getting from these solutions, sales flow in. Today we're the leader in these product segments.

The biggest pain point of the feed industry today is the escalating cost of feeding the animals.

What are your recommendations for strengthening the feed segment in India?

Collaboration with customers is key. Understanding their challenges and looking at a variety of ways to solve them means we can help a diverse range of operations. We are more focused on creating a win-win situation by providing products and services with demonstrable value and becoming a partner with them instead of having a transactional business. The biggest pain point of the feed industry today is the escalating cost of feeding the animals. NOVUS recently acquired BRI (BioResource International, Inc.), a company specializing in feed enzymes. With the strong feed enzyme solution range of BRI, we can help reduce the feed cost for our customers.

What are your future endeavors?

South Asia represents a huge growth opportunity for NOVUS. My top priority in this role is fostering a collaborative work environment across my teams, building a culture adhering to NOVUS' core values and establishing us as a trusted partner for all our customers and stakeholders. NOVUS will continue to stand apart by not only providing superior quality products but also by offering professional, knowledgeable service support and adeptly addressing industry challenges through collaboration.

NOVUS will continue to partner with industry experts and knowledge leaders to elevate intelligent nutrition for our customers and bring innovative concepts and solutions to the industry for profitable and sustainable livestock farming.

DEMOCRATIZATION OF INFORMATION

Agriculture is a global industry, and farmers around the world need access to technological tools and information. The power of the internet continues to grow, with over 5.35 billion people worldwide now connected online! Recent data reveals that the global population accessing the internet has surged from 53% in 2018 to an impressive 66% in 2024. This remarkable increase highlights the ever-expanding reach of digital connectivity, enabling people from all corners of the globe to access information, connect with others, and engage with a vast array of online resources.

English has achieved global status, with approximately 1.5 billion individuals speaking the language worldwide. But not all farmers speak English fluently. Providing agricultural apps in local languages ensures that language barriers do not prevent farmers from accessing important information and utilizing the full potential of agricultural technologies. Overall, designing agricultural apps in different languages is essential for ensuring inclusivity, accessibility, and relevance to a global audience of farmers and agricultural stakeholders.

Power of Apps

Over the past decade, agricultural apps have undergone a profound transformation, shifting from basic computing and record-keeping functions to sophisticated platforms powered by cutting-edge technologies. Innovations such as IoT, machine learning, and artificial intelligence (AI) have propelled these apps to a new level, with a primary focus on delivering actionable insights to empower users in enhancing crop health and productivity.

Providing agricultural apps in local languages ensures that language barriers do not prevent farmers from accessing important information and utilizing the full potential of agricultural technologies.

About the **AUTHOR**

Dr. Sat Kumar Tomer
Founder and CEO, Satyukt Analytics Private Limited

Sat2Farm represents a significant leap forward in agricultural technology, offering farmers invaluable real-time data to improve their farming practices. By harnessing satellite-based technology, the application provides a comprehensive overview of crucial factors affecting crop production, ranging from soil health to pest and disease management. This holistic approach enables farmers to make informed decisions regarding resource allocation, ultimately leading to enhanced yields and reduced input costs.

Expanding Language Support

One of the key advantages of Sat2Farm is its ability to level the playing field for farmers of all sizes and resources. By democratizing access to precision agriculture tools, the application empowers farmers to optimize their operations regardless of their scale or financial capabilities. This democratization of information not only enhances individual farm productivity but also contributes to broader agricultural sustainability and economic prosperity.

Earlier, Sat2Farm, a satellite-based agricultural monitoring system, primarily focused on providing its services in English. However, to reach a wider audience and cater to users from different linguistic backgrounds, Sat2Farm has expanded its language support to include various international languages such as Swahili, French, Spanish, Malay, Portuguese, Turkish and Arabic with the aim to make its services accessible to a global audience and to better serve users who may

not be proficient in English.

Access to Comprehensive Database

Sat2Farm users now have access to a comprehensive database covering over 80 pests and diseases that commonly affect crops worldwide. Additionally, they can benefit from 80+ crop calendars available in their preferred language, facilitating optimized farming practices. Furthermore, irrigation advisories tailored for over 50 crops are provided, offering users valuable insights to enhance their irrigation management strategies.

To access Sat2Farm in their preferred language, users simply need to download the Sat2Farm application on their mobile devices from the google play store, install it, open the app and can select the language of choice and then sign up.

Swahili, recognized as an official language in Tanzania and Kenya, is also widely spoken in Uganda, the Democratic Republic of Congo, and the Comoros Islands. Given the significant portion of our client list from African nations, integrating its native language into the app was a priority.

French is the official language in over 25 nations, while Spanish holds official status in 21 countries. Around 16% of Malaysia's population is engaged in various agricultural activities as part of their employment. Close to twenty-four percent of Malaysia's total land area is specifically designated for agricultural purposes. Therefore, Malaysia heavily embraces technological advancements in agriculture, employing modern agricultural technologies to enhance productivity and efficiency.

Democratization of information not only enhances individual farm productivity but also contributes to broader agricultural sustainability and economic prosperity.

With its commitment to democratizing access to precision agriculture tools, Sat2Farm has recognized the importance of language accessibility in reaching farmers across diverse regions and cultures to provide services such as real-time monitoring of soil health, crop health, pest and disease forewarnings, soil moisture estimation, irrigation advisory, weather forecast etc.

BREEDING FAST FOR BETTER FUTURE

Wheat, which is often called the golden grain that feeds billions of people, is facing a lot of problems. It's having a hard time keeping up with the growing world population's increasing need for food. Experts predict that by 2050, the demand for wheat will increase by a whopping 50%, making it really important to produce more wheat.

In the fast-paced world of farming, where time is running out, there's a big change happening in how we grow crops. Especially with wheat, the usual way of breeding plants is being challenged. The old, slow way of growing wheat isn't keeping up with the changes in our climate and the needs of more and more people. Now, there's a brand-new way of growing wheat that is super-fast and efficient, promising to make different kinds of wheat much quicker. But that's not all—it also brings in better quality wheat and makes it better at handling tough conditions.

About the **AUTHOR**

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Mining the Genome

Just being fast isn't the only thing that matters. We also need to be smarter, not just quicker. That's where genomic technologies play a crucial role. By understanding the genetic makeup of wheat, we can identify the specific instructions that lead to desirable traits. Using molecular markers and advanced prediction models, we can precisely focus our efforts on breeding, choosing specific genes rather than depending on random changes. This focused method reduces the need for trial and error, making the development of wheat varieties more efficient and streamlined.

Accelerating the Wheat Breeding Time

Traditionally, growing new kinds of wheat took a long time—sometimes many years. This slow process made it hard to keep up with the growing need

for food and deal with the changes in the climate that affect how well crops grow. But now, thanks to new technologies like CRISPR-Cas9, things are changing. CRISPR-Cas9 is a powerful tool that let scientists change the wheat plant's DNA in a very precise way. This precision means we can add specific features to the plants much faster than before. By directly changing the genetic code, scientists can make the wheat plants better at fighting diseases, produce more, and handle tough environmental conditions. Using these advanced tools not only speeds up the process but also helps breeders respond quickly to the changing needs of farming.

Speed Breeding: A Quantum Leap

Speed breeding is a groundbreaking method in growing wheat faster. It brings in a new era of fast agricultural advancements. This method involves changing the light and temperature conditions to speed up how quickly wheat plants grow and reproduce. The impact is huge because it not only shortens the time it takes to breed wheat traditionally but also makes it quicker to evaluate many potential varieties. In simple terms, speed breeding imagines a world where wheat breeding isn't limited by seasons. Instead of waiting for years to see the results of breeding, researchers can now get results in just a few months. This method promises to significantly speed up the development of different types of wheat.

The main idea behind speed breeding is manipulating the light and temperature in controlled environments. By creating the best conditions for plant growth, researchers can make plants reproduce faster, speeding up the breeding process. This not only makes breeding programs more efficient but also helps scientists quickly respond to new challenges in agriculture. Being able to create and test wheat varieties at an unusually fast pace is especially important as climate change makes global temperatures shift and weather patterns become less predictable. Speed breeding allows researchers to choose and develop wheat varieties that can better handle the challenges of a changing climate.

Beyond Yield

Food security is not just about having enough food; it's also about having nutritious food. In modern wheat breeding, a crucial aspect is biofortification, which enhances the nutritional content of grains. Picture wheat varieties with more zinc, iron, and vitamin A, helping to fight hidden hunger and improve the health of millions. By including biofortification in faster breeding programs, we can fully unleash the nutritional power of wheat.

Speed breeding allows researchers to choose and develop wheat varieties that can better handle the challenges of a changing climate.

Precision Breeding for Quality Grains

Scientists are working to make wheat grow faster, but it's not just about speed. They're also focused on improving the quality of wheat in various ways. This includes making sure it's more nutritious, tastes better, and can handle different environmental conditions.

One major focus is making sure wheat is packed with essential nutrients, recognizing its important role in global diets. At the same time, breeders are working on making wheat more resistant to diseases and increasing the amount it produces. This detailed approach to breeding is more exact than before, using advanced genetic markers and data-driven methods to understand the genes that influence wheat quality.

The quicker breeding timelines aren't just about being efficient; they show a commitment to improving the quality of wheat and making it more resilient to stress. Precision breeding techniques help speed up the development of wheat and also enhance its nutritional value, stress tolerance, and commercial potential.

A Call to Collaboration

The change in when we grow crops isn't just done by one person but involves a group of scientists, farmers, and decision-makers working together. It's important for these people to collaborate to handle the ethical questions about changing genes, make sure everyone can use new farming technologies, and share better types of wheat around the world.

The change in how we breed wheat is a big deal in farming. It's happening because of new science and people working together. Things like fast breeding, picking genes, and making wheat that can handle stress have made wheat grow faster and be better quality. This change isn't just about today's needs but also about making sure we have enough good food for the future. By using faster cycles, picking specific traits, and making wheat stronger, we can deal with the challenges of a changing world. Working together is crucial for these new ideas. It means that in the future, our fields will produce a lot of healthy wheat. We want to use science, teamwork, and a shared commitment to make wheat better. Let's change how we think about wheat, not just for the next harvest, but for a future where we have lots of high-quality wheat to feed our growing world. This is our chance to leave a legacy that goes beyond what one person can do and gives hope for a future with plenty of good, sustainable food.

SUSTAINABLE AGRICULTURAL PRACTICES *for Addressing Water Scarcity*

In recent years, India has been grappling with erratic weather patterns, posing significant challenges to its agricultural sector. As the backbone of the nation's economy, agriculture faces immense pressure to adapt to these changing conditions, with water scarcity as a critical issue.

Erratic Climate and Water Scarcity

The continuous temperature rise has a profound impact on water resources, exacerbating the threat to agriculture and food security. According to a study published in the journal Science Advances, rising temperatures are compelling Indian farmers to intensify groundwater usage for irrigation, which is endangering India's food and water security, just when it needs to feed its growing population of 1.4 billion.

The below-average rainfall in the most recent 2023 monsoon season has left several regions of the country grappling with drought conditions and water scarcity challenges. A recent prediction by the India Meteorological Department (IMD) warns of heightened summer heatwaves, further intensifying water concerns in rural India. Even several regions and cities are facing water scarcity in terms of drinking water supplies. Amidst these challenges, sustainable agriculture solutions offer a ray of hope in mitigating the impact of water scarcity and ensuring food security for our country's billion.

Efficient Water Management Practices

Efficient water management practices, such as drip irriga-

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tion and rainwater harvesting, are paramount in addressing this issue. According to data, these practices can reduce water consumption by 25-85%. Additionally, micro-irrigation techniques have the potential of optimizing water usage, enhancing soil health, and minimizing crop diseases.

Innovative solutions like the use of Zeba, a patented sustainable superabsorbent product that is biodegradable, further augments water conservation efforts. Adoption of Zeba can lead to a 15-20% increase in water efficiency compared to traditional irrigation methods, benefiting crops like sugarcane and groundnuts. Similarly, subsurface irrigation systems have demonstrated their efficacy in delivering water directly to the root zone, thereby reducing water wastage and maximizing crop yields.

Government Initiatives

Government initiatives like Mission Amrit Sarovar is a visionary initiative that helped construct and rejuvenate water bodies in rural India. These water bodies, known as 'Amrit Sarovars', serve as lifelines to countless rural communities, offering sustenance and prosperity, thus combating the water crisis that grips rural India and pave the way for water sustainability at the grassroots level.

UPL has deployed various water management initiatives like increasing the water storage capacity by 2 lakh cubic meters of the local ponds, lakes, and rivers by creating new structures and rejuvenating the water bodies in aspirational districts like Narmada and other parts of rural India. This leads to water sufficiency in agriculture and helps farmers in diversifying their crops.

Government initiatives like Mission Amrit Sarovar is a visionary initiative that helped construct and rejuvenate water bodies in rural India.

Sustainable Water Management Practices

Statistics reveal the critical need for sustainable water management practices in agriculture. For instance, a low evapotranspiration of 1 mm below climate normal in autumn and monsoon can decrease the yield variability of groundnut and chickpea by 36.71% and 35.44%, respectively. Moreover, water-saving irrigation practices have been shown to reduce water consumption by up to 85%, offering a tangible solution to water scarcity challenges.

Additionally, the implementation of zero tillage and laser leveling techniques can further enhance water efficiency in agriculture. Zero tillage preserves moisture in the soil, reducing the irrigation cycle for crops, while laser leveling technology ensures precision in irrigation, minimizing water wastage due to uneven terrain.

Thus, the adoption of sustainable agriculture solutions is imperative in addressing water scarcity and ensuring the resilience of India's agricultural sector. By embracing innovative technologies and holistic approaches to water management, we can safeguard food security, empower farmers, and build a more sustainable future for generations to come. Together, let us work towards a greener, more resilient agricultural landscape that thrives in harmony with nature.

POTENTIAL AND ROLE OF SHREE ANNA

India produces several types of millets - 'Shree Anna' such as jowar, ragi, bajra, foxtail millet, barnyard millet, kodo millet, proso millet, little millet, sama, etc., which have a number of health benefits, and have been an integral part of Indian diet for centuries. India is the largest producer of millets in the world. During 2021, its share was highest with 43.90 per cent. However, there has been a steady decline in area under millets in the country from 37.37 million ha in in 1960-61 to 10.92 million ha in 2021-22, while production has showed fluctuating trends and declined from 25.09 million tonnes in 1992-93 to 16.00 million tonnes in 2021-22 and target is set to reach 45 million tonnes by 2030.

The share of area and production under millets decreased from 39.90 per cent and 25.51 per cent in 1966-67 to 10.99 per cent and 4.92 per cent in 2021-22, respectively in the total area and production of cereals. The major reasons for decline in area under nutri-cereals revolve around lack of profitability, input subsidies, and price incentives for these crops, changes in consumer preference due to difficulty in processing, their low shelf life, and greater importance being given to fine cereals (wheat and rice), their low social status and their lack of supply in public distribution

Trends in Area, Production and Productivity

The production of the millets increased from 16.84 million tonnes (MT) in 1960-61 to 25.09 MT in 1992.93 and thereafter production decreased to 16.00 MT in 2021-22 with an annual growth rate of (-) 0.13 per cent. During this period, area of the millets also registered the annual growth rate of (-) 1.87 per cent. During the study periods highest growth in productivity was observed in bajra (2.45 per cent) followed by ragi (1.42 per cent), jowar (1.20 per cent) and small millets (1.01 per cent). The trends in productivity of millets has showed the increasing trends, however, it was highest in case of ragi, followed by bajra, jowar and small millets. The average decadal productivity has showed the increasing trends in all nutri-cereal crops. It may be concluded that the area and production during the study period registered a negative growth while productivity of different millets grew with the positive CAGR with better farming practices.

The important nutrients present in millets are believed to deliver many health benefits and freedom from cardiovascular diseases.

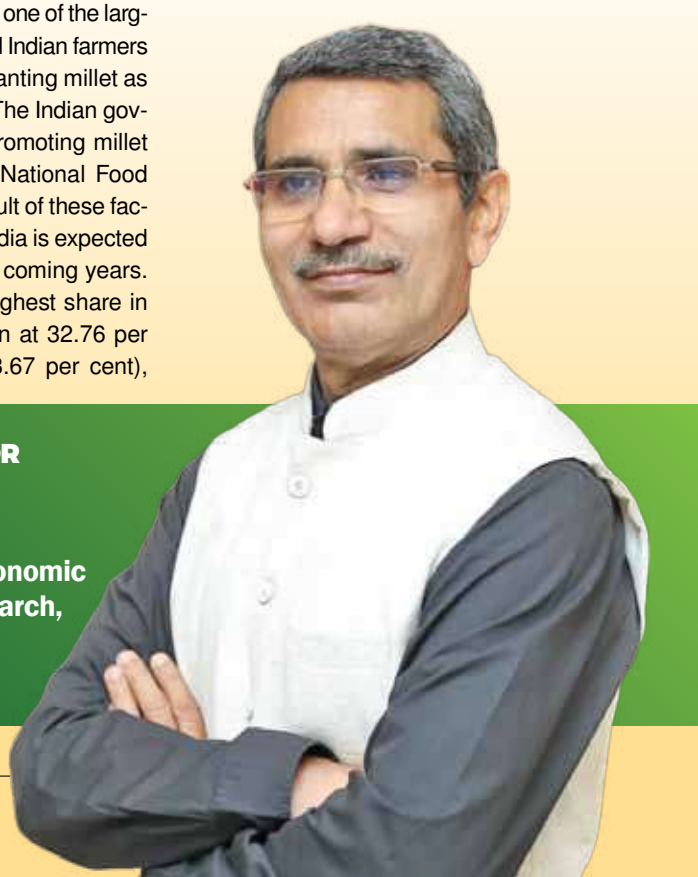
Indian Millet Production Scenario

In India, millet production has been on the rise in recent years. India is one of the largest producers of millets and Indian farmers have been increasingly planting millet as a drought-resistant crop. The Indian government has also been promoting millet production as part of its National Food Security Mission. As a result of these factors, millet production in India is expected to continue to grow in the coming years. The Rajasthan has the highest share in the total millets production at 32.76 per cent, followed by UP (13.67 per cent), Karnataka (11.73 per cent), Maharashtra (10.96 per cent), MP (7.24 per cent) and Haryana (7.0 per cent). These 7 states together accounts for 91.25 per cent of total millets production during 2022-23.

Export of Millets and Millets Products

During 2022-23, the export of millets and millets related products from the country were worth 169049.11 MT and valued at Rs. 608.11 crore. India's export of millets and millets related products grew by 1.58 per cent from Rs.448.22 crore in 2013-14 to Rs.608.11 crore in 2022-23.

The main markets for India's millet exports are UAE (17.8 per cent) followed by Saudi Arab (13.7 per cent), Nepal (7.4 per cent), Bangladesh (4.9 per cent), Japan (4.4 per cent), USA (4.1 per cent), Germany (3.8 per cent), Libya (3.6 per cent), Egypt (2.9 per cent) and Oman (2.9 per cent). These 10 countries, together, accounted for 65.4 per cent of the total millet exports. India can increase her millet exports by targeting top importing nations



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and organise sensitisation programmes on export opportunities for millets start-ups. APEDA and Indian Institute of Millet Research are preparing a promotion strategy for millets and millet value added products.

Millets to achieve Sustainable Development Goals

Millets support efficient, inclusive, resilient, and sustainable agri-food systems for better production, better nutrition, a better environment, and a better life. Promotion of millet cultivation, therefore, could help to meet India's global commitments towards Sustainable Development Goals (SDGs).

Millets: The Storehouse of Nutrition

The important nutrients present in millets are believed to deliver many health benefits and freedom from cardiovascular diseases. Millets are rich in non-starchy polysaccharides, fibre, and low on the glycaemic index, which controls blood sugar levels, and are the ideal grain for diabetics. The soluble fibre and millet protein help to improve gut health and reduce cholesterol levels. Millets are gluten-free grains, a viable choice for people with celiac disease.

Policy Recommendations

While millets are gaining popularity among consumers, the actual consumption is not increasing (12.6 kg/capita availability in 2021-22), and supply can't match it if large sections start consuming millets.

Millets support efficient, inclusive, resilient, and sustainable agri-food systems for better production, better nutrition, a better environment, and a better life.

Hence, we need two-pronged strategies to manage supply and demand-side issues.

A. Promoting Consumption

a. Awareness campaigns involving celebrities and on the lines of those used for eggs in 1980s- 'Sunday Ho Ya Monday Roz Khao Ande'.
b. Serving millet-based food and snacks on flights and premium trains.
c. Include millets in flagship schemes of the government such as Mid-Day Meal Programme and the Integrated Child Development Services (ICDS) scheme.
d. Including millets in PDS (GoI issued guidelines and states like Odisha and Karnataka implemented).
e. There is a need to improve value chains and provide processing/value addition facilities so that consumers can get tasty and cheaper millet-based food
f. Primary target should be urban consumers, Governments canteen and use of social media can be a game changer

B. Improving the Production and Promoting Value Chains

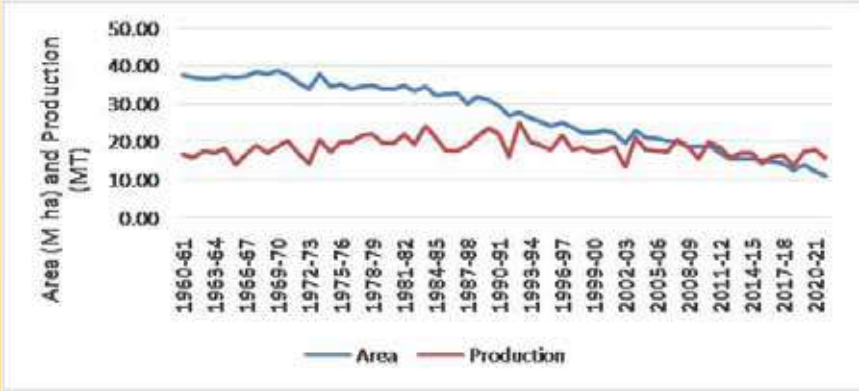
a. Enhancing the production base of millets.
b. Varietal improvement to enhance productivity and profitability.
c. Millet growers need to be incentivised through cash compensation and other measures.
d. Since there are several small producers in millet economy, organising them into FPOs, joining them through NRLM and SHGs is needed.
e. Promoting millets in watershed and Wadi projects of NABARD is being done and scaling up and linking to value chains is needed.
f. Special incentives for entrepreneurs / FPOs for purchase of processing machinery (the cost could be about Rs.15 lakh to Rs.30 lakh).
g. Fiscal incentives including tax concessions along the value chains is recommended.

C. Other General Suggestions

a. There is a need for concerted efforts to sensitise farmers to shift towards more remunerative but less water guzzling crops, especially millets.
b. Government should introduce millets flour in the rations to soldier and as well as officers.
c. NAFED should set up a millet corner in all its retails outlets, install millet vending machines.
d. There is an urgent need to strengthen the seed chain by creating adequate number of seed-hubs.
e. There is a need to improve the yield gap between various geographies of millets cultivation.
f. Millets also can be distributed through PDS.
g. NABARD along with APEDA is opening a line of exports with Rs.600 crore NABARD Fund is being utilised for promoting start-ups in millets. The funding is done through NABARD subsidiary, NABVENTURES.

** The views expressed are those of the author and not of the organization he belongs to, usual disclaimer applies.*

Trends in Area, Production and Productivity



FODDER TREES

A Promising Alternative

Trees producing shoots or sprouts of tender twigs and stem from woody parts with their leaves browsed by domestic and wild animals to varying extent are known as fodder trees. Fodder trees can be grown either in combination with agricultural crops under agroforestry system or on separate land usually not fit for other crops. One of the main advantages of trees over crop is to tap underground water with their deep root system particularly in the period of rainfall scarcity. In case of livestock, tree fodder is generally known as emergency fodder or scarcity fodder, and specifically in small ruminants (Sheep and goat) and other browsing animals (camel), it is an integral component. It is assumed that out of total feed available for sheep and goats, 60% of total feed comes from tree-fodders only. It is more in case of goats and camel since they spend more than 90% time in browsing on top feeds and hardly 10% to graze on surface vegetation that too when sufficient top feeds are not available.

One of the main advantages of trees over crop is to tap underground water with their deep root system particularly in the period of rainfall scarcity.

Khejri *(Prosopis cineraria)*

Commonly found in the dry and arid region of Rajasthan, the Indian Khejri tree is a drought-tolerant tree and can survive in harsh climatic conditions. The tree is also known for its ability to fix nitrogen, which improves soil fertility, helps in soil conservation and prevents desertification. It provides nutritious forage for animal, edible pods for human consumption and fuel wood for household energy and it is rightly called Kalpvriksha of arid lands. Khejri leaves are small in size but highly nutritive and palatable. On an average a full-grown tree is expected to yield about 50-60 kg of dry fodder per annum. The fodder is a rich source of protein (12-14% CP) and phytochemicals (6-12% tannins).

Neem *(Azadirachta indica)*

Native to the Indian subcontinent, the neem plant is very drought tolerant and yields a lot of forage even during the dry season. Considering the drastic decline in forage availability during the dry season, such an evergreen plant can contribute significantly towards alleviating the nutritional inadequacies experienced by ruminants during the dry season. Neem leaves are being fed to sheep and goats and constitute a significant part of the ration (up to 20%) without any adverse effects. A mature tree can produce 350 kg of dry leaves a year, which may be used for feeding of livestock during famines. It is not that palatable due to bitter taste, but dry leaves often included in the ration of large ruminants. The nutritive value is 6-7% DCP and 50-60% TDN. Neem cake can also be used as feed and up to 10% may be included in the concentrates. Neem oil and cakes are also used in agricultural practices, as pesticides, neem-coated urea and are thus propagated throughout India. Neem is suitable for dune fixation and for soil reclamation in areas where salinity occurs.

Jal *(Salvadora spp)*

Salvadora persica is known as 'Meetha Jal or toothbrush tree and Salvadora oleoides is known as 'Khara Jal' or saltbush. S. oleoides coppices fairly well, a dense, almost impenetrable growth is formed by a parent stem surrounded by a ring of root suckers. The tree produces edible fruits and palatable leaf fodder for goat, sheep and camel. The fruit is highly relished by the local people either as raw fruit or in the form of juice during summer. A full-grown tree can produce about 20-25 kg dry leaf fodder per year. The leaf fodder contains moderate CP

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Some of the desirable characteristics of trees and shrubs cultivated for fodder production are easy establishment and rapid early growth in order to compete effectively against weeds, thornlessness and perenniality, high productivity under repeated cutting, grazing or browsing, resistance to local pests and diseases, high seed production ability or reliable vegetative propagation, little or no fertilizer requirement and high production of good quality forage in terms of protein and mineral contents, palatability and digestibility. Providing top feeds is a promising strategy to bridge the deficit of green fodder in India.

(9.0-11%) rich in phytochemicals (tannins, saponnins) and a good source of Ca (2-3%). Jal can be planted either on field bunds or as agroforestry plantation. The tree is often lopped for camel fodder. Fruits fed to cattle are said to increase milk production. Seed cake is suitable as livestock fodder and contains 12 % protein.

Ardu *(Ailanthus excelsa)*

It can be grown on wide range of soil conditions; however, sandy loam soil is best suited for it. A. excelsa, a coppicer and fast-growing tree, can be cultivated in conjunction with forage and food crops. A full-grown tree produces on an average 5-7 quintals of green leaves twice in a year i.e. in the month of November – December and May – June. Ardu leaves are excellent tree fodder with high palatability and serves as nutritious fodder for camel, sheep and goat. The fodder contains about 16-20% CP with good digestibility (60-65% total digestible nutrients (TDN) and thus promise as a fodder that can sustain moderate production in livestock.

Indian Jujube *(Ziziphus nummularia)*

The Indian jujube, commonly known as Ber is one of the most ancient cultivated fruit/fodder trees in arid regions of India. The leaves are very much relished by the small ruminants and also by the camels and are rich source of protein (11-14%). Its leaves contain 6-8% digestible crude protein and 50-58% total digestible nutrients, making it a nutritive fodder for animals. This tree is commonly grown in the rural areas as top-feed species. Even in drought years when normal field crops fail, this top-feed can provide fodder for animal. The tree is heavily lopped during winter for its leaf fodder known as Pala. A full-grown tree can produce about 2.5-3 kg dry fodder leaves over a year. The leaves are liked most by camel, goat and sheep, even more than Khejri leaves.

Drum stick/Moringa *(Moringa oleifera)*

Highly palatable to cattle, goat, sheep and camel, it is mainly planted commercially for its pod and leaf production. Due to its high nutrient contents in leaf, this tree is now recommended for intensive fodder cultivation by planting in close row spacing. In a year, 6-7 cutting of fodder can be obtained. A full-grown tree can produce 80-100 kg dry leaf fodder. The leaf is very rich in CP (22-25%), but even the forage (including twigs) can provide 15-18% CP and 60-70% TDN that can replace part of concentrate in the ration of livestock. It is also a rich source of phytochemicals that have reported benefits in livestock nutrition, health and production. Drumstick may play a substitute as green fodder in dessert areas.

Silvi-Pasture System for Arid Regions

Silvi-pasture system involving two-tier or three-tier system increases the biomass availability two times. Combination of any or a mixture rows of fodder trees with 'Dhaman' grass (Cenchrus spp) or 'Sewan' grass (Lasirus scindicus) pasture can successfully maintain the arid-ecosystem through check of dune shifting, soil erosion, optimum water usage and forage biomass production for sustainable integrated or mixed crop-livestock farming. A total of 7-8 sheep can successfully be reared in one-hectare area of land in this region. A biomass yield of 25 and 35 Q DM/ha is being recorded in two and three-tier silvi-pasture system, respectively.

SOIL TESTING

FOR INCREASED PRODUCTIVITY AND SUSTAINABILITY

Soil, the bedrock of agricultural productivity and environmental stability, harbors a complex web of physical, chemical, and biological properties. As humanity grapples with the challenges of feeding a growing global population amidst escalating environmental concerns, the significance of soil testing emerges as an indispensable tool in ensuring sustainable agricultural practices and ecological balance. Soil testing serves as the compass guiding farmers towards informed decisions regarding nutrient management, soil reaction (pH) adjustment and soil amendment strategies. By meticulously analyzing soil samples, soil scientists gain insights into the soil's nutrient composition, enabling precise fertilization tailored to the specific needs of crops. This precision agriculture approach not only optimizes resource utilization, but also mitigates the risk of nutrient imbalances, thereby bolstering crop health and resilience to environmental stressors. Nonetheless, by identifying soil deficiencies and imbalances early on, soil testing facilitates proactive remedial

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measures, preempting yield losses and fostering sustainable intensification of agricultural systems. Beyond its agricultural ramifications, soil testing assumes paramount significance in safeguarding environmental health and resilience.

For Efficient Nutrient Management

Soil testing helps ensure efficient nutrient management in crop production and environmental protection due to reduced carbon equivalent emissions as excessive application of fertilizers driven by uninformed practices, poses a potent threat to soil and water quality, precipitating eutrophication, soil degradation, and ecological imbalances. Just as individuals need nutrients, so does the crop. All the major nutrients required for basic plant nutrition, such as nitrogen (N), phosphorus (P), and potassium (K), as well as micro-nutrients required in smaller amounts; e.g., calcium (Ca), magnesium (Mg), sulphur (S), iron (Fe), zinc (Zn), copper (Co) and manganese (Mn) are found in fertile soil. In addition to having a non-saline (electrical conductivity, E.C. <0.8 dS m^{-1}) and nearly neutral soil reaction (pH=6.8-7.5), a rich soil typically has good quantity of soil organic matter to improved soil structure, moisture retention and nutrient availability. However, most soils lack sufficient concentrations of all essential plant nutrients, or may have deteriorated soils' properties which often make it difficult for plants to absorb nutrients.

Soil Sampling for Fertility Determination

In the realm of soil science and agricultural management, the depth at which soil samples are collected holds profound significance, as it directly influences the accuracy and relevance of the insights gleaned. Soil sampling at a depth of 15 cm emerges as a standard practice. The soil horizon extending to a depth of 15 cm encapsulates a crucial domain wherein the intricate interplay of nutrient dynamics unfolds. Beyond its role in nutrient dynamics, soil sampling at a depth of 15 cm offers invaluable insights into soil structure, compaction, and root zone characteristics. By assessing soil structure and compaction at this depth, agri-experts can discern impediments to root growth, identify zones of soil compaction, and implement targeted remedial measures to enhance soil aeration, water infiltration, and root penetration.

Through soil analysis, farmers can identify the extent of salinity in the soil and implement appropriate strategies to mitigate its effects, such as leaching excess salts, using salt-tolerant crops, or improving drainage systems.

By meticulously analyzing soil samples, soil scientists gain insights into the soil's nutrient composition, enabling precise fertilization tailored to the specific needs of crops.

Management of Salt Affected Soils

Through soil analysis, farmers can identify the extent of salinity in the soil and implement appropriate strategies to mitigate its effects, such as leaching excess salts, using salt-tolerant crops, or improving drainage systems. This targeted approach is essential for reclaiming salt-affected lands and ensuring sustainable agricultural productivity. Appraising soils for salt management, involves understanding the distribution and concentration of salts within the soil profile. The process typically involves collecting soil samples from various depths to assess the extent of salt accumulation and to devise appropriate management strategies.

Soil Analysis in Orchard Plantation

In the context of orchard plantation, soil analysis plays a critical role in site selection and orchard management. Soil analysis helps orchardists identify suitable locations with optimal soil conditions for specific fruit crops. Furthermore, it allows for precise nutrient management and soil amendments tailored to the needs of fruit trees, promoting healthy growth, high yields, and superior fruit quality. Appraising soils for orchard plantation involves comprehensive soil sampling to assess various soil properties and characteristics across different depths. Collecting soil samples from multiple depths allows for a thorough understanding of the soil profile, enabling better decision-making regarding orchard establishment and management.

Need to Analyse Soil Samples

By assessing nutrient levels such as nitrogen, phosphorus, and potassium, farmers can tailor their fertilizer applications to meet the specific needs of the soil and crops. Without this analysis, there's a risk of either under or over-fertilizing, which can lead to reduced yields, poor crop quality, and environmental pollution due to nutrient runoff. To implement a healthy crop production programme, samples are tested for soil pH, E.C., available-P, available-K and soil organic carbon (SOC). Generally, depending on these soil properties, crops are produced on a very wide range of soil types with varying requirements for fertiliser. Applying too many fertilisers might cause an imbalance in the soil, which will eventually have an impact on the ecosystem and contaminate the water and the undersea life. The ideal management strategy is to sample soil often and repeatedly.

MODERNIZED AGRICULTURE IN INDIA

India's population currently accounts for 17.63% (1.375 billion) of the global population and is expected to reach 1.7 billion (+23.6%) by 2050. India will overtake China as the world's most populous country by 2027 (UN, 2019). The growing food requirement of an expanding population will undoubtedly necessitate an increase in agricultural production.

If no policy changes are made to keep up with demand, by 2050, India would need to boost its food grain production, including pulses, by 49.6% (457 million tonnes). This is a difficult undertaking for India, given its global natural resource base is only 2.4% land and 4% water. The climate crisis is anticipated to intensify this problem. Rising food demand from an already depleted natural resource base, combined with climate change issues, will make it hard to meet without significant adjustments to our agricultural and food production systems.

If no policy changes are made to keep up with demand, by 2050, India would need to boost its food grain production, including pulses, by 49.6% (457 million tonnes

Agriculture 4.0

In 2015, "Fourth Industrial Revolution or 4IR" or "Agriculture 4.0" was proposed with this in mind. The term 4IR alludes to the impending revolutionary period in which information and communication technologies (ICT) will merge. The revolution will result in new technological advancements in six areas - artificial intelligence (AI), robots, the Internet of Things (IoT), unmanned vehicles, 3D printing, and nanotechnology. The Fourth Industrial Revolution will involve a number of new revolutionary technologies that employ big data to integrate the physical, biological, and digital worlds in a way that will touch all aspects of life, including agriculture. Accepting this reality, affluent countries such as the United States, Netherlands, Australia, Israel, and Japan are attempting to restructure agrifood value chains through mechanisation, automation, and modernization.

The 4IR aims to scale and commercialise agriculture in smallholder family farms in India. The requirement for digitalization in Indian agriculture is well understood and accepted; attempts have also been made to digitise the existing agrifood value chain.

Digital Agriculture Mission

In September 2021, the Ministry of Agriculture & Farmers Welfare of the Government of India announced the launch of the Digital Agriculture Mission 2021-2025, while also sign-

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ing Memorandums of Understanding (MoUs) with five private partners, CISCO, Ninjacart, Jio Platforms Limited, ITC Limited, and NCDEX e-Markets Limited (NeML), to advance digital agriculture through pilot projects. The Digital Agriculture Mission aims to encourage and accelerate projects based on emerging technologies such as artificial intelligence (AI), blockchain, remote sensing, Geographical Information Systems (GIS) technology, and the utilisation of drones, sensors, and robotics.

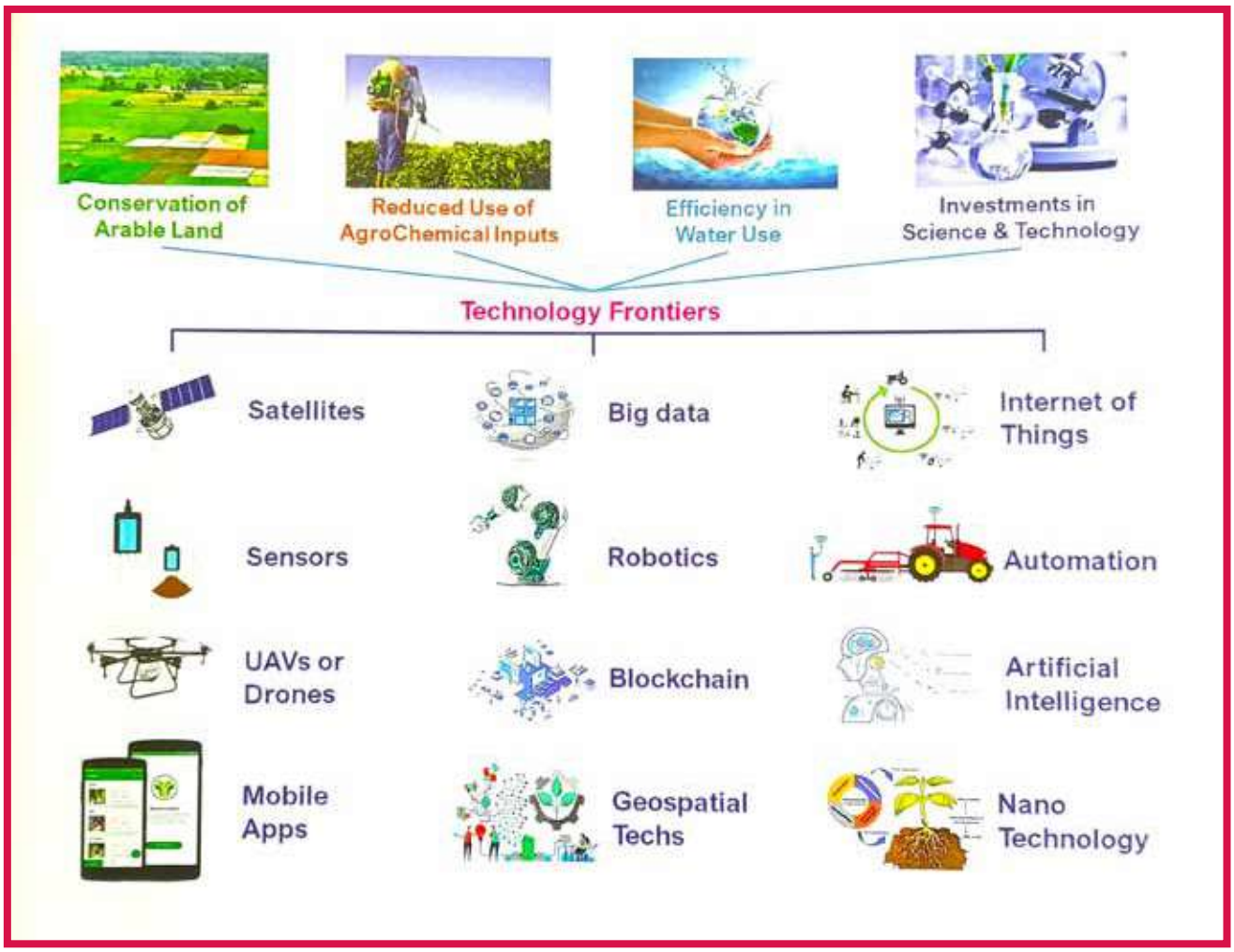
The unmanned aircraft system (UAS), which includes unmanned aerial vehicles (UAV) or drones, is an example of current 4IR and smart farming research. UAS can assist farmers in lowering production costs by making better use of resources (agrochemicals, fertilisers, water, farm machinery, and so on), producing higher yields of higher quality, increasing farm profitability, and providing environmental benefits. Having a competitive agriculture sector with good quality standards benefits the economy greatly.

Smart Farming

In response to this pattern, future open-field agriculture is predicted to transform into a high-tech agribusiness. Rapid breakthroughs in the Internet of Things and Cloud Computing are driving the phenomena known as digital agriculture or Smart Farming. While Precision Agriculture merely considers in-field variability, Smart Farming goes a step further by basing management duties on data as well as location, with context and situation awareness prompted by real-time events. These characteristics often involve intelligent help throughout technology deployment, maintenance, and use.

Rapid breakthroughs in the Internet of Things and Cloud Computing are driving the phenomena known as digital agriculture or Smart Farming.

Smart Farming is a development that emphasizes the following:



Smart sensing and monitoring

Measurement of farm processes such as crop growth and development, soil health, weeds, pest and disease infestation, moisture and plant water stress, land topography, and location-specific weather information using sensors, satellites, unmanned aerial vehicles, etc., combined with external data to supplement direct observations.

Smart analysis and decision making

Analysing and processing voluminous data from direct measurements in the sensing and monitoring stage and comparing it to the norms that specify the desired performance in a way that surpasses human intelligence, wisdom, and experience, and that can be fed to farmers for appropriate intervention to optimise production environments.

Smart control and precise delivery

Planning and carrying out the chosen intervention to rectify (e.g., variable rate application) farm process performance utilising smart precision equipment and tools in a cyber-physical farm management cycle to usher in a new era of superfusion.

Smart Farming to Accelerate Development

New technologies, such as the Internet of Things and Cloud Computing, are expected to accelerate development and bring more robots and artificial intelligence into farming. Big data applications in smart farming are not limited to crop production; instead, they play an important role in enhancing the efficiency of the entire agri-food supply chain, increasing farm profitability, and alleviating concerns about food security and sustainability. Furthermore, customers are increasingly worried about food safety and nutritional components of food that affect their health and well-being.

Benchmarking, sensor deployment and analytics, predictive modelling, and the use of better models to manage

crop failure risk and provide predictive insights to future farming outcomes (predictive yield model), drive real-time operational decisions, and reinvent business processes for faster, innovative action and game-changing business models are examples of Big Data applications in agriculture. Humans will always be involved in the process, but at a much higher intellectual level, with machines handling the majority of operational duties. As a result, growers are turning to smart farming to handle complicated issues such as climate change, water shortages, diminishing soil health, commodity price volatility, rising input costs, and so on.

India - Drone Spray Technology Initiatives

Keeping global trends in mind, the Indian government issued the Unmanned Aircraft System (Drone) Rules, 2021 and Drone (Amendment) Rules 2022 with the goal of striking a compromise between UAV safety and operational capability. The number of drone permission forms was reduced from 25 to six. The digital sky platform will be built as a business-friendly, single-window online solution. Drone flight authorization are not necessary for distances of up to 400 feet in green zones or up to 200 feet between 8 and 12 km from the airport perimeter. Micro drones (for non-commercial use), nano drones, and R&D groups affiliated with State Agricultural Universities and the Indian Council of Agricultural Research do not require a pilot's licence.

Furthermore, the Ministry of Agriculture & Farmers Welfare, Government of India, released Standard Operating Protocols on the use of drones for spraying of agrochemicals (pesticides, fungicides, and herbicides) to accelerate mechanisation in crop protection, with the aim of increasing efficiency and efficacy of applied agrochemicals for pest control by reducing time, volume of water, quantity of chemical and manpower required for spraying, and minimising drift to non-targeted areas. Moreover, the announcement in the 2022-23 Budget to promote the use of "Kisan Drones" in agriculture will allow the drone industry to collaborate and partner with the National Agricultural Research and Education System, which includes ICAR Institutes, State Agricultural Universities, farmers, FPOS, and NGOs, to improve farm operational efficiency and maximise profitability. Thus, UAVs are increasingly becoming a crucial monitoring, decision support, and smart input delivery tool for farmers, FPOs, and researchers facing agricultural difficulties.

TRANSFORMING INDIAN AGRICULTURE THROUGH MEGA FOOD PARKS

Within India›s agriculture sector, the food processing industry is seen as the engine of growth essential to the sector›s expansion. The food processing sector must develop at double-digit rates for the agriculture sector to exceed the 4% growth criterion and meet the growing food demands of the nation›s expanding population. India's contribution to the global food trade is currently less than 3%, despite predictions that it could double in the next ten years. An estimated 35% of agricultural produce, or $10 billion USD, has been wasted and lost in value as a result of inadequate processing facilities. The introduction of the Mega Food Parks Scheme aims to address these issues by offering cutting-edge facilities for food processing all the way from the farm to the market.

Transformation of Indian Agriculture

Over the next five to seven years, the impact of Mega Food Parks on the agribusiness industry is poised to increase significantly. The state-of-the-art processing infrastructure established at Mega Food Parks is significantly amplifying the exports of processed foods, with exports representing a pivotal market for such products. Several Mega Food Parks have assisted farmers to experiment and diversify their agricultural practices. Establishing these food parks in hilly, tribal, and challenging terrains has not integrated farmers from these regions into mainstream agriculture, contributing to the overall economic development of these areas.

All operational food parks are contributing in a big way to reducing wastage of agri and horticulture produced through more than 2.5 lakh MT capacity of modern cold and ambient warehousing that has been created in these projects.

A Classic Example

Clear instances of their transformative influence include Patanjali's journey, initiated by its Mega Food Park in Haridwar, which propelled the company into an FMCG powerhouse. With food product revenues approaching USD 1 billion, Patanjali sources produce directly and indirectly from over 10 lakh farmers, promoting local entrepreneurship and elevating farmer incomes by commercialising seemingly niche products like buransh juice.

Likewise, Gujarat Agro Infrastructure Mega Food Park is poised to attract a total investment of nearly Rs. 650 crores, significantly benefiting many farmers. Similarly, the Himalayan Mega Food Park aids apple growers in Uttarakhand with its apple juice concentrate facility, while the Cremica Food Park transforms the prospects of tomato farmers in Himachal and neighbouring regions through a world-class pulping facility. These success stories underscore the profound and expanding influence of Mega Food Parks in shaping the agribusiness landscape.

Repositioning as Food Hub

Mega Food Parks are evolving into job hubs for prominent Indian and global food brands, facilitating the export of food products worldwide. In adapting to the post-Covid global landscape, where food supply chains are undergoing significant realignments, Mega Food Parks play a crucial role. Leveraging India's inherent strengths and renewed government focus, these parks position India as a major global sourcing hub and a substantial consumption market. This transformation, facilitated by Mega Food Parks through processing and value addition, not only unlocks the true potential of the agriculture sector but also creates substantial opportunities for Indian businesses and start-ups in the global market.

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MADHYA PRADESH'S AGRICULTURAL ODYSSEY

Madhya Pradesh, known as "the heart of India," has indeed become the heart of India's agricultural success. The agricultural diversity of this state, like its cultural diversity, is unparalleled, owing to its diverse climate and soil types across 11 agro-climatic zones. From rice-wheat cropping systems in certain regions to cotton-jowar cropping patterns in others, the state's varied agricultural landscape underscores its potential for diverse crop cultivation. Madhya Pradesh has a rich history of agricultural experimentation and expansion of cultivation. Before independence, a major part of what is now Madhya Pradesh was ruled by semi-autonomous Maharajas, who decided the agricultural policies of their states.

Under the Krishi-Unnati concept, technologically integrated platforms are being developed to offer comprehensive services to farmers and facilitate data-driven decision-making.

Transformation to Model State of Agriculture

This region of what is now Madhya Pradesh has turned itself into a model state in agriculture. The state's Agricultural Department was set up in 1916 and reorganised in 1931. After that, men trained in the science and practice of agriculture were placed in every tehsil to undertake agricultural demonstrations. To meet the requirements of the sugarcane-growing districts, the Agricultural Engineering Department also set up sugarcane crushing mills. Central Experimental Farms for Agriculture were established in Ujjain and Gwalior.

One of the Agriculture Department's most important activities had been the introduction of improved crops, and improved varieties of jowar, bajra, till, cotton, wheat, gram, and sugarcane. In addition, selected varieties of ground nuts, Spanish peanuts, paddy, arhar, linseed, barley, turmeric, and potatoes had been introduced. A Marketing Section was created under the Commerce Department in 1938. When it comes to agricultural equipment, agricultural engineer Mr. Don W. Gryphon produced a plough (named Scindia Plough) in all respects adapted to the small Indian cultivator. It was cheap; at

Marketing Avenues

The Madhya Pradesh State Agricultural Marketing Board oversees operations through its 7 zonal offices and 13 technical divisions spread across the state, managing 259 mandis and 298 sub-mandis. With the implementation of corrective measures by the state government aimed at boosting mandi revenues, there has been a notable increase in their income. To streamline operations and facilitate direct sales for farmers, the board has introduced two major online platforms: the E-Anugya (e-permit) System and the 'Souda Patrak' App. These platforms simplify processes and enable farmers to sell their produce directly to the mandis, promoting efficiency and transparency in agricultural transactions.

Government Initiatives

Key endeavours include enhancing irrigation infrastructure, ensuring electricity accessibility, improving rural road connectivity, and refining the state's agricultural procurement system. Additionally, the government has prioritised the availability of certified seeds and implemented policy initiatives across pivotal sectors such as irrigation, power, roads, financing, and procurement, thereby facilitating agricultural expansion in the state. These efforts were acknowledged when the Madhya Pradesh government received the Krishi Karman Award for the 7th time in 2021.

Various forward-looking initiatives in the agricultural sector include: Pradhan Mantri Kisan Samman Nidhi (PM-KISAN), Mukhya Mantri Kisan Kalyan Yojna, Pradhan Mantri Fasal Bima Yojana, Paramparagat Krishi Vikas Yojana (PKVY), National Agriculture Development Plan, National Mission on Agriculture Extension "ATMA", National Food Security Mission, Soil Health Card Scheme, Agricultural Mechanisation, Pradhan Mantri Krishi Sinchai Yojana (Microirrigation), Distribution of Certified Seeds, among several others.

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Madhya Pradesh stands as one of the leading producers of food grains, pulses, and oilseeds in the nation. Over the past two decades, the agricultural sector in Madhya Pradesh has witnessed remarkable growth. In the fiscal year 2022-2023, the primary sector accounted for 36.32 percent of the state's Gross Value Added (GVA). Emphasizing sustainable agricultural practices, the Madhya Pradesh government has been actively advocating for organic farming initiatives in recent years, striving to promote environmentally friendly agricultural methods.

GAME CHANGERS

Crop Diversification

A scheme has been launched to encourage the cultivation of remunerative crops, market-driven varieties, and resilient crops such as ragi, barley, coarse grains, kodo-kutki, ramtil, spices, medicinal crops, fruits, and vegetables.

Agricultural Technology Integration

The state is leveraging remote sensing and emerging technologies like GIS, IoT, data analytics, artificial intelligence, machine learning, and blockchain to establish an integrated service delivery ecosystem. Under the 'Krishi-Unnati' concept, technologically integrated platforms are being developed to offer comprehensive services to farmers and facilitate data-driven decision-making.

Agri-GIS (Geographic Information System) and Remote Sensing

GIS and remote sensing techniques are employed to assess land use, watersheds, and crop management, facilitating data-driven planning and monitoring.

MP Kisan Mobile App

An integrated mobile platform, the MP Kisan App, has been designed to provide farmers with comprehensive information and services related to land and agriculture.

Unique Farmer ID (UFID)

By amalgamating various digital databases, an integrated farmer database has been established. This aids in localised data-driven planning, precise estimation of crop area and production, and expedited claim settlement during natural disasters, thereby enhancing farmers' income. Madhya Pradesh has made significant strides in these three domains and is poised to provide comprehensive services to farmers in alignment with the central directive. Noteworthy achievements in this endeavour include the establishment of a remote sensing-based crop area calculation system and the successful implementation of complete e-Girdawari in 2022. Additionally, farmers can now register and authenticate their crops using remote sensing, artificial intelligence, and machine learning technologies through a dedicated mobile application.

The Madhya Pradesh Warehousing and Logistics Corporation operates 293 branches, offering a total working capacity of 218.93 lakh metric tonnes for the scientific storage of agricultural produce.

Warehousing on the Rise

Storage services are very important for farmers. In Madhya Pradesh, there has been a consistent rise in both the average capacity and utilisation of storage services. The Madhya Pradesh Warehousing and Logistics Corporation operates 293 branches, offering a total working capacity of 218.93 lakh metric tonnes for the scientific storage of agricultural produce. The primary objective of the corporation is to furnish storage facilities to farmers. Additionally, farmers belonging to the general category receive a 30 percent concession in storage fees, while those from Scheduled Castes and Scheduled Tribes benefit from a 40 percent concession. Banks have extended approximately Rs. 246.25 lakh in assistance during FY2021-22 and Rs. 271.43 lakh until November 2022 for FY2022-23, based on warehouse receipts issued by depositors.

Madhya Pradesh's prominence as a major producer of kodo kutki, pulses, and other agricultural commodities further cements its position in India's agricultural landscape. With consistent growth rates in production and strategic initiatives like the One District, One Product (ODOP) scheme, Madhya Pradesh continues to be at the forefront of agricultural innovation and productivity enhancement.

STAYING SOIL SMART
FOR AGRICULTURAL PRODUCTIVITY, SUSTAINABILITY AND FOOD SECURITY

Soils are the basis of life as they support humans, plants and animals forever. Safeguarding and ecologically managing soil is therefore of utmost importance, particularly in the context of change in climate, disforestation and loss of biodiversity. Soils are tremendously diverse and continue to deliver high crop yields while operating a range of environmental functions, if they are managed carefully. A healthy soil has a blend of particle sizes, a well-built structure, good permeability, and the capacity to retain water. For farmers, achieving the right balance between nutrients, cost of inputs like labour, water, and fertilizers, and minimizing environmental impacts is essential but it is difficult to perform. At the same time, too much use of fertilizers in the soil may depreciate the quality of crops and decrease productivity. Hence, it is necessary to accurately measure the nutrients in the soil through proper analytical testing. Conventional methods used to determine soil quality are costly and time-consuming. Thus, soil testing laboratories need to digitally convert their operations to support smart farming.

Being soil smart

The advancement of sensors, drones and smart irrigation operated by the Internet of Things (IoT) etc. is disruptive, the way that decisions are made, and how inputs are applied. Remote sensors placed around the farm or on farm equipment enable farmers to monitor humidity, temperature, pH, moisture, and nutrients diligently and remotely.

A total of 1765 soil testing laboratories have been duly authorized to issue soil health cards as part of the Soil Health Management (SHM) initiative under the National Mission for Sustainable Agriculture (NMSA).

The sensors can also be linked to an automated drip irrigation system through cloud- based analytics, to make sure that soil humidity does not fall beyond a minimum limit. This irrigation procedure is more effective and lets the farmers to invest time on other responsibilities. By operating irrigation systems to provide water during times of least evapotranspiration, during nights, farmers can considerably improve their water footprint. As this technology increases further, the precise use of fertilizers based on the requirements of the soil will also be optimized.

Ground sensors can be merged with aerial technologies to reinforce data. Remote sensing and Geographic Information Systems (GIS) tools have changed how spatial variation, soil quality and soil degradation are evaluated, and how interventions are applied. Satellites are vital in providing timely weather information, which allows farmers to determine whether irrigation or other inputs will be needed.

Smart Technologies and Farmers

In order to make certain that farmers gain the most from these technologies, it is essential that they are conscious of them and can easily understand the information provided. Even though smart technologies are becoming more affordable day-by-day, they are still out

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of reach for many smallholder farmers. For instance, the Smart Farm kit costs between200and 600USDs. Improving digital literacy is essential to empower farmers to use the information.

Perhaps the most impressive technology within the suite of digital solutions for agriculture till now is the smart phone. Not only it creates a direct contact with the farmer, but also a mobile phone is used to collect, collate, process and transmit customized and real time data and information, all at a distance of a tap of a button at any time.

Without the proper infrastructure to connect farmers in the first place, the full advantages of digital technologies will not reach them and so will not be fully attached within the agricultural sector.

Informatics and IoT Supported Soil Assessment for Smart Agriculture

A lot of IoT sensors are used to accumulate environmental and machine metrics for decision-making on improving soil quality. Big data applications also play a vital role in smart farming. The IoT sensors are capable of capturing large volumes of data for more analysis. Big data provides insights into farming operations, would be helpful in real-time decision-making, and would benefit business processes. The agriculture sector is likely to gain appreciably from the implementation of IoT applications.

Soil Testing & Emerging Technologies

Agriculture Laboratory Information Management System (LIMS)

Agriculture Laboratory Information Management System (LIMS) for agriculture & farming stores all data gathered from different devices and analytical instruments in a common database, thus allowing easy access. A LIMS eases generate custom Certificates of Analysis (CoAs) that comprise the details of samples, tests, and test results. A LIMS solution for agriculture & farming helps to reduce the test turnaround time without compromising the quality of test results.

There are about 1007 Agri startups working in the field of improving soil fertility across the globe

Land Preparation Tools

Contemporary testing tools such as Soil Information Systems are a classic example of technology which is developed to support farmers for good understanding of the composition of soil beneath their feet. These systems help us to exhaustively interpret the precise nature of the soil health. Once a farmer is able to recognize the strengths and weaknesses of their fields, they can exploit this information to plant the ideal set of crops to meet these conditions. With the support of aerial infrared pictures of their farmlands, farmers can now stay one step forward of their challenges and bring together information that would easily not be possible from a ground level.

Machine Learning and Digital Soil Mapping

Information about soil properties can be predicted using the machine learning approaches. The most important properties of soil prediction are Calcium, Phosphorus, pH, Soil Organic Carbon, and Sand. These properties significantly impact the yield of crops. Four well-known machine learning models, namely, multiple linear regression, random forest regression, support vector machine, and gradient boosting, are used for prediction of soil properties. Experimental results have revealed that the gradient boosting outperforms the other models in terms of coefficient of determination. Gradient boosting is able to predict all the soil properties phosphorus. It will be helpful for the farmers to know the properties of the soil in their particular terrain for effective crop management.

Innovations in Soil Fertility and Bank Finance

Agri-Clinics are envisaged to provide expert advice and services to farmers on various technologies including soil health, cropping practices, plant protection, crop insurance, post-harvest technology and clinical services etc. which would augment production of crops/ animals and guarantee better income to agrarians.

Financing to Agri-Clinics and Agri Business Centres' is a Central Government sponsored scheme. The objectives are to strengthen transfer of technology and extension of service, to provide self-employment opportunities to technically trained persons and to provide a package of soil and input testing facilities and other consultancy services. The scheme is in force since 2004. MANAGE, Hyderabad has established ACABC Incubation Centre at MANAGE, Hyderabad, with aim to provide start-up training to graduates in Agriculture. Those trained graduates can apply for start-up loans from the financial institutions.

There are about 1007 Agri startups working in the field of improving soil fertility across the globe, and they have come out with ten major technological initiatives for scaling up Agri productivity. In our country, there are numerous Agri startups like Gramophone, Krishitantra and ipag helping farmers for enriching soil nutrients, avoiding soil, pests and insects.

A total of 1765 soil testing laboratories have been duly authorized to issue soil health cards as part of the Soil Health Management (SHM) initiative under the National Mission for Sustainable Agriculture (NMSA). Strategic Lead Generation serves as a valuable resource for the respective Single Point of Contact (SPOC) to strategically generate prospective leads for the implementation of the scheme. These soil testing laboratories contribute to the Soil Health Management initiative supporting in the strategic generation of leads for scheme implementation through a comprehensive list.

BUILDING IMPACT ECOSYSTEMS

Vineet Rai is the Founder of Aavishkaar Group, an Impact Investment Platform touching millions of people in Asia and Africa, using an entrepreneurship based development approach. In an interaction with Agriculture Today, Vineet talked about building impact ecosystems to deliver real Impact as enshrined in the vision of Aavishkaar Group. "We exist to bridge the Opportunity gap for the Emerging 3 Billion". Vineet believes that Impact Investing has the potential to change the world of finance irreversibly. Excerpts from the interview.

You have played pivotal role in bringing all the stakeholders on a single platform. How is this platform going to change the landscape of agritech?

I think all the platforms must have some relevance or the other. It would be narcisstic to claim that you will change the way startup ecosystem or agriculture or agritech startup will change. But this is a platform that will allow the democratization of the startup and agritech. The idea behind the startup mahakumbh is to bring all the Indians and all the sectors together to be a part of celebration. Agritech pavilion aims at bringing diverse set of ideas to be showcased to everybody else. Secondly, it aims at celebrating the spirit of entrepreneurship. The tagline of Agritech Pavilion is Udhami Kisan, that makes farmers as entrepreneurs. We are trying to symbolize the pavilion as the transitioning phase of agriculture. Seeing a kisan coming from subsidy background to support credit background and moving onto entrepreneurial thought process is forward-looking.

Although we talk about robotics and AI integration into agriculture, we haven't seen the application at ground level. So how soon can we see them applied at field level?

We have to first ask this question as to how relevant is precision farming to a small farmer. And that's where lies the answer to your question. It's very difficult to adopt. So let's say that the robotics product costs Rs.5 Lakh. How many farmers would actually be able to adopt it? So therefore, SAS (Software as a service) should have farm products, mechanization as a service. In fact, it is an experiment that has been going on since 2007 but did not work very well. Many companies came and went.

But those are the kinds of experimentation that will need to be done for robotics to play an engaging and effective role. We still have arbitrage issues, even though labor has become very difficult to find in the farms. So as the labor

cost goes up, we will be left with limited choice. And I think we will find ways and mechanisms to integrate it. It's a process and will take time in order to happen. But drone participation in agriculture has become very significant in a very short period of time.

In which segment in agriculture do you find more startups coming up?

In agriculture, there is input side, productivity side, post harvest infrastructure side and finance side. And then comes the direct to consumer (d2C) branding, positioning and processing. In the input side, AgroStar is a startup in which Aavishkaar was among the first ones to invest. They work on productivity and farm productivity and innovation. Then you have Ergos, which is actually on post harvest infrastructure side. Then you have Samunnati as a post financing company and then you move to Soulful, which is actually millet processed foods for rich couples and their children who want to be on millet diet, or are conscious of their health and also of their children.

So, you can actually see agriculture in different segments and then of course, there is agro chemicals, bio chemicals etc.

How do you see the policy environment for startups?

Policy environment is positive and at the political level I think we have got a very strong positive impact. Now, from political state, there is transitions to bureaucracy. From there to financial institution, then to R&D institutions (which is agriculture industry in exchange etc.) to education. And between these percolations you find resistance. So, I think political transformation is complete. There is absolutely no step back. Bureaucracy I think, is in early to mid stage of transition. The financial institutions are at early stage of transition because now you heard NABARD talking about equity and the Chairman actually said that "credit penetration has gone up. How do we get investment credit penetration?"

That's a big statement coming from NABARD, which only talked about refinancing. At agri research level, we are still struggling. For agricultural industry, we are still probably 30 years behind of what is happening in the political sector. So, it has to be streamlined and hopefully in the next five years, more regression, more success, more scale is expected. I mean, it's quite funny to say that when I first made investment in 2007, the term agritech was not known and the term agri tech started being used as late as 2014.

So what are the new technologies that you see coming into agriculture in next five years?

That will be a billion dollar question and will be very difficult for me to answer but I do see massive application of artificial intelligence, generative AI and all kinds of technological innovation that are taking place across the world. It could actually be the utilization of infrared rays and actually understanding what is the quality so it will be on quality, precision, traceability, something as rudimentary as drip irrigation to satellites. But I think the biggest transition will be from crop to horticulture and fruits and vegetables. Generally you will move from very basic cereals and that transition is very clear. I think the bigger challenge will be to see how will technology play a role in water conservation, which I think will be our biggest challenge as a country.

At agri research level, we are still struggling. For agricultural industry, we are still probably 30 years behind.

What are the future plans of Aavishkaar in agri-tech?

Yeah, that's interesting question. So we are right now thinking of actually looking at deep tech on one side, agriculture on the other side and financial services.

And then climate as an overarching theme. Within climate, we are actually looking at climate tech on one side, and we are looking at carbon bio sequestration.

We believe agritech is still going to be the leading segment coming in in terms of innovation. It will take a more gradual path. So patience and long term thinking will be the way we look at it.

We are not going to get excited just because great new ideas come in. We have been around too long to actually get excited.

And education-wise, do you see a transition?

I see lots of engineers coming and showing interest in agriculture these days. And most of the founders are IITians and do not have background from agriculture universities, I actually am a great believer that lateral thinking does help. I don't get so excited by just hearing about IIT. I think people coming from tier three institutions have better context to bring about a change, than the person with no context. Now if you have a person from IIT, IIM and other reputed institutes, coming from the tier three towns and has actually context of agriculture and access to best of education, then we will definitely make a difference. But I think the education curve is also smoothening. While IIT has a brand name, the knowledge level is not so far away. The brand gap is very large but I don't believe that the knowledge gap is that wide. So my belief is that there will be a democratization on the education side also. So while linguistically we use IIT as a brand and assign a certain value to it, we see a fairly high level of variation between the systems. My general belief is that engineers or people with technical background will play a very big role in transitioning to the agricultural sector, not necessarily IIT.

PRECISION FARMING AND AI INTEGRATION TRANSFORMING AGRICULTURE

Agriculture is the main sector of the food and GDP of a country, making up 6.4% of the world economy. Fuel and jobs are provided by agriculture to millions of people. For feeding the world and meeting the nutritional demand of rising population we need precision agriculture tools of modern era. AI can be used to monitor crops, detect pests, diagnose soil faults, and recommend the application of fertilizers and pesticides, thereby helping farmers make better decisions at every stage of crop cultivation.The integration of AI in precision agriculture holds tremendous potential to revolutionize farming practices, increase yields, and contribute to sustainable food production.

What is Precision Farming?

Also known as Smart agriculture / digital agriculture / modern agriculture, it is defined in relation to 5 Rs (i.e. applying the Right Input, at the Right Amount, to the Right Place, at the Right Time, and in the Right Manner.) This approach to farming utilizes modern tools such as robotics, Internet of Things (IoT), motion sensors/ detectors, drones, GPS, GIS, and VRT, as well as artificial intelligence. The data gathered from tools includes information about the crop yield, weather, rainfall, and soil health. After that this data is used to increase the resource allocation, crop growth, management of nutrient and chemicals, irrigation, pesticide, and insecticide management, harvesting, and post-harvest operations of crops. The main objective of modern techniques is to improve the effectiveness and productivity of farming, reduce the cost of cultivation, and maintaining the healthy ecosystem, which results in increased yield, lower input cost, and a reduced environmental impact.

AI is now being used to predict the crop yields, identifying the potential disease and pest outbreaks, and boost irrigation pattern.

AI and its Integration in Precision Agriculture

AI is the science or technology that creates the programmed machine that think and act like humans and perform the tasks according to the need of human being. AI can analyze large and complex data very easily that helps to perform the task very quickly.

Necessity of AI integration

AI based technologies have taken agriculture to the next level. Artificial intelligence algorithms have the capability to examine complex databases gathered from different sources such as drones, VRT, RTK, and soil sensors. AI is now being used to predict the crop yields, identifying the potential disease and pest outbreaks, and boost irrigation pattern. Using insecticides, fertilizer, and irrigation more efficiently is the outcome of precision agriculture techniques. These solutions minimize the damaging effects

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of pesticides on the environment and promote sustainable agriculture practices. It also helps farmers by reducing their financial risks by making wise decisions about storage, distribution, and price.

AI Integrated Tools in Precision Agriculture

VRT (Variable Rate Technology)
As the name indicates VRT allows farmers to apply variable rates of fertilizers, nutrients, pesticides etc., across the different parts of the field according to their need. AI will automatically apply the variable rates by collecting the data from field and optimize the VRT. This is a mostly used technique in the field of agriculture.

Remote sensing
Remote sensing technology is used to collect data without direct contact with surface. Remote sensing is used to collect data about soil mapping, disease outbreak, weather elements with the help of satellites and drones. AI will automatically interpret the data.

GPS (Global Positioning System)
GPS is a satellite-based navigation system that allows farmers to get the exact location of farm equipment's, creating field mapping. GPS is enabled with VRT, GIS (Geographical indication system) to optimize the rates of input and farm productivity. AI will provide the interpreted data connected with GPS so farm equipment will provide the exact input.

RTK (Real Time Kinetics)
This is a smart device that receives the signals from the satellites and transfer signal to the various farm equipments.

Yield monitors
These devices are used to track the yield of crop after harvesting. This device provides us with the valuable data on productivity of different parts of the field so AI will optimize the farm inputs accordingly. It also provides the tracking of crops for storage and transportation. It measures the yield losses throughout.

Remote sensing is used to collect data about soil mapping, disease outbreak, weather elements with the help of satellites and drones.

Smart irrigation
In recent years, many commercial developments made in the field of precision irrigation. Sprinkler irrigation and drip irrigation techniques can be controlled by sensors in accordance with the flow and amount of water needed by plants. Flow is controlled by sensor technologies, so water loss is minimized, and soil erosion is reduced. This whole system will be controlled by an AI algorithm-based Application which provides farmers with insights when to provide irrigation or when to not.

Drone
Drone techniques will be implemented for aerial applications of fertilizers and pesticides. Drones are also used for the transport of materials.

An Entrepreneurship Idea

AI Powered Digital Market places
Artificial intelligence algorithms with modern agricultural tools analyze the demand of consumers and supply the desired products to buyers, it will minimize the spoilage of food and consumers will get fresh food material (environment will benefit). These markets will remove the middleman in between so farmers can get actual selling prices. Along that a transparency model is made so that buyers get information about the ingredients in food, chemicals used, nutrients in it, or any processing that is done. It will build the trust of buyers in farmers. Through digital tools sellers will get real time feedback from buyers and personalization can be done. Through home delivery model buyers can order directly from their home.Besides some challenges related to access of technology, infrastructure, and customer acquisition, the potential online market is great. This online market can be accessed through a website or mobile application.

Livestock management
An Artificial intelligence-based application will be made in accordance with dairy and husbandry management. This system uses different sensors to track the health of husbandry animals, their feeding habits, disease alert etc. It will analyze the quality of milk and develop data with the nutrients present in milk. This will help farmers to improve the efficiency of dairy units in terms of productivity. AI based applications will send notifications to farmers when they are hungry, need water, or have any health issue. So farmer will get real time updates. Farmers will also be able to order feed materials for their animals through the single application and farmer will get nutritious feed material from the trusted quality animal feed providers.

THE WAY AHEAD

With continuous technological advancement, Artificial intelligence (AI)-driven robots take careful consideration, when cropping and adapt instantly to each plant's conditions. Self-driving tractors will improve the crop growing methods, spraying of fertilizer (chemical/biofertilizer) and pesticide, and harvesting operations by traveling fields with exact accuracy. Smart irrigation techniques will emerge rapidly. Weather forecasting technology provides data helpful for farms for cultivation in accordance with rainfall, temperature, humidity etc. Farms which work as self-sufficient ecosystems, reducing waste and maximizing resource utilization. AI will also improve environmentally friendly and sustainable techs.Drones will be utilized with their full potential for planting, fertilizers spray etc.

INNOVATION DRIVES DEVELOPMENT

In the fast-developing landscape of agriculture, the emergence of Agriculture 4.0 is signalling a modern age of innovation and efficiency. This revolution is headed by technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and robotics, all transforming conventional farming traditions.

India's agriculture sector is undergoing an alteration with new technologies restructuring traditional farming practices. Furthermore, it adds close to 18 % of the nation's GDP and supports employment of more than 55% of the nation's population, as per the existing figures. From automation to artificial intelligence, these improvements are changing the way agriculture is performed in the country, guiding amplified efficiency and productivity.

Understanding the Evolution of Agriculture

From prehistoric civilizations to advanced industrial farming, agriculture has come a long way. We've observed the switch from physical labour to automation, and at present, we're entering the period of smart farming with Agriculture 4.0.

Concept of Agriculture 4.0

This latest wave of farming encompasses the incorporation of technologies like IoT, AI, and data analytics to enhance processes, upsurge efficiency, and guarantee sustainability in agriculture.

The execution of the concept in the Indian landscape has become more important than ever as it is anticipated that by 2050, the requirement for food will increase suddenly by 70%, in line with fast inhabitants' growth. A UN study discovered that approximately 9.9% of the world's residents still go starving, so the notion of nourishing nearly 10 billion mouths is a frightening view. With ecological variations hard to forecast, we must turn to innovation in agriculture technology.

This latest wave of farming encompasses the incorporation of technologies like IoT, AI, and data analytics to enhance processes, upsurge efficiency, and guarantee sustainability in agriculture.

Impact of IoT in Agriculture

Exploring IoT Applications in Farming

Internet of Things (IoT) devices are popping up in fields everywhere, from smart sensors monitoring soil moisture levels to drones scouting crop health. These connected devices gather real-time data, empowering farmers to make informed decisions and maximize yield.

Benefits of IoT Integration in Agriculture

With IoT, farmers can eliminate guesswork and introduce precision farming. By leveraging IoT data, farmers can optimize irrigation, monitor livestock, and even track weather conditions – all leading to improved productivity and sustainability.

Harnessing Artificial Intelligence for Farming

AI Technologies Transforming Agriculture

AI enables farmers to analyze vast amounts of data, predict crop diseases, and even automate routine tasks. With AI on their side, farmers can unlock new levels of efficiency and productivity.

AI in Crop Monitoring and Decision Making

AI-powered drones and cameras can now survey crops with unmatched accuracy, helping farmers make data-driven decisions in real-time.

New Technology Driven Products

Let's study how Farmers across India are now increasingly embracing new technology driven products like Microbots™ technology of IPL Biologicals to enhance their crop production.

Optimize yields and increase return on investment: Using Microbots™ in farming offers a tremendous chance to produce notable harvests and, as a result, secure a prosperous and expanding future for sustainable farming and

regenerative agriculture.

Enhanced uptake of nutrients: Indian farmers who employ Microbots™ technology report that their crops absorb more nutrients. These microbes maximize absorption and promote healthy growth by precisely delivering nutrients to plant roots.

Healthy and safe food: Using Microbots™ now farmers are growing healthy crop with less chemicals or no chemicals and producing healthy food

Revolutionizing Crop Watering Techniques

When it comes to watering crops, traditional methods can be challenging. But, Agriculture 4.0 includes innovative irrigation technologies that are changing the sphere -

Challenges in Traditional Crop Watering

Watering crops can be a risky act – too much or too little water can spoil the harvest. Traditional methods often rely on guesswork, leading to inefficient water usage and potential crop damage.

Innovative Irrigation Technologies in Agriculture 4.0

Implement smart irrigation systems powered by IoT and AI. These technologies analyze soil moisture levels, weather forecasts, and crop water needs to deliver the perfect amount of water at the right time. By optimizing irrigation, farmers can conserve water, boost crop yields, and ensure a bountiful harvest.

Enhancing Crop Spraying Practices

The Role of Precision Agriculture in Crop Spraying

Precision agriculture is revolutionizing how we approach crop spraying by customizing applications based on specific crop needs and environmental factors. This targeted approach not only maximizes efficiency but also minimizes waste, making it a win-win for both farmers and the environment.

Agriculture is an important contributor to India's flourishing economy. With about 54.6% of the entire workforce occupied in agriculture and similar segment activities, the sector contributes to 17.8% of the country's gross value added (GVA). During 2021-22, the country recorded US$ 50.2 billion in total agriculture exports with a 20% increase from US$ 41.3 billion in 2020-21.
In the domain of farming, Agriculture 4.0 is the lexicon that the whole world is conversing about.

AI enables farmers to analyze vast amounts of data, predict crop diseases, and even automate routine tasks.

Advancements in Automated Spraying Systems

Automated spraying systems are taking center stage, utilizing technologies like sensors, GPS, and drones to precisely target and apply pesticides or fertilizers. These systems not only reduce human error but also ensure accurate and uniform coverage, leading to healthier crops and higher yields.

With a considerable worth of around USD 457.26 billion in 2023, this crucial segment is on a rising curve, anticipated to increase at a remarkable Compound Annual Growth Rate (CAGR) of approximately 4.9% between 2024 and 2032. The prediction foresees the Indian agriculture market booming to a denomination of nearly USD 703.30 billion by 2032. As we justify the influence of Agriculture 4.0 expanding, it is evident that the amalgamation of technologies like IoT, AI, and robotics is restructuring the agricultural landscape in multiple ways. The potential for improved productivity, sustainability, and efficiency in farming is enormous, presenting a preview into a future where innovation drives development. Embracing these progressions and being at the front of technological integration will be fundamental for agriculturalists and shareholders eyeing to prosper in the vibrant sphere of modern agriculture. The journey towards a smarter, more sustainable agricultural industry is well underway, and the innovations of today are paving the way for a brighter tomorrow in the field of farming.

About the **AUTHOR**

Harsh Vardhan Bhagchandka, President of IPL Biologicals

QUALITY SEED PRODUCTION

As Entrepreneurial Skill Development

Agriculture feeds nation! Seed feeds agriculture! Quality seeds always play a vital role in agriculture and allied sectors. Quality seeds are produced and distributed under the various seed legislations viz., Seed Act 1966, Seed Rule 1968 and Seed Control Order 1983. Hence, the person entering quality or certified seed production business should follow the legal norms and should have proper seed seller licence. As per the Seed Control Order 1983, no person can involve in seed business without a licence. Hence it is necessary to enrich the knowledge of students and the youths through hands-on training in quality seed production with seed legislation.

Kalasalingam Academy of Research and Education gives such training to the students through Experiential Learning Programme for the past four years. So far the students have produced both Foundation and certified class seeds of Black gram var. VBN 8, Cluster Bean var. Pusa Navbhar, Paddy var ASD16 and Tomato var. PKM-1. Kalasalingam Academy of Research and Education is the only successful PKM1 tomato seed producer in Virudhunagar District of Tamil Nadu. Every year a team of students can get hands on training on certified seed production, it includes seed farm registration, field inspection, seed processing at an approved processing unit, seed quality test and bagging, tagging, sealing and marketing certified seeds. All the above mentioned processes are entered in the Seed Production Enforcement and Certification System (SPECS) portal.

What is SPECS?

Seed Production Enforcement and Certification System (SPECS) is a unique portal, started in the year 2018. Earlier the seed farm registration and its follow up actions were maintained manually by the Assistant Director of Seed Certification office. Now, the SPECS portal is user-friendly and this portal helps to know the current status of seed production in various districts of Tamil Nadu. Moreover, it tracks the status of registered seed farms. This portal provides the overall data for the seed farm registration, number of field inspections carried out by Seed Certification Officers (SCOs), the total number of seed samples received by Seed Testing Laboratories, the number of substandard samples and Standard samples, the status of tagging, etc.,

SPECS portal is user-friendly and this portal helps to know the current status of seed production in various districts of Tamil Nadu.

About the **AUTHORS**

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Kalasalingam Academy of Research and Education, Tamil Nadu

How does SPECS portal work?

Seed Producer

The person who wants to start seed production should register in SPECS with the help of the Assistant Director of Seed Certification office. Under single seed producer, many seed growers can be added. After seed producer registration in SPECS, a unique user name and password will be provided. Once the seed crop is raised, the seed farm should be registered in SPECS by giving the farm details and the procurement details of source of seeds sown. After seed farm registration in SPECS portal,

SPECS portal for Seed producer to register seed farm and follow up actions

the details should be printed and triplicated copies are to be submitted to the Assistant Director of Seed Certification. After this, the details of the fixed date of SCO's field inspection, SCO's estimated yield detail, seed processing request, Seed Testing Lab results, Foundation/ Certified seed tag request and tagging can be followed through the portal.

Seed Seller

The seed 'Producer' option is used for the initial process from seed farm registration to the tagging process. Consequently, the available quantity of the certified seeds should be entered in 'Seller'- Stock entry. In the 'Seller' option, the seller licence with expiry date will be displayed. And the status of the service sample submission, the details of official sample taken during seed marketing/distribution, any legal disputes, stop sale order etc., will be displayed transparently.

Students have so far, produced both Foundation and certified class seeds of Black gram var. VBN 8, Cluster Bean var. Pusa Navbhar, Paddy var ASD16 and Tomato var. PKM-1. Kalasalingam Academy of Research and Education is the only successful PKM1 tomato seed producer in Virudhunagar District of Tamil Nadu.

Motivating Quality Seed Production

Quality seed production plays a vital role in increasing Seed Replacement Rate (SRR) in the country. At present the Seed Replacement Rate in India is around 15% and this ratio varies from crop to crop from 7% in staple crops to a maximum of 70% in some vegetables and fruits. Hence, we are in need to increase the Seed Replacement Rate of our nation by producing and supplying quality or certified seeds to the farmers. Hence, it is mandatory to motivate the youths in quality seed production and distribution with the awareness of Seed Act 1966, Seed Rule 1968 and Seed Control Order 1983. By supplying quality seeds to our farming community, awareness can be created among the farmers about the importance of certified or quality seeds. The steps taken to motivate the students in seed production programme through Experiential Learning Programme fulfils the need of NEP2020 by paving the way to our graduated students to become an Entrepreneur/Agripreneur in seed business.

TOWARDS FINANCIAL EMPOWERMENT

According to the latest Agriculture Census of 2022, India's agricultural sector involves approximately 148 million farmers, with nearly 80 percent categorized as small and marginal farmers. The average size of land holding in India is 1.15 ha and will decrease even more in coming years due to land fragmentation, industrialization and urbanization which are forcing farmers to quit farming and look for more viable livelihood options. Moreover, small and marginal farmers are exposed to the high risk of farming due to climate variations, uncertainties in production and market demand and lack of access to support services and markets. So, there is an urge to tackle the strategies that can enhance the farmer's income as well as for sustainable agriculture and the environment.

Strategies for Doubling Farmer's Income

Market Management

Small-scale farmers lack updated market information which plays crucial role in understanding economic fluctuations. Poor infrastructure, limited access to finance, deficient transport and communication exacerbate market failures. The absence of fair pricing might deter farmers from enhancing production. A comprehensive policy-level framework integrating marketing systems into agricultural development is imperative to address this. Encouraging sustainable localized marketing in remote regions could significantly boost farmer's incomes.

Encouraging sustainable localized marketing in remote regions could significantly boost farmer's incomes.

Agriculture Price Policy

The Government of India announces minimum support prices (MSPs) for 24 commodities, a measure intervening in markets to shield agricultural producers from steep price drops. To double the farmer's income, expanding this price policy to encompass more agricultural products becomes pivotal.

National Agriculture Market (e-NAM)

Currently, APMC-regulated market yards confine agricultural commodity trading primarily to local mandis at the initial point of sale after harvest, often limited to Taluka/tahsil or district levels. Even within states, the absence of a unified agricultural market results in additional transaction costs when moving the produce within the particular state too.

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Trading across district and state borders necessitates multiple licenses, fostering a fragmented, cost-intensive agricultural economy and obstructing the seamless movement of agricultural goods.

Amendment of the APMC Act

This regulation bars direct farmer sales to exporters or processors, hampering agricultural processing and exports. It confines market setup authority to state governments, restricting private investment in infrastructure. In state, market fragmentation obstructs free commodity flow which leads to increased handling and mandi charges and elevating consumer prices without equitable farmer benefits. Revising APMC acts across states is vital for fostering competitive markets and NAM involvement.

Contract farming

There is a need to encourage the states to do contract farming under which the buyer can provide the farmer access to modern technology, quality inputs, other support and a guaranteed price. It had been given much importance in the model APMC Act, 2003.

Farmer Producer Organization

The majority of farmers in India possess small and marginal land holdings, impacting the potential scale economies crucial in agricultural produce marketing. These smaller sizes often result in increased transportation and associated expenses, rendering them uneconomical. Therefore, the formation of cooperative farmer groups can significantly improve their bargaining power, enabling them to secure better prices for their agricultural produce.

Establishment of terminal markets

A terminal market typically in urban areas acts as a hub for assembling and trading commodities. It aims to shorten perishable supply chains, connect farmers directly to markets and elevate farmer income, introduce market transparency and establish fair prices for agricultural produce. Offering backward linkages enables farmers to secure higher prices

Nutrition farming addresses essential goals by providing nutrients and generating extra income through crop diversification and cost-effective cultivation.

and consequently increase income.

Post-Harvest Management

India stands self-reliant in food production, yet it contends with post-harvest losses ranging from 22% to 30% and merely processes 2-3% of its agricultural produce. By mitigating post-harvest losses, there's a substantial opportunity to augment farmer's incomes.

Direct Marketing

Direct marketing of food products to consumers adds value to farming produce, reducing middlemen's involvement and boosting farmer's income. Successful initiatives of direct marketing viz., Apni Mandi, Uzhavar Sandai, Rythu Markets and VFPCK (Vegetable and Fruits Promotion Council, Kerala) etc should be replicated nationwide with necessary adaptations to encourage and enhance their impact.

Agricultural Input

Farmers urgently require improved seed accessibility that meets varietal purity, high germination rates and disease-free standards. Soil test-based nutrient management and efficient water management is crucial for sustainable agriculture. Rainfed areas benefit from Participatory Watershed Development Programs Implementing suitable risk mitigation mechanisms is essential to safeguard farmer's viability and the agricultural sector's sustainability as a business.

Climate-smart agriculture (CSA)

CSA helps to transform and reorient agricultural systems effectively to support development and ensure food security in a changing climate along with a sustainable increase of agricultural productivity and incomes.

Integrated farming system
The IFS approach stabilizes income through natural resource management and livelihood diversification. It will also help in increasing family labour employment. It involves the use of outputs of one enterprise component as inputs for other related enterprises wherever feasible.

Crop insurance
Crop insurance is a good measure to protect the farmers against the uncertainties of crop production, due to natural factors beyond the farmer's control. Presently, the Pradhan Mantri Fasal Bima Yojana (PMFBY) scheme is a good initiative that covers yield losses, post-harvest losses and localized calamities due to weather.

Diversification of agriculture
Small and marginal holdings account for around 80% of the total operational holdings in the country. Diversification towards high-value cash crops will help in improving the income of farmers by enhancing resource use efficiency.

Enhancing income by improving the yield of crops
Farmer's income can be increased by enhancing the crop yield sustainably. Globally, India lags in productivity of crops and it is of utmost importance that the productivity per ha is raised urgently to pull out farmers from poverty. Adoption of soil health cards, superior cultivars, the latest technology and better access to irrigation will improve production and productivity.

Increase in cropping intensity
The farmers must be encouraged to grow multiple crops during all the cropping seasons and cultivate the agricultural land available. Farmers should be encouraged to use more innovative cropping system techniques and these cropping systems enable intensive use of farmland and farmer's time without the risk of competition between crops for the use of resources.

Bridging yield gap
In India, the yield gap is very high as compared to other countries. Extension agencies need to develop and disseminate location-specific package of practices of different crops and need to ensure adequate quality and timely availability of inputs.

Use of biotechnology for enhancing yield
The introduction of Genetically Modified (GM) traits through biotechnology has led to increased yields independent of crop breeding. GM traits such as insect and herbicide tolerance, help to increase yields by protecting the yield that would otherwise be lost due to insects or weeds. In India, insect-resistant cotton (Bt cotton) has led to a 24% increase in cotton yield through reduced pest damage and a 50% gain in cotton profit among smallholders..

Nutrition farming
Nutrition-sensitive agriculture aims to improve food availability, sustainability and nutritional content that emphasizes the cultivation of high-nutrient crops and biofortified varieties. Nutri farms or gardens have gained traction, offering nations a means to enhance nutritional security. Nutrition farming addresses essential goals by providing nutrients and generating extra income through crop diversification and cost-effective cultivation.

Agriculture Extension Strategies

Use of ICT in agriculture
The introduction of Information and Communication Technology (ICT) in agriculture offers direct support to farmers by providing timely information and fostering knowledge-sharing within the farming community. Promoting ICT in agriculture stands as a catalyst for doubling farmers' incomes.

Public-Private Partnership in Agriculture
India faces a wide extension worker-to-farmer ratio of 1:5000 (approximately 60 thousand extension workers), surpassing ratios in Ethiopia (1:476) and China (1:625). To achieve the goal of doubling farmers' income in five years, fostering public-private partnerships in agriculture is imperative.

Promotion of Farmer's Organizations
Farmer's Organizations can improve their bargaining power, decrease transaction costs for input procurement and transportation and streamline the processing and marketing of agricultural goods notably boosting their earnings. Integrating FOs into the planning, design and execution of agricultural and rural development policies is essential to enhance the income of small and marginalized farmers.

Agreprenureship Development
Developing agripreneurship necessitates robust support systems and capacity-building initiatives to transition farmers from agriculture to entrepreneurial ventures. Sensitizing farmers to off-farm and non-farm income-generating activities is crucial for augmenting their earnings. Agricultural extension programs must equip farmers with comprehensive education and training, fostering technical, managerial, entrepreneurial and interpersonal skills essential for the profitable management of the agricultural sector.

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