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CROP HEALTH

Augmenting National Income

AGRICULTURE
TODAY
GROUP

75
Azadi Ka
Amrit Mahotsav

G20
भारत 2023 INDIA

INTERNATIONAL YEAR OF
MILLETS
2023

पशुपालन और डेवरी विभाग
Department of Animal Husbandry and Dairying

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2nd Edition of

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CROP HEALTH FOR A COMMON FUTURE

When demand is more and supply is constrained, there tends to be wariness on the supply side which is usually reciprocated by either increasing supply or optimising supply. In agriculture, we are forced to choose the latter option. As our resources are progressively truncated with each passing day, we have to become more efficient and judicious by protecting whatever we produce. Crop health has thus become an important determinant of our food security. Evolved into a broader perspective, crop health encompasses the well being of each and every component associated with production landscape starting from water, soil, climate, crop and environment.

Today our challenges have changed from what it was seventy years ago. Climate change, the biggest of all challenges, as iterated by the Prime Minister in the recently concluded G20 Agriculture Ministers' meet in Hyderabad, has a profound influence on crop health. The climate anomalies open up a Pandora's box, starting from a direct reduction in crop yield to resurgence of pest and diseases. With regional variations in the impact of climate changes, a common solution is impractical, which then calls for a multiregional and multidisciplinary approach to evolve remedies becomes pertinent. This further impresses upon the fact that strong regional research activities that addresses the local problems are equally important and need the support in terms of infrastructure and investment from the government.

Research and development are important areas that can no longer be considered secondary to the policies and schemes to address the inequities existing in the agriculture landscape. Keeping crop health in perspective, we have to look into each component closely. From seed health to post harvest health, newer research priorities can be designed. Green chemicals effective in lower doses and safer chemistries need to be promoted. Newer biological entities and biotechnological approaches have to be promoted. A regulatory environment that is encouraging and inspiring innovation can transform India's agriculture sector. Technology that ensures access to precise and safe utilisation of inputs can ensure sustainability.

For the present and the future generations, crop health is important. The common future of this planet hinges upon a sensible, timely, progressive and collective approach in crop health.



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ENRICHING SOIL HEALTH, ENHANCING CROP YIELD, ENSURING SAFE FOOD

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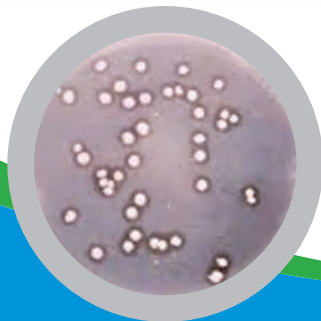
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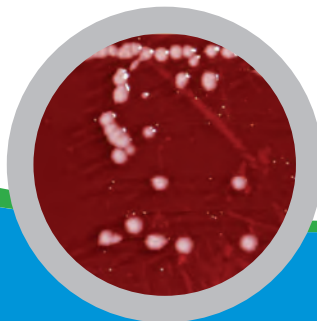
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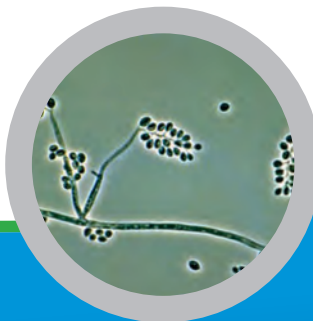
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AGRICULTURAL PRACTICES FOR BETTER SOIL HEALTH, CROP HEALTH AND YIELD

Hyderebad became the host to the G20 Agriculture Ministerial meeting which was held from June 15 to 17. The three-day event, attended by more than 200 delegates from G20 member countries, invited countries and International Organizations was graced by the Agriculture Ministers from various countries and the Director Generals from International Organizations.

Outcome Report

The G20 Agriculture Ministers Meeting adopted Outcome Document and Chair's Summary focussing on

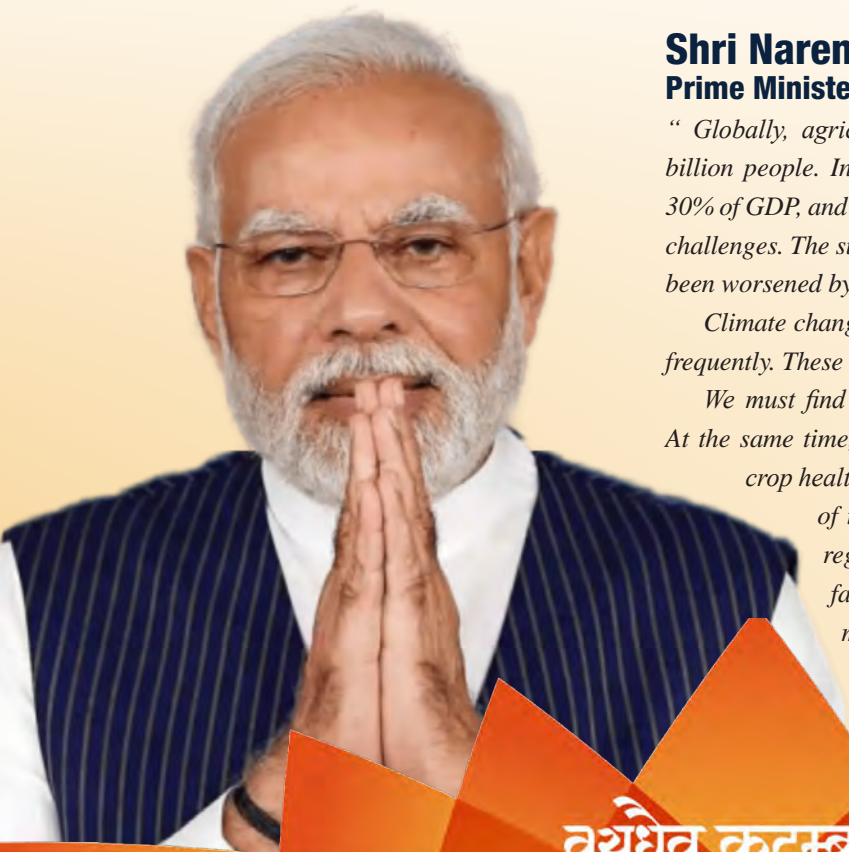
food security and Nutrition for all. The Outcome document also included the Deccan High-Level Principles and International Millets and Other Ancient Grains Research Initiative. The document also called for strengthening policies and collaborative actions for climate-resilient and sustainable agriculture and food systems.

The Document said that the Deccan High-Level Principles demonstrated the G20's collective responsibility in reinforcing and complementing efforts across geographies in response to global food security crises by means of facilitating humanitarian assistance. It further said this assistance will be offered

to countries and populations in vulnerable situations, enhancing availability and access to nutritious food. The document also called for strengthening policies and collaborative actions for climate-resilient and sustainable agriculture and food systems.

Stress on Food Security and Nutrition

While acknowledging the long-term increase in global food production to meet the needs of a growing population, the G20 Ministers of Agriculture, in the document, said they are gravely concerned by the worsening global food insecurity situation and intensifying



Shri Narendra Modi, Prime Minister, India

“ Globally, agriculture provides livelihood for over two point five billion people. In the Global South, agriculture accounts for almost 30% of GDP, and over 60% of jobs. And today, this sector faces several challenges. The supply chain disruptions caused by the pandemic have been worsened by the impact of geo-political tensions.

Climate change is causing extreme weather events more and more frequently. These challenges are felt most by the Global South.

We must find ways to strengthen global fertilizer supply chains. At the same time, adopt agricultural practices for better soil health, crop health and yield. Traditional practices from different parts of the world may inspire us to develop alternatives for regenerative agriculture. We need to empower our farmers with innovation and digital technology. We must also make solutions affordable for small and marginal farmers in the Global South.”

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malnutrition rates, in several developing and least developed countries. In the document, the G20 Ministers of Agriculture reiterated the urgency noted in the G20 Matera and Bali Leaders' Declarations emphasising the need to work together to promote food security and nutrition.

In their 'Call for Action' on 'Food Security and Nutrition', the ministers noted with concern the high prices, ongoing disruptions in global supply chains, and excessive price volatility of food and fertilisers. Resilient, uninterrupted and reliable supply chains are essential for stabilising the availability and affordability of food for all, especially for people in vulnerable situations, they said. They called for initiatives to promote innovations in crop development, production and consumption patterns.

Towards SDGs and 'One Health'

In the outcome report sustainable agriculture and food production, food security programmes and international trade were recognised to be critical for the implementation of the 2030 Agenda towards achieving the United Nations



Sustainable Development Goals (SDGs). The ministers resolved to collaborate in areas such as climate-resilient technologies, nature-based solutions and ecosystem-based approaches and foster better dissemination of existing traditional and local knowledge for sustainable agriculture.

They called for an integrated and multi-sectoral 'One Health' approach to simultaneously balance and optimise the health of people, animals, plants and ecosystems, and combat anti-microbial resistance (AMR) to reduce

the risks from emerging and currently occurring zoonotic diseases with pandemic potential and other threats to global public health security. The ministers underscored that policies promoting resilient and sustainable agriculture, food systems and supply chains have enormous potential to bring about inclusive welfare and sustainable development. Besides this, the relevance of digital solutions in agriculture were also highlighted.



Shri Narendra Singh Tomar
Union Minister for Agriculture

“India is very prosperous and powerful in the agriculture sector and shares its knowledge and experience in the global interest of the agriculture sector, for which we will be ready in the future as well. In the last nine years, many new dimensions have been established in the agriculture sector in the country, through which the welfare of medium to small farmers is the main objective. In view of climate change and environment, decisions have been taken in the interest of the agriculture sector. In this direction, on the initiative of India, the International Year of Millets (Shri Anna) declared by the United Nations is being celebrated in the country and the world. Along with this, India is also bringing awareness among farmers regarding crop diversification. Climate-suitable varieties have been developed by the Indian Council of Agricultural Research. India is ready for the progress of farmers and agriculture sector through the promotion of organic and natural farming and sustainable agriculture system. Groups such as the G-20 have great utility, including building a common strategy to address agricultural challenges.

Mainly, the challenges in agriculture today are not only India's but global. All countries should work together. For this, a grouping like the G20 is a very useful platform. I feel all countries would be successful in finding solutions together to the contemporary challenges through consultation. “

AMICABLE REGULATORY PROCEDURE FOR INTRODUCTION OF NEWER MOLECULES



actively promote the registration of as many molecules as possible, so that the farmers have a wide range of choices that are required to meet very large variety of crops and their pests, diseases, weeds and vermin including the problems of resistance.

Regulatory Norms for Encouraging Better Products

India has seen the ravages of sudden outbreak of newer pest problems many times in the past: products like synthetic pyrethroids and the weedicides Isoproturon had to be given emergency approvals for their use in India to grapple with the pest/weed challenge posed by their sudden outbreak. The dreaded weed Phalaris minor is one of them. Recently, the outbreak of black thrips in Chilli, fall armyworm in maize, resistance to herbicides in Phalaris had to be dealt with by the Registration Committee by short-circuiting registration process and enhancing the label claims of existing products.

With the focus on increasing agri-exports as well as the shift to horticulture,

Molecule discoverers abroad are discouraged to register the non-patented molecules without RDP, because they spend crores to register them, but get readily copied by others at a fraction of their cost

Agriculture globally is facing challenges due to climate change. In India this challenge is even greater having the 2nd largest arable land of approximately 167 million ha, with a population of 1.4 billion and growing. Requirement of food and nutritional security, quantity and quality, changing food habits, growing need for fiber & bio-fuels and our focus on agricultural exports are the challenges faced by the Indian farmers who have to constantly work towards increasing productivity, volume and maintaining consistent quality of his produce all the while surviving the biotic pressure of pests, diseases and weeds which can destroy up to 25-30% of their crops.

The complexity of these “enemies” keeps changing, needing newer approaches for their management wherein Crop Protection Chemicals (CPP) play a major role. Hence farmers need a very large arsenal of agrochemicals for crop protection. Strategically, therefore India’s pesticides registration related regulations ought to be framed to pro-



About the AUTHOR

Dr Kalyan Goswami,
Director General,
Agro Chem Federation of India
(ACFI)



the farmers have become very conscious of using environmental friendly products and have taken in stride banning of some of the old toxic products. They are constantly looking for newer, better and safer CPP products to protect their crops. It is a fact that we have 311 registered products in India, yet still use 57 molecules which are more than 50-60 years old. Easing introduction of newer products will speed up switching to environmental friendly molecules and benefit our farmers.

India must encourage the registration of newer and safer molecules

Molecule discoverers abroad are discouraged to register the non-patented molecules without RDP, because they spend crores to register them, but get readily copied by others at a fraction of their cost. Countries such as Vietnam and Pakistan have registered more than 550 pesticides, whereas Brazil, EU, USA have more than 600-700 molecules registered and each of them follow globally established practice of providing RDP for a given period of time. In turn the farmer's benefit due to the high range of available products.

If we look at patented molecules - the discoverer applies for the patent soonest as he discovers a new molecule, and its 20-year validity period begins from that date. But it takes 5-7 years to generate the

entire dossier on toxicology, bio-efficacy, products stability, chemistry, formulation, research, packaging etc. leaving around 12 years or so for its commercial launch. Yet, further patent time is lost to get the same molecule registered country wise which needs another 2-3 years. Some countries, in order to have the farmers view, make all efforts to compress this time slot. In India, before application, the applicant has to generate bio-efficacy related data including residues in each crop for which the registration is sought. This itself takes 2-3 years. Subsequently, the RC takes 4-6 years before granting the registration effectively leaving very little time for a patented product to enjoy its patent benefit in India.

RDP to Patent Expired Molecules

The cost of molecule discovery is now over US\$ 300-350 million dollars (Rs2400-2800 Crores) spread over 10 years period and the number of molecules are far fewer than real. Due

RDP is required to give an opportunity for the first-time registrant to recover his initial cost of registration, extension, stewardship and marketing during the period of exclusivity

to these high costs only, 2-3 molecules see commercialization thereby further reducing availability of newer products. Hence, the next best option to attract registration of maximum molecules and give RDP to patent expired molecules. RDP is required to give an opportunity for the first-time registrant to recover his initial cost of registration, extension, stewardship and marketing during the period of exclusivity. By no stretch, it prevents others to register the same molecule. Anyone can register the same molecule during the RDP product by submitting the required data for registration and this is what differentiates this from a patented molecule. RDP effectively prevents the 'copy cat culture' and prevents the free ride that RDP opponents wish to enjoy on the costs incurred by the first registrant.

RDP registration in no way affects the sale of existing registered generic products. The cost and consequences of high price/poor efficacy in the judgement of the farmers is a risk the first-time registrant takes, and there appears no reason why regulatory authorities, or those who oppose RDP on the grounds of high prices should be involved in this. The demand for "protection" of domestic industry possibly emanates from the desire to perpetuate the market dominance of certain decades old molecules, and to prevent introduction of newer crop protection technologies. But industry cannot prosper and grow without rapid increase in the number of registered molecules in India.

Needless to say, India going forward must be open to all possible newer technologies/products which help our farmers to manage the pest/disease/weeds challenges. There appears no logical reason why our regulatory procedure should not be tuned to encourage the introduction of maximum number of molecules in India and encourage healthy competition amongst products which shall benefit the farmers.



GROWTH OF AGROCHEMICALS IN “AMRIT KAAL”

India's agro-chemical industry has come a long way in past 75 years and with right policy and enabling environment this sector holds promise for a flourishing future in next 25 years.

In the last five years, the crop protection market in India has grown at a CAGR of 6.3%, with the market growing to INR 24,570 crores in 2021 from INR 19,270 crores in 2017 and is expected to reach a level of INR 35,500 crores by 2027. Government of India has termed the next 25 years as the "Amrit Kaal". For the agro-chemical sector partnerships and imple-

mentation would be the key to realize its potential. There is need to engage with all stakeholders to ensure a predictable, science-based policy and regulatory regime for further enhancing the ability of the crop protection sector to make our farmers and Indian agriculture sustainable — to which CropLife India is committed.

Pursuit Towards Greener Chemistries

The crop protection industry has been contributing significantly to not only enhancing productivity but also to the sustainable growth of Indian agriculture. Agrochemicals have enabled India to tackle national crop emergencies like control of Phalaris minor weed in wheat, *Heliothis armigera* bollworm in cotton or brown plant hopper insect pest in rice over the years.

The R&D based crop protection indus-

try has been launching new molecules with increased efficacy and reduced application rates over time. The application rates, in the case of insecticides such as organophosphates (malathion, chlorpyrifos, etc) and carbamates (carbaryl, aldicarb, etc) during the 1960s and 1970s were as high as 1000 – 3,000 grams of active ingredient per hectare. By the 80s, with the advent of cartap and synthetic pyrethroids, the rates came down to 50-500 grams per hectare. From the 90s to the early 2000s, there was further advancement through moderate toxicity chemicals like triazoles and neonicotinoids, having dosages of 25-200 grams per hectare. Since the mid-2000s, the active ingredient application has fallen to well below 100 grams; in some cases — such as sulfonylureas and diamides — it is as less as 4 grams per hectare. The pursuit towards greener chemistries continues and the industry is well aware of its responsibility to reduce the environmental footprint.

While the global average consumption of pesticides is 3 Kg/Ha., India consumes only 0.3 Kg/Ha

Indian Agrochemical Sector

The notion that India consumes a lot of agrochemicals is another misconception around Crop protection industry. While the global average consumption of pesticides is 3 Kg/Ha., India consumes only 0.3 Kg/Ha. In contrast, China consumes 13.06 Kg/Ha., Japan 11.8 Kg/Ha., and Brazil 4.7 Kg/Ha. In fact, Indian agriculture productivity per hectare is very low because of unavailability of newer and better technology chemicals.

Another critical aspect is that while there are 1175 molecules available globally, only 318 are registered in India. A further breakdown reveals that only about 75 molecules and their combinations are being used to protect 140 million hectares of diverse Indian agricultural crops.

About the AUTHOR

Durgesh Chandra
Secretary General - CropLife India





The US, EU and Brazil have around 450-750 approved molecules. Even country like Vietnam has more than 500 registered molecules.

These statistics indicate the fact that our farmers have limited choice to fight against the ever-increasing host of pest and diseases. Therefore, it is imperative that the industry is provided an enabling environment to bring newer and greener chemistries for the benefit of the farmers.

Policy Initiatives for a Vibrant Indian Agrochemical Sector

There is a need for a predictable science-based policy and regulatory regime for building a robust manufacturing base in the country.

Registration Timelines – Internationally, time required to register products is much less as compared to India. There is an imminent need to look at the registration timelines and bring it in line with international norms without compromising on the safety and efficacy and sustainable aspects. All registration categories under section 9(3) for molecules to be introduced first time in the country should be given priority. New molecule introduction needs to be encouraged and facilitated. There is a need to adopt Global Best Practices

Minor Changes legislation - At present any minor changes to the recipe is like a new registration and leads to enormous delays. Internationally minor changes are

The R&D based crop protection industry has been launching new molecules with increased efficacy and reduced application rates over time.

allowed without the need for elaborate data requirements all over again. India should also allow minor changes without the requirement of large amount of data.

Upgradation of Labs - India should implement Organization for Economic Co-operation and Development (OECD) requirements in letter and spirit and encourage data generation under Good Laboratory Practice (GLP). Peer review on toxicological data should be adopted by India similar to the pattern adopted by OECD member countries. Government should avoid any hasty decision to ban or a policy environment restricting use and introduction of new molecules.

It also needs to ensure that there is adequate duration of protection of regulatory data for the first-time registrants. This will enable them to not only recoup some of their investments but also steward the product properly. A period of exclusivity is granted by countries across the world for first time registrants in accordance with the WTO and TRIPS guidelines. In fact, it would ensure "Innovation Protection" and

would encourage more discoveries in India leading to creating a robust manufacturing base.

It is pertinent to mention here, if farming was not already difficult, with crops having to compete with 30,000 species of weeds, 3,000 species of worms and 10,000 species of plant-eating insects the newer and more complex pests like Fall Army Worm (FAW) and locusts combined with climate change are threatening the very existence of farming. In addition, bugs, molds and rodents threaten farmers' post-harvest and the Crop Protection products are the only solution that can prolong the life of crops and prevent post-harvest losses.

With support of the central and state governments, focus on new technologies as well as an enabling environment, Crop protection industry will surely witness its Amrit Kaal.



Breeding and Biotechnological Applications FOR SUSTAINABLE CROP HEALTH MANAGEMENT

On average, GMOs
have increased crop
yields by 22% and
reduced chemical
pesticide quantities by
37%.

Plant Breeding has always played a pivotal role in human history from revolutionizing agriculture to feed the ever-growing population. However, longer time invested in variety development and breeding cycles presents a stumbling block to an accelerated response of plant breeders to the growing demand for food production. Breeding and biotechnological approaches for crop health management is aimed at increased substantially agricultural production with enhanced nutritional content and enhanced tolerance to abiotic and biotic stresses.

Pre-breeding with Crop wild Relatives

Pre-breeding is an opportunity to introgression of desirable genes, from wild species (primary, secondary and tertiary gene pools) into elite

breeding lines/ cultivars/ genotypes, to overcome the linkage drag. Crop wild relatives (CWRs) are good reservoir of untapped genetic diversity, which may not exist in the cultivated gene pool that can be used to improve the numerous trait of interest including resistance/ tolerance against diseases, insect-pests, drought, salinity, cold, heat and good agronomic adaptation with quality improvement.

Resistance Breeding

Host plant resistance need to be integrated into a crop management system. This will not only have to take

into account the availability of plant resistance genes but also other factors affecting crop phenotype such as agronomy, breeding system, alternative control measures and most importantly the potential of the pathogen to evolve new pathotype.

Resistant varieties are the only solution to various viral diseases in crop plants threatening its cultivation. Recently, Anand Agricultural University has developed highly resistant varieties through resistant breeding approach that includes GAO 5 and GAO 8 in Okra, GAU 4 in Black gram, GAM 5 and GAM 8 in Green gram.

Considering the various direct and indirect impacts of climate change on food production and agriculture along with rapid deterioration of arable land and perplexity of rainfall patterns, all these factors triggering various abiotic stresses such as drought, heat stress and biotic stresses like pest and disease attacks, the sophisticated techniques laden biotechnology toolkit has potential to address these immense challenges.

Transgenic Crops

Transgenic /Genetically modified (GM) crops have been developed since the 1980s and were first

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Speed breeding can potentially accelerate the discovery and use of allelic diversity in landraces as well as in CWR to be further used in developing improved crop varieties.



commercialized in a few countries in the mid-1990s. According to PRS India, transgenics has been commercially released in about 32 crops and flower species with a total of 439 different transgenic events. In 2018, GM crops were grown in 26 countries on an estimated 474 million acres of about 14% of the world's arable land.

The most widely used GMO traits thus far involve herbicide tolerance and insect resistance. India is both the world's largest cotton producer and largest Bt cotton producer with an adoption rate of 95% for Bt cotton. On average, GMOs have increased crop yields by 22% and reduced chemical pesticide quantities by 37%. Within less than 10 years after its first commercialization, more than 90% of the cotton growers had switched to GMO seeds showing that Bt cotton adoption has significantly and sustainably reduced chemical pesticide applications, leading to large health and environmental benefits.

Marker assisted breeding

Genetic markers associated with agronomic traits can be introgressed into elite crop genetic backgrounds via marker assisted breeding (MAB). It allows stacking of desirable traits

into elite varieties to make them better adapted to climatic changes. The ultimate goal of crop breeding to develop super-varieties by assembling multiple desirable traits, such as yield related, superior quality, tolerance/resistance against biotic and abiotic stresses and good environmental adaptation. It is very challenging, difficult and time consuming to combine all traits in single genotype by traditional breeding.

Genome editing

Clustered regularly interspaced short palindromic repeat (CRISPR)/CRISPR-associated protein (Cas) system from *Streptococcus pyogenes* developed in last decade has been most versatile tool in breeder's toolkit to introduce desirable or novel traits and accelerate development of new crop varieties. A recently invented technique is gene editing, a much more precise form of genetic modification which often uses CRISPR technology.

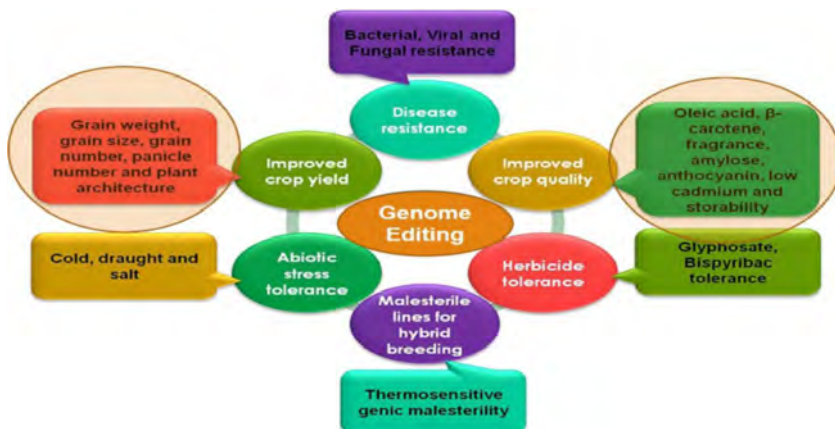
On 30 March 2022, the Government of India released the Office Memorandum for Exemption of the Genome Edited plants falling

under the categories of SDN1 and SDN2 from the provisions of the GMO Rules, 1989. If validated to be free of transgenes, they will be exempted from the current GMO regulations and can be released as a new variety and used for further development and evaluation. Many major countries like USA, UK, Mexico, Brazil, Argentina, Canada, India, China, Japan have implemented legislation that regulates genome edited crops, and now also two African countries have followed suit.

Speed Breeding

Speed breeding can potentially accelerate the discovery and use of allelic diversity in landraces as well as in CWR to be further used in developing improved crop varieties. The current pace of yield increase in staple crops like wheat, rice and maize is insufficient to meet the future demand in the wake of rising population. A major limiting factor in plant breeding is the longer generation times of the crops, typically allowing 1 to 2 generations in a year. Several 'speeding breeding' protocols, using extended photoperiods and controlled temperatures have enabled breeders to harvest up to 6 generations per year by reducing the generation time by more than half. Such protocols have been reported in several important crops such as spring wheat, rice, barley, chickpea and canola.

Food security and nutritional security of human being are dependent on effective crop health management wherein, crop breeding and biotechnology played key role in the past, present and future. Breeding resilient varieties is the best solution for crop health management as it is the cost effective, durable, ecofriendly and free from health hazards.



NURTURING CROP HEALTH

For A Resilient Future of India's Agriculture



India, once an aid-dependent nation, has today emerged as one of the largest food producers and exporters in the world. With foodgrain production estimated to be 330.53 MN Tonnes in 2022-23 our country is a far cry from the 1950s and 1960s. However, despite our productivity breakthroughs, we continue to lag behind other major countries.

Several factors are recognised as being responsible for holding Indian agriculture back from realising its full potential. These range from small landholdings and inadequate irrigation to a lack of technological intervention and poor access to credit. But one major drag on Indian agriculture that often goes unrecognized is crop health.

Crop Health – Key to boost immunity and sustainable farming

The healthier a crop is, the better are its chances of repelling diseases and withstanding adverse conditions. Just as crucial for the productivity of farmers are investments in mechanisation and digitisation, and so is the investment in crop health. Yet, while a lot has been discussed and written about the benefits of using modern technology, novel irrigation methods and improved mechanisation, awareness about crop health continues to remain low. For instance, only 55% of farmers in case of less developed states compared to 92% in developed states are aware about

Unseasonal and extreme weather events from rising temperatures will expose crops to previously unforeseen extremes thereby increasing the risk of invasive pests spreading in agricultural eco-systems.

About the **AUTHOR**

Rajavelu NK,
CEO – Crop Protection,
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Educating farmers and also distributors about the products available and, most importantly, their correct use should be the first port of call in driving awareness about crop health.

Soil Health Card Scheme (SHC), a first step to sustainable farming and ensuring proper steps for better crop health.

The lack of awareness about crop health has already cost us. It is estimated that 15%-25% of our agriculture production is lost every year due to pests alone. With today's erratic weather pattern further impacting the yield of farmers, creating awareness around crop health is the need of the hour as climate changes do have a direct bearing on crop health.

Climate Change – Key to be considered for crop protection

Unseasonal and extreme weather events from rising temperatures will expose crops to previously unforeseen extremes thereby increasing the risk of invasive pests spreading in agricultural eco-systems. While this will make our farms more vulnerable than ever before and threaten food security, small farm holders whose livelihoods depend on crop health will be impacted the most.

And it is herein that just like there are immunity boosters and supplements for humans to improve their resilience to disease, there are crop protection products that can make crops resilient to climate change.

Crop Protection Products – Key to sustainable yield

Proper utilization of crop protection products is imperative for good health of the crop and hence better yield for the farmer. Purely considering them as yield boosters can lead to more harm than good. Hence, be it biostimulants or pesticides, improper dosage would not only lead to these products turning ineffective for the purpose they are meant to but also damage the soil.

With farmers today largely unaware about the exact fitment, pest issues vis-

à-vis best solution to address the issue, knowing when to use crop protection products and when not to can make the difference between successful and not so optimum yield. Additionally, it adds on to the operational costs of the farmers.

Enhancing Awareness – Key for resilient Indian agriculture

Educating farmers and also distributors about the products available and, most importantly, their correct use should be the first port of call in driving awareness about crop health. A large reason for this persistent lack of awareness is the informal nature of the crop protection products market. Trade and channel partners, for instance, are driven by the need to achieve a certain level of sales and margins. The unsuspecting farmer is therefore sold products that s/he doesn't need and ends up using incorrectly which hurts the farm's yields.

The government has stepped in to regulate the space, certainly when it comes to biostimulants, which are essentially yield-boosting products. It requires companies to register and prove the efficacy of their biostimulants

before being allowed to sell them. Rules like these are crucial in protecting against the sale of ineffective, spurious products to farmers. They are a key part of ensuring crop health.

But, ultimately, raising awareness is what holds the key to giving crop health the same due as mechanisation, digitisation and irrigation in India's push to boost its agricultural productivity.

To do that private players will have to step in and work in conjunction with the government. Studies will have to be commissioned. Any effort to raise awareness will need to be built on a solid scientific foundation. Forums and discussions will need to be held. Outreach programmes, similar to initiatives aimed at educating farmers on the use of technology, will also need to be conducted.

The Green Revolution was a landmark moment in the story of post-Independence India. It helped us achieve food security. But we can't rest on its laurels. We need to equip our agriculture sector to meet the challenges of tomorrow. Our freedom from dependence on food aid was hard won. Let's build on it, not squander it.



ZINC FOR SUSTAINABLE AGRICULTURE GROWTH

India, with around 1.43 billion people, is now the world's most populous nation. The health of the farm sector is critical for the economic and social well-being of the country more than ever. India has achieved domestic food security and has become a net exporter of farm output to the world. India's foodgrains production is estimated to increase to 330.5 million tonnes in 2022-23, setting a new record compared to the previous year's 315.6 million tonnes. The next challenge is India's transition from food security to nutritional security.

Crop Loss

It has been observed that the contribution of agriculture to the country's economy has been decreasing over the past few years. The primary reason behind this is that crop yields in India are much lower than in North American and European regions, and in similar countries, such as China. Furthermore, the farmers lose a significant part of their income as their crops are being attacked by pests and weeds. Pests and diseases pose a threat to food security, which is aggravated further by climate change.

According to the Government of India statistics, about 15 to 25% of

If the plant is deficient in zinc, it would be susceptible to diseases and pests attack.

crops are lost due to pests every year. Crop care measures play a vital role in protecting the crop and the produce from pests and increasing farm productivity. The government along with prominent manufacturing companies is taking initiatives to reduce the impacts of pests on the yield by introducing new products. Integrated Pest Management Practices (IPM) are being recommended with more emphasis on the use of biologicals, like biopesticides, green pesticides and pesticides of plant origin like neem formulations.

Zinc - Critical Yet Deficient

Zinc plays a key role as a structural constituent or regulatory co-factor of a wide range of different enzymes and proteins in many important biochemical pathways. These are mainly concerned with carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, maintenance of the integrity

of biological membranes and resistance to infection by certain pathogens. If the plant is deficient in zinc, it would be susceptible to diseases and pests attack.

Zinc deficiency in plants retards photosynthesis & nitrogen metabolism, reduces flowering and fruit development, prolongs growth periods, resulting in delayed maturity, results in lower yield and poor produce quality and, results in sub-optimal nutrient-use efficiency. Some of the common deficiency

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symptoms of zinc in plants are, light green, yellow or bleached spots in interveinal areas of older leaves, the emerging leaves are smaller in size and often termed as “little leaf”, the internodal distance in case of severe deficiency becomes so short that all the leaves appear to come out from the same point, termed as “rosetting”.

However, zinc has emerged as the most widespread micronutrient deficiency in soils and crops worldwide, resulting in severe yield losses and deterioration in nutritional quality, adversely impacting the human health. Almost half of the soils in the world are deficient in zinc. India is not an exception, around 40% soils in India are deficient in zinc.

Effect of Zinc on Disease and Pest Management

The effects of zinc sulphate (33% Zn) fertilizer on the incidence of rice stem borers (*Scirpophaga* species) (Lepidoptera: Pyralidae) in rice crop showed that Zn had significant influences on the stem borers population and paddy yield over the unfertilized control. The study implies that due to suppressive effects of Zn-fertilizer on rice stem borers at crop maturity stage, there was increased grain yield (Sarwar 2011).

Zinc plays a pivotal function in the plant response to pests and diseases. Several studies have shown that, in most cases, Zn fertilization decreased plant symptoms. The multifunctionality of Zn in all living organisms provides this element key roles in basal metabolism, defence, and virulence, turning Zn into a highly valuable tool to understand the mechanisms underlying the plant–pest/pathogen interactions.

In addition to their role in plant growth and development, zinc finger proteins regulate plant responses to biotic stress conditions. Zn-efficient genotypes have been found to be more disease resistant, showing a positive relationship between increased plant growth and reduced pathogen susceptibility.

Almost half of the soils in the world are deficient in zinc.

Defence Triggers

Zinc is an important nutrient element to plants as it regulates various physiological processes resulting in the development of responses against diseases. Zn is responsible for the

activation of various defence related enzymes like alcohol dehydrogenase and superoxide dismutase as well as helps in the synthesis of defence-related proteins like metallothionein and zinc finger proteins. Upon infection, there is rapid production of reactive oxygen species which accumulates at the site of infection. This initiates the defence response in the plant. Zn deficiency increases the amount of amino acids in root and shoot exudates which further potentiates the pathogen infection.

The inclusion of zinc in crop protection in addition to crop production recommendation emerges as a crucial factor in combating pest and disease challenges and enhancing agricultural productivity. While challenges such as pests and diseases persist, concerted efforts are being made to mitigate the impact of pests and diseases and promote sustainable practices. The adoption of innovative farming techniques, diversification of crops, and investment in research and development will be crucial for future. Additionally, continued collaboration between the government, research institutions, and private sector stakeholders would go a long way in driving agricultural innovations and strengthen pest and disease management practices for sustainable agri growth in India.

ENABLING ENVIRONMENT FOR INNOVATION



“ By 2050, India’s population is expected to reach 1.7 billion people. Food demand is projected to increase by 70%. But Climate change and limited resources are going to exert tremendous pressure on production systems. We need to broaden the toolbox of farmers”, says Dr. KC Ravi, Chief Sustainability Officer, Syngenta India Pvt Ltd and Chairman Crop Life India. In a conversation with Anjana Nair, Group Editor, Agriculture Today, Dr Ravi discusses the current regulatory environment prevailing in India and the relevance of innovation in crop protection segment.

What is the extent of crop loss due to biotic and abiotic stress ?

According to various estimates, on an average 20-40 per cent of agriculture production is lost annually due to various stresses across the world. It is estimated that by controlling fungal diseases alone in the world’s five most important crops we could feed an additional 600 million more people. Crop Protection solutions have been playing a pivotal role in protecting the produce of the farmers from diseases and pests at various stages of the crop. According to ICAR study, the loss in value terms of India’s agriculture produce due to uncontrolled weeds alone would be to the tune of over Rs 80,000 crores, without the use of crop protection products.

Indian farmers need newer technologies and solutions that are safer (with lower A.I. doses/ha) environment-friendly and more effective

How significant is India's crop protection industry ?

India's agro-chemical industry has come a long way in past 75 years and with the right policy and regulatory environment this sector holds promise for a flourishing future in next 25 years. The India agrochemicals market size is valued at almost USD 6 billion in 2022. According to estimates the market is expected to further expand at a Compound Annual Growth Rate of 8.5% between 2023 and 2028 to reach a value of almost USD 9.82 billion by 2028. India is currently the fourth largest producer of agrochemicals in the world.

But when we compare India and the world there is a huge gap in terms of utilization of advanced molecules in crop protection. Why do you think this is happening?

It is not entirely correct to say that India is not using advanced chemistries. Some innovative and advanced technologies are being introduced in India at the same time as when being introduced globally. However, if we need to have a steady stream of innovative technologies, an enabling environment is required and would further boost introduction of latest technologies.

The statistics around the number of molecules is also quite revealing. We have a little over 300 molecules registered in India out of 1175 molecules available globally. The US, EU and Brazil have around 450-750 approved molecules. Closer home countries like Vietnam and Pakistan also have more than

tête-à-tête with Anjana



500 registered molecules. If we look at the usage pattern only about 75 molecules and their combinations are being used to protect 140 million hectares of diverse Indian agricultural crops. This also limits the choice of our farmers to fight against the ever-increasing host of pest and diseases.

How can the policy and regulatory atmosphere encourage introduction and adoption of novel molecules in plant protection ?

Internationally it takes less than half the time to register products as compared to India. There is an imminent need to look at the registration timelines and bring it in line with global best practices without of course compromising on the safety, efficacy and sustainable aspects.

There is a need to accord priority for molecules to be introduced first time in the country, through separate cell - All reg-

istration categories under section 9(3) for molecules to be introduced first time in the country should be given priority. New molecule introduction needs to be encouraged and facilitated.

India should implement Organisation for Economic Co-operation and Development (OECD) requirements in letter and spirit and encourage data generation under Good Laboratory Practice (GLP). Peer review on toxicological data should be adopted by India like the pattern adopted by OECD member countries.

At present any minor changes to the recipe is like a new registration and leads to enormous delays. Internationally minor changes are allowed without the need for elaborate data requirements all over again.

Any hasty decision to ban or a policy environment restricting use and introduction of new molecules will be like throwing the baby along with the bath-



water. Industry and Government should work towards ensuring that the farmers are equipped with the best technologies to produce more from less in an environmentally sustainable manner.

It also needs to be ensured that there is adequate duration of protection of regulatory data for the first-time registrants. This will enable them to not only recoup some of their investments but also steward the product properly. A period of exclusivity is granted by countries across the world for first time registrants in accordance with the WTO and TRIPS guidelines. In fact, this in my opinion would ensure "Innovation Protection" and would encourage more discoveries in India leading to creating a robust manufacturing base.

Chemical crop protection industry has been saviours of Indian agriculture whenever there has been a severe and unexpected outbreak of pests and diseases. Do you think they are not duly recognized ?

The Indian crop protection industry has been contributing to agriculture productivity and sustainability in a major way. But the industry or the role of crop protection is often not given enough credit. As far as the productivity aspect is concerned, most of the agro-chemical prod-

The R&D based crop sciences industry has been launching new molecules with increased efficacy and reduced application rates over time.

ucts in India, which have significantly helped reduce production losses from pest and disease attacks, owe their introduction to the R&D based crop sciences industry. These companies have been at the forefront of innovation, contributing to the first-time introduction of more than 95 per cent of crop protection products in use today. Such products have enabled Indian farmers to tackle national crop emergencies – whether it is control of Phalaris minor weed in wheat, Heliothis armigera bollworm in cotton or brown planthopper insect pest in rice.

If we look at the sustainable aspect, the industry has over the decades been reducing the environmental footprint. The R&D based crop sciences industry has been launching new molecules with increased efficacy and reduced application rates over time. The pursuit towards greener chemistries continues and the industry is well aware of its responsibility to reduce the environmental footprint. But the perception is still as though chemicals are mixed randomly by hand in a shady shack. This has to change.

For any new crop protection molecule to reach the market, it takes more than 11 years of intensive R&D efforts and an

average investment of around \$ 300 million. There is also another misconception that needs to be highlighted here and that is the notion that India already consumes a lot of agrochemicals.

What should be our future strategies ?

While we need to strengthen the hands of our farmers and provide them with the tools to deal with the multiple challenges to provide nutritious food on our plate, it is also imperative to make farming profitable to the large, small holder farmers in our country. This is only possible if a predictable science-based policy and regulatory environment that incentivises innovation and R&D is provided. Indian farmers need newer technologies and solutions that are safer (with lower A.I. doses/ha), environment-friendly and more effective.

The government and industry are working together on key reforms for "Making India a Global Agrochemical Manufacturing Hub". Public Private Partnership in a mission mode will definitely make Indian agriculture and Indian farmers Aatma Nirbhar.



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SCAN TO REGISTER

New Technology to Protect the Food for Future



production and that demand is rising, it does not have the luxury of losing food to a manageable problem.

Pesticide Overuse

Using pesticides in agriculture to limit pest manifestation is currently the most extensively used approach to manage a pest on a global scale. The pesticide industry is currently valued close to 218 billion dollars, and it is predicted to grow by 25% over the course of the next ten to twenty years. The pesticide business has made a historically significant contribution to reviving the food system, but it has also contributed to problems with biodiversity loss, water contamination, and human health. There is enough data to conclude that it both positively and negatively affected society and the environment.

The necessity to comprehend the efficiency of pesticide when it comes to application of pesticide is necessary since there has always been a tradeoff to maximize the benefits of pesticides and negotiate their impact. Millions of farmers in India use pesticides primarily to control pests; the way they are now used is largely random rather than data driven advisories. Numerous research indicate that pesticide use is higher than is necessary, which presents a chance to reduce pesticide use below the threshold level for greater benefits and fewer harm. In order to maximize profits and protect crops from rapid changes in pest density or the advent of new pests, random pesticide use will grow, especially in cash crops even farmers had to plough back in fear of emergence of pest.

Millions of farmers in India use pesticides primarily to control pests; the way they are now used is largely random rather than data driven advisories.

Pest and pathogen have been a menace to plants, and agriculture has lost billions of dollars owing to them internationally. This major problem has the world's economy suffering. The threat from pests and pathogens will expand exponentially because of the unprecedented change in the weather as some of the studies shows it, which is being felt everywhere. It may cost billions of dollars to control the rising exponential. The study has already shown that some insects' distribution has risen because of the warmer winter, and migratory insects' routes are predicted to alter how the weather is changing. India is not an exception when it comes to food loss, and some studies suggest that billions of dollars' worth of food and fiber are lost due to pest infestation. Despite the fact that India is self-sufficient in food



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Government Intervention

The government needs to help farmers more than ever in managing pests and technology can be instrumental in alerting farmers about possible damage and rationalizing the use of pesticides to maximize their effectiveness while minimizing environmental harm. It is possible to map out historical pest infestations and characterize the causes of such infestations using time series data, and then build an IOT-based pest surveillance infrastructure in areas where there is a higher risk of pest infestation.

The network of Krishi Vigyan Kendra's (KVK's) in India can be employed because of their extensive coverage of the nation. When a forecast is available, it can be used to create a regional advisory to control pest infestations in high-risk areas of the country where the likelihood of infestation is high. These advisories can be shared with a wide network of local pesticide dealers or distributors in addition to farmers. The targeted advisories will not only improve use efficiency by minimizing harm to the envi-

India is experiencing a period of opportunity due to its strong communication infrastructure, high rate of smart phone ownership among the younger population even in rural areas, and start-up ecosystem, which is prepared to push technology frontiers to new heights

ronment, but also will also assist farmers and the entire ecosystem in rationalizing pesticide use.

Capitalizing on Communication Infrastructure

The current method of managing pesticides is antiquated and not assisting farmers in controlling risk and the cost of production is rising in the absence of any system. India is experiencing a period of opportunity due to its strong communication infrastructure, high rate of smart

phone ownership among the younger population even in rural areas, and start-up ecosystem, which is prepared to push technology frontiers to new heights. This is the ideal moment to make connections and fill in the gaps using smart forecasting models to produce the appropriate advice and to use communication infrastructure to distribute information for the benefit of the farmers in managing pest manifestation in India.

Government is the organization that can take the lead in developing an infrastructure for pest forecasting, and KVKs can take it to the next level. Not just now, but possibly in the future given the way things are changing, pest scouting and forecasting, the dissemination of advisories, and decision-making regarding warnings will definitely help to save the billions of dollars that would otherwise go missing in the economy and harm the natural environment. Farmers will continue to rely on the conventional system and the cost of production will rise to manage risk if we do not change the system in time that favors everything to transition from conventional to risk averse.



THE EVOLVING LANDSCAPE OF CROP HEALTH MANAGEMENT

Crop health management has witnessed several noteworthy trends in recent years. The crop health sector is subject to dynamic trends that drive innovation and progress.

Precision Agriculture

One significant trend in crop health management is the increasing adoption of precision agriculture techniques. These techniques leverage advanced technologies such as remote sensing, drones, and data analytics to optimize resource utilization, detect diseases and enhance crop monitoring.

Use of biofertilizers not only helps in nutrition management but also helps improve soil health as it increases the number of soil microbes, thus, increasing soil's carbon content, thereby, promoting better crop and soil health.

Biological Control

The integration of biological control methods into conventional farming practices is gaining momentum. Biopesticides and biofertilizers are gaining prominence as environmentally friendly, innovative, and sustainable alternatives that offer effective nutrition, pest, and disease management while minimizing the impact on human health and the ecosystem. This trend aligns with the growing demand for sustainable and eco-friendly agricultural practices.

Soil Health Management

Techniques such as cover cropping, conservation tillage, and soil amendments help enhance soil fertility and structure. The use of biofertilizers not only helps in nutrition management but also helps improve soil health as it increases the number of soil microbes,

thus, increasing soil's carbon content, thereby, promoting better crop and soil health.

Integrated Pest Management (IPM)

IPM emphasizes the use of multiple pest control strategies, such as biological control, cultural practices, and targeted pesticide use to minimize the negative impact on the environment and human health. This holistic approach reduces reliance on chemical pesticides and promotes sustainable pest management.

Digital Solutions and Data Analytics

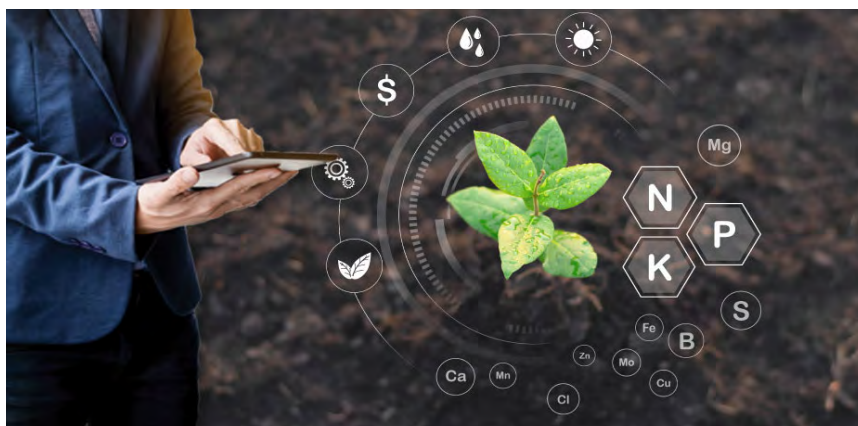
The adoption of digital technologies, including sensors, drones, and data analytics, is revolutionizing crop health management. Real-time monitoring, disease detection, and precise application of resources optimize crop production while reducing costs and environmental impact.

Climate-resilient Crop Varieties

With climate change posing challenges to crop health, there is a growing focus on developing and adopting climate-resilient crop varieties. These varieties exhibit tolerance to drought, heat, pests, and diseases, ensuring sustained productivity under changing climatic conditions.

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This system avoids synthetic chemicals and promotes biodiversity conservation, enhancing crop health while ensuring environmental sustainability.

Role of Public and Private Sectors:

Public Sector: Government plays a crucial role in developing and implementing policies, regulations, and research initiatives to promote sustainable crop health practices. The public sector, including government agencies, research institutions, and extension services, play a crucial role in developing and implementing policies, providing research and development support, disseminating knowledge, and facilitating technology transfer. Public sector initiatives aim to promote sustainable crop health practices, ensure food safety, and safeguard the environment.

Private Sector: The private sector, including agrochemical companies, seed manufacturers, biological solutions companies, and technology providers, contributes to the crop health sector through the development and commercialization of innovative products, technologies, and services. They collaborate with farmers, researchers, and policymakers to address evolving challenges and improve crop health management.

The crop health sector is witnessing dynamic changes driven by emerging trends, increasing scopes, evolving policies, and different production systems. Sustainable crop health management practices are vital for meeting food demand while preserving the environment. By recognizing the roles of public and private sectors and embracing innovative approaches, we can cultivate resilient crop systems that ensure food security, environmental sustainability and well-being of farmers and consumers alike.

Policies and Regulations

Government and international organizations recognize and have implemented policies and regulations to promote sustainable agriculture practices. Key policy areas include :

Pesticide Regulation: Stricter regulations govern pesticide use to reduce chemical residues in crops and protect human health. Government establishes Maximum Residue Limits (MRLs) and promotes responsible pesticide use through training programs and monitoring initiatives. These regulations help protect human health and promote integrated pest management strategies.

Sustainable Agriculture Initiatives: The government encourages sustainable agriculture practices through various initiatives, including organic farming promotion, focus on the use of biological solutions, agroecological approaches, and incentives for adopting environmentally friendly practices. Such policies aim to reduce chemical inputs, conserve natural resources, and promote biodiversity.

Soil Conservation : Policies emphasize soil conservation practices to mitigate erosion, improve soil fertility and enhance water retention capacity. The government incentivizes farmers to adopt practices like cover cropping, conservation tillage, etc, through subsidies and support programs.

Biodiversity Preservation: Policies promote biodiversity conservation within agricultural landscapes. Measures

such as establishing protected areas, promoting agroforestry, and conserving natural habitats contribute to enhancing ecosystem resilience and crop health.

Biosecurity Measures: The government is implementing strict biosecurity protocols to prevent the introduction and spread of invasive pests and diseases, including quarantine measures, surveillance programs, and regulations for import and export.

Research Funding: The government allocates resources to research and development in the crop health sector, funding supports the development of innovative solutions, encourages collaborations between research institutions and farmers, and facilitates the transfer of knowledge and technologies.

Different Production Systems

Crop health management can vary across different production systems.

Conventional Farming: Conventional farming relies on synthetic inputs, including pesticides and fertilizers to maximize crop yields. While this system provides high production levels, concern regarding environmental impact and sustainability have prompted a shift towards more sustainable practices.

Organic Farming: Organic farming systems prioritize ecological balance and rely on natural inputs, crop rotation, biological nutrition and pest management solutions, and soil health management to maintain soil health and minimize chemical inputs.

GM MUSTARD

FOR SELF-SUFFICIENCY IN OILSEEDS



in a self-pollinating plant like mustard. It requires the use of a male sterile line as female parent, but natural male sterility is difficult to come by and a rare occurrence.

GM Mustard Technology

University of Delhi has overcome this bottleneck in GM mustard technology, using a two gene system called barnase-barstar. The 'barnase' gene stops the development of pollen resulting in male sterility. This male sterile female is crossed with 'barstar' line that blocks the action of barnase to produce plants that are fertile and high yielding. DMH-11 hybrid was developed using barnase-barstar system

India's dependence on the edible oil imports to meet its growing domestic demand has been cause of concern over the years. Government has been encouraging farmers to take up oilseed production to bridge the gap between production and consumption. These efforts have yielded some results and oilseed production has increased in recent years, especially for soybean and mustard but we are a long way from self-reliance in oilseeds. India is expected to import 14.37 million tonne (mt) of vegetable oil in 2022-23 compared to 14.07 mt that was imported in 2021-22. Though this is an improvement on 15.32 mt imported in 2016-17, it remains the prime guzzler of foreign currency.

Bottleneck in Mustard Breeding

Soybean and mustard are the major crops forming 35 and 32 percent respectively of the total oilseed production. Mustard has a special status in India as its part of our tradition and exclusive cooking oil for certain cuisines. Even though multiple mustard varieties and hybrids are available, its

production is much below the global average. Mustard is also severely impacted by fungal diseases and insect infestation as well as abiotic stresses like soil salinity, high temperature and drought. Breeding for high yielding, resilient varieties is the way forward for mustard. Development of hybrids with higher vigor and yields has been done in mustard but the process is complex

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“The approval of GM mustard is a step in the right direction leading to self-sufficiency in oilseeds as well as attaining nutritional security.”

GM Safety

It is a fact that GM crops are safe to grow and consume. GM crops are the one of the most regulated technologies in the world. Numerous reviews and assessments by the government regulators across the world has confirmed the safety of the GM crops. Several international organizations such as the FAO, WHO and OECD have repeatedly confirmed the safety of the biotech crops and foods derived from them to be as safe and nutritious as foods derived from conventionally or organically grown crops.

The approval of GM mustard is a step in the right direction leading to self-sufficiency in oilseeds as well as attaining nutritional security. The barnase-barstar technology for hybrid production offers a great opportunity for improvement in mustard production. It can be used to efficiently develop hybrids with critical disease resistance and climate resilient traits. High yielding and high oil producing hybrids will encourage farmers to take up mustard cultivation and further help address the gap between oilseed production and consumption in the country.

with the Indian variety ‘Varuna’(barnase) and East-European variety ‘Early-Heera 2 (EH-2)’ (barstar). DMH-11 in its various trials has been shown to yield up to 28-37% more than various zonal checks. Though the barnase-barstar technology has been used for hybrid production in other crops across the globe and the crops have been consumed for more than 25

years, the DMH-11 and its parent lines were rigorously tested and evaluated for toxicity and allergenicity due to novel gene inclusion. Multiple year and multiple location trials as well as food safety evaluation data were analyzed and considered by experts in GEAC before approving GM mustard for commercial cultivation and consumption.

“Multiple year and multiple location trials as well as food safety evaluation data were analyzed and considered by experts in GEAC before approving GM mustard for commercial cultivation and consumption”.



CROP HEALTH FOR A SUSTAINABLE FUTURE

Crop health is an essential aspect of agriculture that significantly impacts global food security and the overall well-being of our planet. Crop health encompasses a range of factors, including disease resistance, pest control, nutrient availability, and environmental adaptability. Healthy crops are more resilient, capable of withstanding adverse conditions, and ultimately yield higher-quality produce. By focusing on crop health, we enhance agricultural productivity while minimizing negative environmental impacts.

advancements in IPM, promoting the use of biological controls, crop rotation, and precision technologies. By implementing IPM strategies, farmers can achieve effective pest control while minimizing the environmental impact.

One example of an IPM strategy is the use of biological controls, such as beneficial insects, nematodes, and microbial agents, to target pests. These natural enemies can help reduce pest populations, preventing the need for excessive chemical applications. Additionally, crop rotation, where different crops are grown in sequence, disrupts pest



Challenges Ahead

Today, agriculture faces numerous challenges that pose a threat to crop health. Changing climate patterns, emerging pests and diseases, soil degradation, and limited natural resources necessitate innovative solutions. It is our responsibility to develop and deliver effective tools and technologies to address these challenges.

Integrated Pest Management (IPM)

Pests and diseases can devastate crops, causing significant yield losses. Integrated Pest Management (IPM) is an approach that emphasizes the use of various tools and techniques to control pests while minimizing reliance on chemical interventions. Our industry has made substantial

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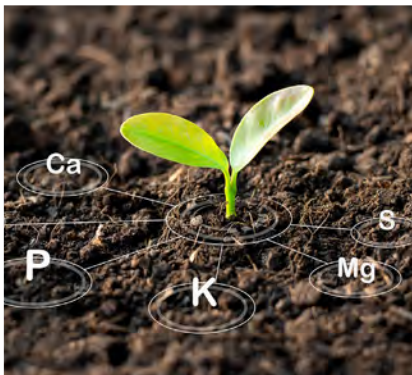
Changing climate patterns, emerging pests and diseases, soil degradation, and limited natural resources necessitate innovative solutions.

life cycles and reduces the build-up of pest populations. Precision technologies, such as remote sensing, satellite imagery, and data analytics, enable farmers to monitor pest activity, optimize interventions, and minimize the use of chemicals.

Crop Protection Products

Agrochemicals play a vital role in safeguarding crop health. Pesticides, herbicides, and fungicides provide farmers with essential tools to combat pests, weeds, and diseases. Our industry is dedicated to developing innovative, safe, and sustainable crop protection products. Through rigorous research and development, we aim to create formulations that maximize efficacy while minimizing environmental risks. Furthermore, we strive to educate farmers on proper application techniques and the responsible use of these products to ensure their efficacy and reduce any potential adverse effects.

One of the key advancements in crop protection is the development of selective herbicides that target specific weed species while leaving the desired crop unaffected. This targeted approach minimizes the impact on non-target organisms and reduces the overall use of herbicides. Similarly, fungicides with reduced environmental persistence and toxicity are being devel-



oped to mitigate the impact on beneficial microorganisms and minimize residues in the environment.

Seed Technology and Crop Improvement

Seed technology is at the forefront of ensuring crop health. Our industry invests heavily in research and development to enhance the genetic traits of crops, such as disease resistance, drought tolerance, and nutrient efficiency. By developing genetically improved seeds, we provide farmers with the means to cultivate more productive and resilient crops. Through innovative breeding techniques and biotechnology, we can accelerate the development of superior varieties, contributing to sustainable agriculture.

Sustainable Agriculture and Environmental Stewardship

We recognize the importance of sustainable agriculture and environmental stewardship. Our industry is committed to promoting practices that minimize the environmental footprint of agriculture. This includes reducing chemical inputs through precision farming, optimizing nutrient management, promoting conservation agriculture, and advocating for responsible water usage. By embracing sustainable practices, we ensure the long-term viability of agriculture while safeguarding the environment for future generations. Precision farming technologies, such as GPS-guided machinery and variable rate applications, enable farmers to optimize the use of inputs, including agrochemicals, fertilizers, and water. By applying these inputs more precisely, we can minimize waste, reduce environmental contamination, and improve resource efficiency. Nutrient management practices, such as the use of controlled-release fertilizers and soil testing, help farmers apply the right amount of nutrients at the right time, reducing nutrient runoff and pollution of water bodies. Conservation agriculture, which involves

minimum soil disturbance, permanent soil cover, and crop rotation, promotes soil health, reduces erosion, and enhances water retention. By adopting conservation practices, farmers can preserve soil fertility, enhance biodiversity, and mitigate the impacts of climate change. Responsible water usage, through efficient irrigation systems and water-saving techniques, ensures the sustainable utilization of this precious resource.

Collaboration and Knowledge Sharing

To tackle the challenges facing crop health effectively, collaboration is vital. Our industry actively collaborates with farmers, researchers, policymakers, and various stakeholders to exchange knowledge, share best practices, and develop innovative solutions. By fostering partnerships, we can harness collective expertise and drive progress in achieving sustainable crop health.

Public-private partnerships play a crucial role in advancing agricultural research and development. By collaborating with academic institutions and research organizations, our industry can access cutting-edge knowledge, support scientific breakthroughs, and translate research findings into practical solutions for farmers. We also work closely with farmers' organizations, extension services, and government agencies to provide training, technical support, and access to information, empowering farmers to adopt sustainable practices and make informed decisions.

Through integrated pest management, innovative crop protection products, seed technology, and sustainable agricultural practices, we strive to ensure the long-term health and resilience of our agricultural systems. By working together and embracing innovation, we can overcome challenges, enhance global food security, and create a sustainable future for agriculture.

One of the key advancements in crop protection is the development of selective herbicides that target specific weed species while leaving the desired crop unaffected

CROP HEALTH MANAGEMENT

A COMPREHENSIVE TAKE

Technological innovations in Indian agriculture are on the rise, fuelled by existing and emerging challenges. Overtaking China, India has become the second best-funded market for agritech startups behind the US. In the last decade, the nature of agritech innovations has evolved, with entrepreneurs and investors now looking for solutions further up agricultural value chains and closer to farms. Sub-sectors with untapped opportunities and increased focus on climate action are the two factors that have primarily contributed to this shift.

India is among the top 10 countries that will be adversely affected by the deepening impact of climate change. With the responsibility of sustaining 17.7% of the global population, the country is facing the urgent task of addressing various agricultural value chain inefficiencies while tackling climate mitigation and adaptation. Over 80% of Indians live in climate-vulnerable districts. By 2030, close to 17 million people could potentially go hungry due to climate change-induced hunger. At the root of it lies crop health management, a sum of various factors and agricultural practices. In order to fortify this basic building block, let's unpack a three-



pronged approach, including scientific innovation, financial services, and policy support.

Though sluggish in growth so far, agrifood life sciences (AFLS) can be our strongest line of defense against climate change.

Agrifood Life Sciences

In Omnivore's decade-long experience, more often than not agritech startups have built their innovations with an eye on reducing environmental stress. That said, two subcategories will directly help farmers manage crop health better - agrifood life sciences and precision agriculture. Though sluggish in growth so far, agrifood life sciences (AFLS) can be our strongest line of defense

against climate change. Innovations in agrifood life sciences can play a critical role in tackling climate mitigation and climate adaptation/resilience. Aside from developing high-yielding varieties of seeds, biological solutions are one of the largest untapped opportunities in agrifood life sciences and an essential tool for sustainable agriculture. Currently, Indian farmers depend heavily upon chemical fertilizers and pesticides. Such inputs are expensive, cause environmental pollution, compromise soil health, and create natural resistance that forces farmers to resort to even more toxic approaches. Biologicals are crop protection or crop nutrition products derived from living organisms and can substitute or complement agrochemical products. BioPrime's work



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with ag biologicals is doing just that. By engineering the diversity of plant microbiota, BioPrime's biologicals can confer plants with acquired traits like drought tolerance, disease resistance, and enhanced yields without any harmful environmental side effects.

Precision Agritech Solutions

While no amount of technology will be able to replicate the complex decisions farmers make on a daily basis, data derived from precision agriculture technologies help make those decisions easier and faster. Fortunately, the rapid development of precision agritech solutions over the past few years is helping farmers reduce expenditures, solve the labour shortage, and navigate erratic climatic conditions. A case in point is the steady adoption of Fasal's on-farm IoT technology that helps horticulture farmers tailor their cultivation plan around crop type, climate, and soil health. This tech-led approach achieves higher productivity, improved yield quality, and increased profitability. As for solving the labour shortage, Niqo Robotics has developed robots specifically designed for smallholder farms. These robots have proven to be effective in reducing chemical usage by up to 60 per cent, resulting in substantial cost savings and alleviating the burden of manual labour.

Insuring Against Climate Vagaries

In order to diversify crops and invest in technology, farmers need adequate and affordable capital presently in short supply. Most Indian farmers are locked out of formal financial services owing to a

While no amount of technology will be able to replicate the complex decisions farmers make on a daily basis, data derived from precision agriculture technologies help make those decisions easier and faster.



system that has struggled to evolve and accommodate them. Common problems in agricultural credit are manifold, including insufficiency of well-designed products, inadequate loan amounts, and lack of smart metrics to establish creditworthiness. Naturally, farmers still depend on informal sources of credit with interest rates as high as 35-40% APR that inhibit their risk-taking ability.

Indian farmers are already struggling with plummeting water tables, depleting soil fertility, and erratic monsoons. But this is only the beginning of a complex web of challenges they will face in the next decade. Crop insurance has emerged as an effective financial tool providing financial protection against crop damage while encouraging proactive crop health management. Traditional crop insurance incentivizes farmers to prioritize crop health through good agricultural practices, potentially reducing losses and premiums. Non-traditional parametric crop insurance in particular is gaining popularity as it provides coverage for losses that are difficult to model & hence insure conventionally. Gramcover's parametric insurance product offers farmers pre-specified payouts based on environmental trigger events ensuring a financial safety net and resilience in the face of economic shocks.

Policy Environment

The landscape of Indian agriculture is undergoing rapid transformation, rendering traditional farming knowledge insufficient for farmers. It is especially true in remote rural areas with limited

access to agricultural technology and scientific assistance. Monoculture poses a persistent challenge for farmers, while regions reliant on water-intensive crops face increasing water scarcity without the necessary guidance to transition to alternative crops. To address these issues, the government has implemented various schemes such as Paramparagat Krishi Vikas Yojana, Pradhan Mantri Krishi Sinchayee Yojana, and Soil Health Card Scheme, aimed at improving crop health and supporting farmers. However, raising awareness about these schemes and identifying beneficiaries has proven to be challenging. This is an area where public-private partnerships can be catalytic. NITI Aayog's push for states to formulate their own agritech policies is a step in that direction. It aims to promote agritech startups, boost land records digitization, and ensure access to quality data and last-mile connectivity to startups so they can expand operations. Farmers will have access to innovative products and services while policymakers will have more granular data which should lead to better governance.

Despite the current global macroeconomic turmoil, all eyes are on the agritech ecosystem to make agriculture a source of sustainable growth, livelihoods, and remunerative jobs for tens of millions of Indians. Improving crop health is no longer about better inputs, more irrigation or going organic. To remain food secure, economically stable and environmentally sustainable, we need a more comprehensive approach that solves all the connected challenges.

BIOLOGICAL SOLUTIONS: KEY TO ENHANCING CROP HEALTH

Over the last decade, awareness among the farmers about the importance of crop health has gradually increased. The main reason for this is the changes in weather pattern affecting the crops. Farmers who were following the traditional practices in terms of sowing, nutrition management, pest and disease control etc. are finding it difficult to adapt to the new challenges. This has led them to look for alternatives that can help them to mitigate these challenges in a sustainable manner.

Time to Innovate

The search for alternatives has led many companies and startups to invest and innovate to help the farmer fraternity in managing the crop health through



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new age technologies. Farmers and technology providers can leverage these tools to make informed decisions, optimize resource use, and enhance crop health.

On the inputs side, innovative biological solutions for seed treatment, foliar and soil application, based on microbes and enzymes are being produced and disseminated to the field addressing the crop nutrition, abiotic and biotic stress. These solutions are highly effective in nurturing and protecting crop health in a sustainable way. The trend is further driven by consumer demand for residue-free produce and the government's focus on promoting organic farming practices.

However, due to a lack of awareness among farmers, widespread adoption of these new solutions remains limited. Also, low quality and spurious products

Biological solutions offer promising complementarities to conventional chemical fertilizers, emphasizing sustainable nutrient management.



in the name of biologicals have created skepticism in farmers' mind.

Although the use of biological solutions is increasing, penetration remains modest.

Policies

The Government of India has been in the forefront in adopting farmer welfare-based policies. Realizing the need for a comprehensive approach to nurture crop health, several schemes have been launched over the last few years. Soil Health Card, PMKVY, PMKSY, etc. have played a key role in addressing several farm-related issues. The government's push to encourage natural farming by promoting the use of organic fertilizers and limiting the use of synthetic fertilizers, aims to convert 10 million farmers to take up natural farming over the next three years by establishing 10,000 bio-input resource centers to create a national distribution channel for micro-fertilizers and pesticides.

The new Biostimulant Guidelines which are being rolled out would enable availability of quality biostimulant products to the farmers. Government is also providing subsidies for organic farming which will benefit farmers as export of these products will have better value realization.

However, there is still a long way to

go in terms of effective farmer uptake. So, what can be done to improve our approach to offering long-term solutions?

Opportunities and Challenges in Biological Approach

Crop Nutrition and Enhanced Soil Health

Biological solutions offer promising complementarities to conventional chemical fertilizers, emphasizing sustainable nutrient management. Biofertilizers like mycorrhizal fungi, rhizobium, phosphate solubilizing fungi can contribute to improved nutrient availability and uptake by plants. These beneficial microorganisms enhance the nutrient availability, leading to better nutrient utilization efficiency. Additionally biological solutions contribute to enhancing soil health, a critical aspect of crop health. It aligns with sustainable farming practices, reducing chemical inputs and preserving soil health. By emphasizing natural farming and minimizing reliance on synthetic chemicals, these solutions promote sustainable agriculture.

Climate Resilience

As farmers grapple with the problems of climate change, biological solutions provide a method to improve crop

resilience. It helps plants to withstand abiotic stresses, such as drought, extreme temperatures, and salinity. By improving the resilience of crops, it enables farmers to adapt to changing climatic conditions and mitigate the negative impacts of abiotic stress on crop health and productivity. For instance, Novozymes' patented, foliar applied LCO Promoter Technology (Lipo Chito oligosaccharides) enhances plant's nutritional capabilities, enhancing stress tolerance and yield performance.

Supporting Smallholder Farmers & Policy Framework

Recognizing the unique challenges the smallholder farmers confront, implementing targeted initiatives can contribute to their overall well-being and sustainable livelihoods. Enabling smallholder farmers to manage crop health through biological solutions will be critical to make high impact outcomes. Policies that promote sustainable agriculture, organic farming, and the use of biological solutions create an enabling environment for smallholders. Government schemes such as the Paramparagat Krishi Vikas Yojana (PKVY), National Mission for Sustainable Agriculture, Soil health card and subsidies for organic farming provide opportunities for smallholders to adopt sustainable crop health practices.



Awareness and Knowledge Gap

Limited awareness and knowledge about biological solutions among farmers pose a challenge. Government and private players involved in bio agriculture are disseminating the knowledge, but further support is needed. KVKs play a crucial role in transferring scientific knowledge, technologies, and information regarding crop health. Currently there are around 700+ KVKs in the country catering to 90 million farmers. There is an urgent need to increase the number of KVKs so that they can serve as a one-stop shop for all farmers. This allows them to make informed decisions and put effective crop health practices in place.

Scaling-Up and Adoption

The vast diversity in India in terms of climate, soil, crop, cultivation practices etc. combined with less per capita land holding is a hindrance to having common solutions at a scale. Customized solutions, region-specific formulations, and farmer-centric approaches are needed to facilitate large-scale adoption of biological solutions. Tailoring solutions to

The New Biostimulant Guidelines which are being rolled out would enable availability of quality biostimulant products to the farmers

specific crops and regional requirements can drive adoption among farmers and ensure their effectiveness.

Quality Biological Inputs and Standardization

Under the Make in India initiative, BioAg focused global organizations with strong R&D legacy need to be encouraged to invest in India specific research and development for biological crop solutions. Regulatory frameworks should enable these players to provide quality and standardized biological inputs, ensuring reliability and efficacy.

Carrier-based formulations and shelf-life enhancement technologies are

being developed to address challenges related to product stability, transportation, and application convenience. These advancements make biological solutions more accessible and user-friendly for farmers, facilitating their adoption and usage in crop health management.

Biological Solutions hold immense promise for enhancing crop health in India sustainably. It is critical to improve nutrient use efficiency, enhance soil health, build crop resiliency thereby increasing yields and economic benefits for the farmers. Successful implementation of this requires collective approach from policy makers, industry bodies, academia, and private players to create awareness, provide quality inputs, enhance adoption and support small holder farmers. This is a key pathway to realise Government of India's vision towards sustainable agriculture.



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BIOLOGICALS A KEY SOLUTION

TECHNOLOGICAL INTERVENTIONS IN CROP HEALTH AND PLANT PROTECTION

The current agriculture sector is facing an unexplained crisis due to the ever-changing climate, the emergence of new pests and diseases, the indiscriminate use of chemicals, and the accumulation of heavy metals. These factors have led to poor soil health and environmental damage. Considering the increasing population growth, the ratio of production to food consumption poses a significant challenge due to shortages caused by various issues within the agricultural industry, despite improvements in agricultural practices. To address these

challenges and revitalize soil richness, it is crucial to explore the technological intervention of biologicals for safe and sustainable agriculture.

Burgeoning Biologicals Market

The global market for biologicals is experiencing substantial and continuous growth and is projected to increase from \$6.2 billion in 2021 to \$15.2 billion in 2029, with a forecasted 11.1% compound annual growth rate (CAGR) from 2023 to 2029. Bio-pesticides, Bio-stimulants, Bio-fungicides, microbial metabolites, endophytes, Bio-nematodes, Bio-herbicides, and Plant Growth Promoters are important biological applications in crop health and plant protection. They contribute to increased agricultural productivity amidst the challenges of a growing population and its associated environmental concerns, resource availability, and quality threats, all the while promoting efficiency, productivity, and sustainability.

Bio Pesticide Play a Major Role

Among all the Biological products, Bio-pesticides play as a major role in breaking 3R's Resistance, Residues, and Resurgence. They are generally considered safe as they are mostly



biodegradable and are naturally occurring substances with insecticidal activity. These Bio-pesticides can work by inhibiting pest feeding or reproduction, directly attacking the pest, or enhancing the plant's natural defense mechanisms.

Generally, Bio-pesticides are classified into three main categories viz., microorganisms, biochemical, and Semiochemicals. Microorganisms for instance produce toxic metabolites that control pests without harming the plant and environment. Fungal strains like *Beauveria bassiana*, *Verticillium lecanii*, *Metarhizium anisopliae*, *Hirsutella thompsonii*, etc., and bacterial bio-pesticides like *Bacillus thuringensis* produce toxins for specific insects, making it an effective Bio-pesticide



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The global market for biologicals is experiencing substantial and continuous growth and is projected to increase from \$6.2 billion in 2021 to \$15.2 billion in 2029, with a forecasted 11.1% compound annual growth rate (CAGR) from 2023 to 2029.

against lepidopteron, caterpillars, coleopteran, dipteran, etc., Biochemical Bio-pesticides, which are structurally related to natural substances and function similarly to their counterparts, are generally considered environmentally safe and non-toxic. Numerous novel inventions focusing on the biosynthesis production of pheromones are currently underway.

Bio Fungicides – A Promising Segment

Species of *Trichoderma* can suppress plant pathogens by directly acting on them or by inducing systemic resistance in plants. They stimulate the production of defense enzymes and secondary metabolites, providing overall protection against disease-causing agents and promoting plant growth. Emerging approaches for controlling devastating plant pathogens include RNAi-based Bio-fungicides that utilize double-stranded RNA (dsRNA) to target essential fungal genes. Recent advances in research, such as Spray-induced gene silencing (SIGS), have shown promise in mitigating both pre and post-harvest pathogen infections. The development and formulation of peptide-based Bio-insecticide products in recent years have overcome some of the cost challenges associated with peptides.

Secondary Metabolites – Appending Immunity

Secondary metabolites, which encode antimicrobial peptides such as iturin, terpenes, and fureno steroids, enhance the activity of Bio-pesticides. These metabolites are not directly involved in the



growth and development of an organism but play a vital role in innate immunity and defensive responses. They repel pests and pathogens, act as signals for symbiosis between plants and microbes, and modify microbial communities associated with hosts to improve plant protection and production.

Among the various metabolites, microbial secondary metabolites (MSMs) are low molecular mass products with unique structures. These diverse metabolites exhibit various biological activities, including antimicrobial, plant growth stimulation, herbicidal, and insecticidal activities. MSMs are derived from plant-beneficial microbes through several mechanisms and physical processes that allow the extraction of bioactive compounds. These compounds act as effective Bio-pesticides and regulate plant growth at all stages of development, stimulating growth, inducing systemic resistance, and ensuring crop productivity under adverse conditions such as nutrient deficiency, salinity, drought, and biotic stresses. They also help restore the soil ecosystem, acting as natural stimulants to enhance plant production and protection in an eco-friendly and sustainable manner.

Among all the Biological products, Bio-pesticides play as a major role in breaking 3R's Resistance, Residues, and Resurgence

Endophytic Microbes - Enhance Yield in a Safe and Sustainable Manner

Certain endophytic microbes and plant growth-promoting rhizobacteria (PGPR) enhance plant growth, nutrient uptake, and play a key role in disease resistance. Microbes such as *Bacillus* spp., *Pseudomonas* spp., *Azotobacter* spp., *Azospirillum* spp., *Paenibacillus* spp., and *Trichoderma* spp. establish a symbiotic relationship with plant roots and provide benefits such as nitrogen fixation, production of plant growth substances, and suppression of disease-causing pathogens. Endophytes and innovative bio solutions contribute to natural impacts on plant metabolism, promoting plant functions to enhance yield in a safe and sustainable manner.

Bio-stimulants – Promising Biological

Bio-stimulants, including products such as seaweed extract, humic acid, fulvic acid, amino acids, microbial inoculants, and PGPRs, stimulate natural processes when applied to soil or plants. They enhance nutrient uptake, improve plant growth, combat biotic and abiotic stresses, and activate plant defense mechanisms. Additionally, they improve soil microbiome activity. These interventions can be used in agriculture to promote sustainable farming practices and improve crop productivity.

DRONES IN CROP HEALTH MANAGEMENT



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The use of drones in plant health management is supported by empirical data that demonstrates their effectiveness in assessing and protecting plants. Drones equipped with specialized sensors and cameras enable detailed data collection and analysis, providing valuable insights into the health of plants and helping farmers make informed decisions. There are several ways by which drones can be utilized to improve plant health.

Assessing Plant Health

Drones equipped with multispectral or hyperspectral sensors can capture high-resolution images of crops, capturing data beyond what the human eye can perceive. These sensors detect the reflection of light in different spectral bands, allowing for the identification of variations in plant health. By analysing these images, farmers can obtain precise information about the plant's chlorophyll levels, nutrient content, water stress, disease presence, and more. This data enables early detection of issues that

may affect crop yield, facilitating timely interventions.

Studies have shown that drones equipped with multispectral sensors can accurately detect stress levels in crops, such as nitrogen deficiency or water stress, even before visual symptoms appear. This early detection allows farmers to implement targeted treatments, optimizing resource allocation and minimizing yield losses.

Precision Spraying

Drones have transformed traditional crop spraying methods by enabling precise and targeted application of chemicals. The integration of data from plant health assessments allows for variable rate spraying, where drones can adjust the amount of chemicals applied based on the specific needs of different areas within a field. This approach minimizes chemical usage, reduces environmental impact, and ensures that plants receive the necessary treatment without wasting resources.

Moreover, drones equipped with machine learning algorithms can

By utilizing advanced imaging technology, data collection sensors, and precise spraying capabilities, drones enable efficient and targeted assessments of plant health, resulting in improved crop management decisions.

analyze plant health data in real-time, identifying areas with pest infestations or disease outbreaks. By integrating this data with GPS technology, drones can autonomously navigate through fields, precisely targeting affected areas for spraying. This targeted approach not only increases efficiency but also minimizes the exposure of non-target plants and reduces the risk of resistance development in pests or diseases.

Monitoring Crop Growth and Development

Drones equipped with high-resolution cameras can capture aerial imagery of crops throughout the growing season. By employing photogrammetry techniques and computer vision algorithms, these images can be transformed into detailed 3D models and orthomosaic maps. These models provide valuable

data on plant height, canopy density, biomass accumulation, and growth patterns, enabling farmers to monitor crop development and identify potential issues.

For instance, changes in plant height or canopy density over time can indicate nutrient deficiencies or disease progression. By analyzing this data, farmers can adjust their management practices, such as implementing targeted fertilization or early disease interventions, to optimize plant health and maximize yields.

Regulatory Aspects

While the use of drones in plant health management offers immense benefits, it is crucial to address the regulatory aspects associated with their operation. Governments and regulatory bodies have developed guidelines to ensure safe and responsible drone use. These guidelines encompass factors such as drone registration, pilot certification, flight restrictions, and privacy concerns.

Regulations regarding the use of drones in agricultural applications may vary across different regions. It is essential for farmers and operators to familiarize themselves with local regulations and obtain any necessary permits or licenses before utilizing drones for plant health management.

Compliance with these regulations ensures the safe and responsible use of drones, protecting both the environment and human welfare.

In conclusion, the use of drones in plant health management can revolutionize the agricultural industry. By utilizing advanced imaging technology, data collection sensors, and precise spraying capabilities, drones enable efficient and targeted assessments of plant health, resulting in improved crop management decisions. The integration of data from drones empowers farmers to implement proactive measures, optimize resource allocation, and mitigate potential risks, ultimately enhancing plant health and increasing agricultural productivity. However, it is crucial to navigate the regulatory landscape to ensure the responsible and compliant use of drones in plant health management.

The integration of data from plant health assessments allows for variable rate spraying, where drones can adjust the amount of chemicals applied based on the specific needs of different areas within a field.



A NEW STAR IN THE HORIZON

Professor Rajeev Varshney, enters the league of coveted Indian scientists of the likes of T Prof. BP Paul, Prof. MS Swaminathan and Prof. Gurdev Khush, when the Royal Society of London elected him to its fellowship for 2023. Currently with Murdoch University (Australia) as Director of the Centre for Crop & Food Innovation; Western Australian State Agricultural Biotechnology Centre; and International

Chair in Agriculture & Food Security, Mr Varshney is the only Indian scientist elected as FRS in the year 2023.

“I feel humbled and honoured to have been elected as a Fellow of the Royal Society. This is like a dream come true for any scientist. I am thrilled to be included alongside the stalwarts and giants such as Norman Borlaug, MS Swaminathan, Jim Peacock, Gurdev Khush, who have been inspirations and role models not only for me but all agricul-

tural scientists across the world.” He added, “I am grateful to my colleagues and collaborators from Australia, India, Germany, and many countries in Asia, Africa, and America with whom I had the privilege of working with over the last 25 years”.

A Stellar Career

An agricultural scientist, specialising in genomics, genetics, molecular breeding and capacity building in developing countries, Varshney is engaged in discovering, developing and delivering innovative R&D solutions to tackle pressing problems facing global agriculture. Varshney is currently Director, Centre for Crop & Food Innovation; Director, WA State Agricultural Biotechnology Centre, & International Chair in Agriculture & Food Security, Food Futures Institute, Murdoch University, Australia. Prior to joining, Varshney served International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in various science, and research leadership roles including the last positions as Research Program Director – Accelerated Crop Improvement; and Director, Center of Excellence in Genomics & Systems Biology, a global agricultural research institute. He holds Adjunct/Honorary/Visiting Professor positions at 10 academic institutions in Australia, China, Ghana, Hong Kong and India.

Varshney, in his research career spanning for more than 20 years, has made significant contributions to improving food security in Asia and Africa by creating genomic resources of major “orphan” tropical crops.

“ Varshney, in his research career spanning for more than 20 years, has made significant contributions to improving food security in Asia and Africa by creating genomic resources of major “orphan” tropical crops.”

About the
AUTHOR

**Professor
Rajeev
Varshney**

Contribution to Food Security

Rajeev Varshney's seminal work on integrating genomic discoveries in crop improvement for developing climate-resilient and nutritious legume crop varieties won him the fellowship. Prof. Varshney in his long and eventful career has decoded genome of 12 tropical crops, analysed genetic variation in more than 5000 lines of legumes and dissected more than 30 agronomic traits at the molecular level in each of three legume crops namely chickpea, pigeonpea and groundnut.

His research paved the way for the development of improved superior legume crop varieties. For instance, India released eight chickpea varieties for drought tolerance and Fusarium wilt resistance, two high-oleic groundnut varieties, and one Fusarium wilt-resistant pigeon pea variety. Similarly, Ethiopia has released two drought-tolerant chickpea varieties. Development and release of several other legume crop varieties are in the advanced stage in Ethiopia, Kenya, Tanzania, Mali, etc.

An economic analysis revealed that benefits of Prof. Varshney's legumes research has reached to about 25 million people in 15 countries in Africa and Asia.

Field Impact

Prof. Varshney's contributions has created far reaching impacts in the real world. His superior varieties have contributed to increasing the productivity and production of these legume crops and thereby the income for poor farmers in more than 13 countries in Africa, and several states in India including Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Telangana, and Uttar Pradesh.

An economic analysis revealed that benefits of Prof. Varshney's legumes research has reached to about 25 million people in 15 countries in Africa and

The Royal Society

The Royal Society, founded in 1660, is the oldest continuously existing scientific academy in the world that unites the most eminent scientists, engineers and technologists from all over the world. Each year at least 52 Fellows and up to 10 Foreign Members are elected from a group of around 800 candidates who are proposed by the existing Fellowship. To date, here are approximately 1818 Fellows and Foreign Members, including up to 85 Nobel Laureates. prominent Past Fellows and Foreign Members of the Royal Society have included Charles Darwin, Lise Meitner, Albert Einstein, Dorothy Hodgkin, Elon Musk and Stephen Hawking.

Asia. In addition, Prof. Varshney and his colleagues have trained 450 scientists in India and developing countries in Africa and South America.

Prolific Author

With 20 books, 500+ publications including 20 papers in Nature journals, h-index of 120 and citations of >60,000 (GoogleScholar), Varshney is a prolific author and a highly cited researcher. He has been honored with elected and honorary fellowships from a dozen academies/ societies, the Royal, being key one and 'more than 20' prestigious awards from USA, Germany, China, India, Nepal, Vietnam, Philippines, UAE. In addition to delivering 40 keynote talks and organizing several international conferences and training courses, Varshney has presented research and novel concepts related to food and nutrition security in several high-level fora such as G8 Conference in the World Bank; Digital Design Agriculture

Session chaired by Mr. Bill Gates; FAO Conferences, Mexico Malaysia; TEDx talk; Ministry of Agriculture, Government of India, etc. Varshney's research and interviews have been published in many Indian/ International print and electronic media.

Future Plans

Professor Varshney is hopeful about the future. "My research group is developing genetic solutions for improving wheat, legume and horticultural crops. We are developing climate-resilient crops with a higher crop productivity by developing and deploying novel genomics and pre-breeding approaches such as pangenomics, haplotype cataloguing, and genomic prediction including Artificial Intelligence, and Machine Learning approaches. We hope that these new approaches will accelerate crop improvement programs for developing better varieties to suit in target environments".



CHANGING LANDSCAPE OF CROP PROTECTION IN RICE CROP

Rice production plays a vital role in ensuring food security by maintaining a stable supply and minimizing dependence on imports. India contributes to almost 15% of the world's rice production, second only to China. Productivity per hectare in India is still much lower than other Asian countries like Indonesia, Vietnam, and Bangladesh. On average, an Indian rice farmer spends USD 75/ha on crop protection products to save their crop from weeds, insects, and diseases, which accounts for about 10% of their total expenditure on the crop.

Pest management is crucial and forms an integral part of the farmers' daily regimen during the peak growing season. Proper pest management practices help optimize yields, minimize expenses for the farmers, and maintain economic sustainability for the country at large. The article discusses the recent trends



Higher spending by rice growers on BPH is being witnessed on more expensive molecules like Pymetrozine and Triflumezopyrim increasing their share in the market



About the **AUTHOR**

Ms. Priyanka Mallick,
Managaing Director
&

Dr. Mukta Sirohi,
Chief Executive Officer
Q&Q Research Insights



Apart from molecule shifting, rice growers in Punjab and Haryana have seen a 35%-40% increase in fungicide application, moving from one application to two applications for disease control.

observed in crop health management in Indian rice cultivation

Increasing Trends of BPH Infestation in North India

Brown plant hopper (BPH) is the most dreaded insect for rice growers in India. Mass-scale losses due to BPH attack, potentially reduce yields by 20-30% in severe conditions. Hopper burns areas experience 100% yield loss. Unlike most other pests, BPH typically strikes late when the crop is already established and entering the reproductive phase. It also impacts crop quality, resulting in yellowing of the crop and chaffy grains.

Key Hotspots : The key hotspots for BPH have traditionally been the southern markets of India, primarily Andhra Pradesh, Karnataka, and Telangana. However, over the last three kharif seasons, BPH has been gaining strong momentum in Punjab and Haryana, with over 85% of growers reporting infestation and nearly 50% indicating severe infestation in Kharif 2022.

Higher spending by rice growers on BPH is being witnessed on more expensive molecules like Pymetrozine and Triflumezopyrim increasing their share in the market. Even a mid-range molecule like Dinotefuran showed a strong uptake in Punjab in Kharif 2022. The average spend on BPH control for growers in Northern India has risen from Rs. 400-500/acre in 2019 to Rs. 850-1000/acre in 2022, nearly doubling the spending owing to increased sprays and the use of more specialized and expensive chemistries.

Shift in herbicide usage patterns - Movement from Pre-emergent to Early / Post-emergent

Currently, 75% of rice farmers resort to chemical weed control, with the highest usage of herbicides reported in Punjab, Haryana, Andhra Pradesh and Karnataka. The usage of pre-emergent

herbicides is very common in these key states.

However, over the last two rice seasons, we have observed an interesting shift. Andhra Pradesh and Karnataka have reported a movement of rice farmers from the pre-emergent (0-5 DAT window) to early post or post-emergent windows (after 8 DAT). Our annual rice panel report, which covers over 800 farmers in these two states, shows a 20% shift currently. This shift is noteworthy and will have future implications as more farmers adopt this practice.

Some notable implications of this shift include the movement towards key molecules

- Bispyribac sodium, one of the key post-emergent herbicides, will have great opportunities in these states.
- Similarly, molecules like metsulfuron methyl + chlorimuron ethyl (brands like Almix, Pimix, Rymix) show good growth potential.
- Pretilachlor, a top pre-emergent brand, is losing share due to this shift.
- Kharif 2022 also witnessed the growth of Triafamone + Ethoxysulfuron owing to this window shift.

In our conversations with farmers who made this shift last season, one key driver was the flexibility of application. Growers who were compelled to spray within 1-3 days after transplanting now have a longer window of almost up to 15 days, making it convenient and less of a hassle.

Sheath Blight Gaining Momentum in Northern Rice Markets

Each year, 40-45% of rice farmers in India face infestation of sheath blight. Infected plants may show stunted growth, reduced tillering, and may eventually result in yield losses for the farmer. In severe cases, yield losses of

up to 50% or more have been reported. Additionally, the disease can affect grain quality, leading to reduced market value and impacting farmers' profitability.

Traditionally, West Bengal and Andhra Pradesh have seen high infestation of the disease, with more than 80% of growers reporting it in their fields. Chhattisgarh is also a key market but has a lower incidence than AP and West Bengal. Hexaconazole is generally the molecule of choice in these markets. However, in the last two years, we have observed a significant jump in sheath blight incidence in Punjab and Haryana. In Kharif 2022, 80% of rice growers in these states reported sheath blight incidence in their fields. This represents a doubling of sheath blight incidence in the last 4 years.

Shifting management Practices

Consequently, disease management practices have also shifted, with a growth in the use of high value strobilurin fungicides, including Azoxystrobin, Trifloxystrobin and Picoxystrobin. This movement is taking away from traditionally used solo molecules like Propiconazole, Hexaconazole, and Tricyclazole. Apart from molecule shifting, rice growers in Punjab and Haryana have seen a 35%-40% increase in fungicide application, moving from one application to two applications for disease control.

This has resulted in increased spending on disease control, and the average Northern farmer is now spending Rs. 950-1000/acre on fungicides. This represents a rise of a whopping 72%, which is bound to impact their profitability from the crop.

Overall, these insights highlight opportunity areas for the crop protection companies in India. By monitoring and understanding emerging trends, businesses can make strategic choices related to product development, marketing campaigns, resource allocation, and expansion plans. Staying updated with the rice growers changing practices and attitude, companies can gain a competitive edge. These changes in market dynamics, and consumer preferences, will also help businesses identify opportunities, adapt their strategies, and differentiate themselves from competitors.

FERTILIZERS AND CROP HEALTH

AN INDIAN PERSPECTIVE

Indian economy depends on the success of Agri climate. With a vast and diverse landscape, the country faces unique challenges in ensuring food security and maximizing crop productivity. One of the key factors contributing to the success of Indian agriculture is the strategic and balanced use of fertilizers. Fertilizers play a crucial role in maintaining soil fertility, enhancing crop health, and meeting the increasing demand for food security in the country.

Ensuring Soil Fertility

India has a predominantly agrarian economy, with a significant proportion of the population engaged in farming. However, the fertility of Indian soils varies widely across regions, with some areas lacking essential nutrients for crop growth. Fertilizers bridge this gap by supplying essential macro and micronutrients to the soil, such as nitrogen (N), phosphorus (P), and potassium (K). These nutrients are vital for plant growth, development, and overall crop health. Micronutrients too are playing major roles increasing soil fertility.

Increasing Crop Yield

Fertilizers play a critical role in increasing crop yields, especially in regions where nutrient deficiencies are prevalent. The application of fertilizers in a balanced



and scientific manner ensures that crops receive an adequate supply of nutrients at different growth stages. According to the Food and Agriculture Organization (FAO), fertilizers can increase crop yields by 30% to 50%, contributing significantly to food production and food security which is key to success of farmer income & overall growth of economy.

India's fertilizer consumption increased from 27.5 million tonnes in 2015-16 to 37.37 million tonnes in 2022-23.

Nutrient Management

The judicious use of fertilizers helps in proper nutrient management, preventing nutrient imbalances and deficiencies. Soil testing and analysis play a crucial role in determining the nutrient requirements of specific crops, allowing farmers to apply fertilizers accordingly. Government and various fertilizers companies are taking

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major initiatives in soil testing. Balanced nutrient management not only optimizes crop growth but also reduces the risk of environmental pollution caused by excessive fertilizer usage.

Addressing Micronutrient Deficiencies

In many parts of India, soil suffers from micronutrient deficiencies, such as zinc (Zn), iron (Fe), sulphur(S) and manganese (Mn). These deficiencies adversely affect crop health and reduce yields. Fertilizers enriched with micronutrients help rectify such deficiencies, promoting healthy crop growth and improving the nutritional content of agricultural produce. Various educative programmes for the farmers have been launched for this purpose to improve crop yield by various agencies.

Fertilizer Consumption

According to the Ministry of Agriculture and Farmers Welfare, India's fertilizer consumption increased from 27.5 million tonnes in 2015-16 to 37.37 million tonnes in 2022-23.

Nitrogenous fertilizers accounted for the highest share, followed by phosphatic and potassic fertilizers. Micronutrient consumption is also showing steady rise & preference by farming community.

A study conducted by the National Academy of Agricultural Sciences (NAAS) estimated that without fertilizers, India's food production would have been 40% lower.

Crop Yield Increase

The Indian Council of Agricultural Research (ICAR) reported that the Green Revolution, driven by the use of fertilizers, led to a significant increase in crop yields. For example, the yield of wheat increased from 663 kg/ha in 1960-61 to 3,507 kg/ha in 2022-23 including all crops.

A study conducted by the National Academy of Agricultural Sciences (NAAS) estimated that without fertilizers,

India's food production would have been 40% lower.

Soil Fertility Management

As per the Soil Health Card Scheme, initiated by the Government of India, around 11 crore (110 million) soil health cards have been distributed to farmers, providing them with information about soil nutrient content and recommendations for appropriate fertilizer application.

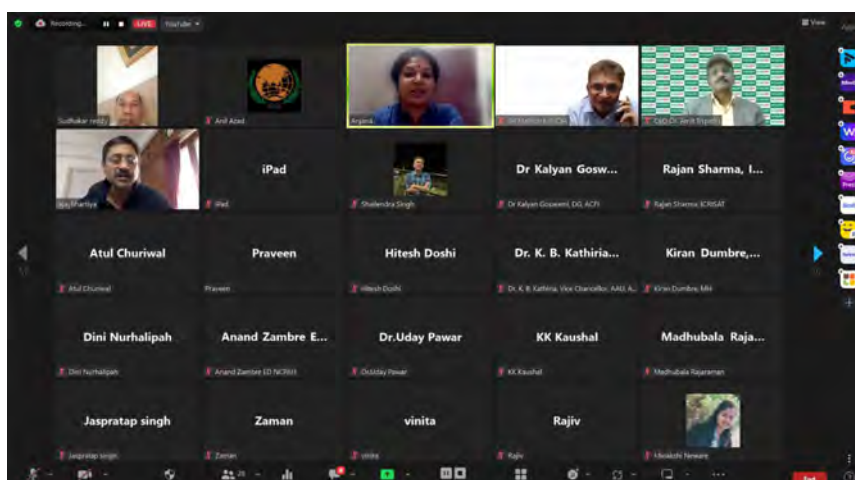
The importance of fertilizers in India's crop health sector cannot be overstated. By replenishing essential nutrients, increasing crop yields, addressing deficiencies and promoting sustainable agriculture, fertilizers contribute significantly to the country's economic growth and GDP.



ATG WEBINAR ON OPTIMIZING CROP HEALTH : STRATEGIES FOR SUSTAINABLE AGRICULTURE

On June 14, 2023, Agriculture Today organised a webinar on the topic, "Optimizing Crop health: Strategies for Sustainable Agriculture". The webinar was attended by a host of dignitaries representing diverse areas. The panellist included Dr SK Malhotra, Former Agriculture Commissioner, GOI & Director, DKMA, ICAR; Dr Nutan Kaushik, DG, Amity Food and Agriculture Foundation; Mr Kalyan Goswami, DG, ACFI, India; Mr Atul Churiwal, MD Krishi Rasayan Exports Pvt Ltd.; Prof Rajan Sharma, Global Cluster Leader, Crop Protection & Seed Health, ICRISAT; Dr Amit Tripathi, CEO, CYTOLIFE Agritech Pvt Ltd and Mr Shailendra Singh, COO, Zydex. The webinar discussed importance of crop health, current regulatory norms for registration of new molecules, challenges, biological methods and newest trends in crop health.

Dr SK Malhotra indicated that it is the need of the hour to take into notice the crop health. He mentioned that crop health can be maintained by good varieties, seed health, soil health management, water health management. Several steps like soil fertility, and soil microbial activity also needs to be addressed. According to him micro climatic conditions and site specific nutrient management are also playing major role in crop health. He also suggested that new molecules must



be introduced and separate queues for biologicals and chemicals is also necessary. He noted that use of drones or application of inputs would also lower the labour cost and enhance production.

Mr Kalyan Goswami pointed out that with regard to registration of new molecules India was far behind. He suggested RDP (Regulatory Data Protection) for the first time registrants for recovering the cost involved in molecule development.

Dr KB Kathiria, laid emphasis on the role of plant breeding in maintaining the crop health. He talked about host plant resistance, genome editing and Speed breeding. He also mentioned about different cost effective crop health management methods which Included

conventional breeding method, use of biotechnology tools, tissue culture etc.

Dr Nutan Kaushik started with ONE HEALTH CONCEPT. She talked about the microbial fortification of the seeds. She discussed how endophytes and purity of environment (Soil, air, water) could help to manage crop health. Use of sensors to detect different crop stress and said that pre diagnosis method could help to optimize the use of pesticides and thus help in managing pest and diseases. She mentioned that scientific validation of traditional knowledge is much needed to enhance production.

Mr Atul Churiwal mentioned the challenges faced during the cultivation which included climate changes soil

salinity, fluctuations in global trade etc. crop diversification, strengthening of soil testing lab, giving priority to research is needed to standardize the seed production. He also said that the upcoming revolution could be a biological revolution as there are more biologicals being used to improve Soil, crop, etc., which may help India witness a change in sustainable system. He also stated that if all the stakeholders including Government, Industries, and farmers come together, it would be possible to tackle the present and future challenges and attain sustainability.

Prof Rajan Sharma, Global Cluster mentioned that basic strategies that can be applied in order to deal with the challenges. Conservation of Germplasm, use of Quality seeds, and host plant resistance can be used to enhance production and manage crop health. He also discussed about the hermetic storage bags which are now used for storing post harvest produce for longer shelf life. He suggested that focus should be laid on strong IPM and INM practices.



Dr Amit Tripathi talked about the nutrition management of plants to tackle the biotic and abiotic stress. Education and awareness among farmers in terms of seeds health, plant health is needed. He also mentioned that empowering plant is in turn empowering human since human health is in all way related to plant health.

Mr Shailendra Singh mentioned that soil had degraded and there is lack of awareness among producer about better

management practices. There is a need to identify more of biologicals and develop different formulation that can work on different conditions. He lamented on the lack of testing facilities for biologicals. He urged for a holistic approach which can improve soil physics, chemistry as well as biology.

The session was moderated by Ms Anjana Nair, Group Editor, Agriculture Today.



CITYGREENS

TRAILBLAZER IN SUSTAINABLE FARMING PRACTICES

Indian agriculture has long been plagued by challenges such as poor productivity, unpredictable weather patterns, inadequate infrastructure, and limited use of advanced technologies. However, one entrepreneur has taken it upon himself to transform the agricultural landscape and empower farmers with innovative solutions.

Change of Territory

Gaurav Narang, the visionary founder of CityGreens, India's largest and most successful hydroponic startup, is no stranger to entrepreneurship. With a background in the pharmaceutical industry, he successfully established and later sold a startup in the domain. However, driven by a desire to address the critical link between food and health, Narang made the audacious decision to venture into agriculture. As a non-agriculturist, Narang recognized the challenges he would face in venturing into an unfamiliar field. Undeterred, he decided to immerse himself in agriculture at the grassroots level, turning himself into a farmer and investing 80 lakhs of his funds into the venture. This hands-on approach allowed him to learn the intricacies of the industry and gain practical insights that would later shape the vision of CityGreens.

Hydroponics Gains Ground

Recognizing the immense potential of hydroponics, a technique for growing plants in water without soil, Narang co-founded CityGreens. The startup's mission was to harness the power of this



With the upcoming investment of an additional five crores and the vision to establish an agri-tech park, CityGreens is poised to create a lasting impact not only in India but also in global markets, furthering its mission to revolutionize farming practices and empower farmers worldwide





plans to shape the future of Indian agriculture. The company is investing close to five crores in developing a 3-acre research farm, where new-age agricultural technologies will be customized and refined to suit Indian conditions. This investment aims to lower costs and increase scalability, ultimately benefiting farmers across the country. Additionally, CityGreens has launched FarmZig, an initiative focused on developing low-cost, resilient, and effective technologies for Controlled Environment Agriculture (CEA) farmers. With FarmZig, CityGreens aims to empower farmers by providing advanced tools and solutions that can significantly increase profits, enhance yields, and reduce costs.

With the upcoming investment of an additional five crores and the vision to establish an agri-tech park, CityGreens is poised to create a lasting impact not only in India but also in global markets, furthering its mission to revolutionize farming practices and empower farmers worldwide. By empowering farmers with innovative solutions, Narang and CityGreens inspire a new wave of agricultural transformation in India.

innovative farming method to increase production, improve sustainability, and elevate the income of farmers. Narang's entrepreneurial spirit and hands-on approach paved the way for CityGreens' success.

CityGreens quickly gained traction, with its groundbreaking hydroponic systems capturing the attention of key stakeholders. The startup received financial grants from the Ministry of Agriculture, the Ministry of Science and Technology, and the Ministry of Housing & Urban Affairs. These grants not only provided crucial support but also validated CityGreens' commitment to revolutionizing Indian agriculture through sustainable and eco-friendly practices.

Inspiring Success

With a turnover of Rs.12 crores+ since its inception, CityGreens has become a trailblazer in sustainable farming practices. The startup's commitment to innovation and research has yielded inspiring success stories among its customers. For example, Gabbar Farms in Gujarat witnessed a multi-fold increase in vegetable yields through the implementation of CityGreens' hydroponic systems, leading to significant financial gains for the farmer. Similarly, Dyna Agri Farms in NCR transformed its operations with hydroponics, enabling year-round cultivation of high-quality, exotic produce and ensuring stable income and busi-

ness even during the off-season period. These real-world examples demonstrate the tangible benefits that CityGreens brings to farmers across the country. The hydroponic systems developed by CityGreens have enabled farmers to achieve remarkable increases in yields and profitability, transforming their livelihoods.

Future Ready

Looking ahead, CityGreens has bold



MINIMIZING FRUITS & VEGETABLES SPOILAGE

One-third of the food that is produced worldwide is either lost or wasted. According to India Agricultural Research Data Book 2004, 30% of fruits and vegetables go waste. Taking estimated production of fruits and vegetables in India at 150 million tonnes, the total waste generated comes to 50 million tonnes per annum.

As soon as the fruits and vegetables are cut off from their natural nutrient supply, their quality begins to deteriorate.

To complete the processes of harvesting faster, artificial ripening chemicals are used which not only damage the quality but also causes long term harmful effects on body. For example- mangoes are ripened quickly after injecting calcium carbide in it. In case of vegetables, chemicals like copper sulfate, rhodamine oxide, malachite green and the deadly carbide are the ones most commonly used to accentuate coloration and freshness in vegetables.

A significant portion of losses of fruits and vegetables during post-harvest period is attributed to diseases caused by fungi and bacteria

Causes of Spoilage

Spoilage can be caused by biological, chemical, or physical factors. The succulent nature of fruits and vegetables make them more prone to microbial spoilage caused by fungi, bacteria, yeast and moulds,. A significant portion of losses of fruits and vegetables during post-harvest period is attributed to diseases caused by fungi and bacteria. It is estimated that 36 % of the vegetable decay is caused by soft rot bacteria. Similarly, fruit rot in aonla and other soft fruits caused by fungi is also very harmful.

High temperature and relative humidity also favour the development of post-harvest decay organisms. More acidic tissue is generally attacked by fungi, while fruits and vegetables having pH above 4.5 are more commonly attacked by bacteria.

Physical spoilage, Physiological

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aging, Spoilage due to insects or rodents, Mechanical damage, Chemical and enzyme spoilage are also types of spoilage. Physical spoilage is caused by dehydration. Physiological aging occurs as soon as harvesting takes place. Neither process can be prevented, but they can be delayed by storing the agricultural products in a dry area at as low a temperature as possible. Insects and rodents can cause a lot of damage. Not only by eating the products, but also by passing on micro-organisms through their hairs and droppings. Spoilage of fruits & vegetables may cause diseases like salmonellosis, shigellosis, botulism, gastroenteritis, etc.

Post Harvest Handling

Perishable fresh produce are handled roughly and transported in open trucks. It takes twenty four hours or more for the fresh produce to arrive at the retailer, typically an open market vendor or a pushcart after harvesting. As it is piled into large cane baskets or on to truck beds without cushioning or packaging, they are exposed to sun which deteriorates the quality of the fresh produce. Faulty system of transport and delayed delivery of fresh produce causes wastage in the retail market.

Supply chain of fruits and vegetables in India is highly inefficient which leads to huge losses and wastages and less income to the stakeholders in return. Apart from the loss of income to the farmers, it incurs additional costs in the supply chain which ultimately forces the final consumers to pay high charges from his pocket. India is throwing away fresh produce worth Rs 13,300 crore every year because of the country's lack of adequate cold storage facilities and refrigerated transport.

Supply chain of fruits and vegetables in India is highly inefficient which leads to huge losses and wastages and less income to the stakeholders in return



Injecting chemicals in tomato for early ripening

Preventive Measures

Artificial Intelligence : Researchers have proposed system to monitor the gas emission level, humidity level, and temperature of fruits and veggies by using sensors and actuators to check the food spoilage level. This would additionally control the environment and avoid food spoilage wherever possible. Additionally, the food spoilage level is informed to the customer by an alert message sent to their registered mobile numbers based on the freshness and condition of the food. The model employed proved to have an accuracy rate of 95 %. Machine learning techniques and artificial intelligence play an important role in food spoilage detection and control

Internet of Things (IoT) : The controlling is done by minutely observing the important parameters which generate vital pieces of information concerning the functioning of these electronic devices.. The experimental results show the live temperature and humidity of the surroundings and the soil moisture of any plant. The sensors are used for measuring the temperatures from the surroundings, storing displayed information with different devices.

Irradiation : This practical technique prevents food deterioration, controls the spread of diseases, and prolongs the shelf life of food. The red flour beetle, a major pest of stored food products particularly food grains, can now be more easily eliminated by gamma irradiation.

Bio-preservation : The use of Lactic acid bacteria (LAB) particularly can be an example of bio-preservation of fruits and vegetable. Microencapsulated Lactic Acid Bacteria can be a potential alternative technique to extend the shelf life of post-harvest fruits and vegetables. Fermentation is also used as a bio-preservation technique to stop food from rotting as a result of chemical compound.

Innovative packing techniques and materials

MAP (Modified Atmosphere Packaging) can be a very good example of this which involves altering the gases around the fruit to produce an ideal environment that slows down ripening and prevents microbial development. Antimicrobial packaging contains ingredients that inhibit microbial growth and prevent rotting. Silver nanoparticles, essential oils, or naturally occurring antimicrobial substances produced from plants (oils from clove, cinnamon, and olive) are a few examples of antimicrobial agents utilized in packaging.

Edible films and coatings are thin layers of material with a thickness typically less than 0.3 mm casted on food products to replace or/and fortify the food's outer layer that can be eaten as a part of the product. As barriers these agents can help control the growth of bacteria, fungi, and other microorganisms, thereby extending the shelf life of food.

SAHYADRI FARMS

THE STORY OF GRIT AND DETERMINATION



In 2020, the government of India launched a scheme for setting up 10,000 Farmer Producer Organizations with an outlay of Rs 6,865 crore to leverage economies of scale, reduce the cost of production and, thus, boost farmers' income. Nashik (Maharashtra) based Sahyadri Farmers Producer Company has achieved what the government of India had envisioned.

Sahyadri Farms has become a trailblazer for Farmer Producer Companies (FPC) and many other FPCs across India are trying to follow



this model. The story of Sahyadri Farms is the story of grit and determination and a dream to revolutionize agriculture.

From Failure to More Failures

Shinde, a youth from Adgaon village in Nashik while completing his B. Tech and M. Tech degrees at the Mahatma Phule Agricultural University at Rahuri was eager to convert theories into practice. He rented a plot to cultivate sweet corn while he was still completing his studies and borrowed money from a private money lender with four percent interest per month. He also planted watermelons with sweet corn. Finally, his hard work paid off. But market rates for corn had come down drastically. Watermelon cultivation failed as the seeds he procured from the market were bogus.

Sahyadri Farms has become a trailblazer for Farmer Producer Companies (FPC) and many other FPCs across India are trying to follow this model

"There is a difference between theory and practice and I was reeling under loan burdens because of my experiments in farming while I completed my education," says Vilas Shinde, Chairman and Managing Director of the Sahyadri Farms while recalling how the seeds of Sahyadri Farms were sown.

From 1998 to 2004, he tried hard to make farming profitable but failed. He even integrated dairy but the same story repeated. He tried setting up his own pasteurizing unit and direct link to consumers. But again failed.

Vilas then tried his luck in grapes cultivation. He wanted to export grapes. The buffalo shelter was converted into a pack house and the pasteurization unit into cold storage. But existing big players refused to help and guide him. But amassing whatever information he could, he dispatched 4 containers of grapes to Europe in 2004. But the trader duped him by fleeing money.

Seeds of Sahyadri Farms

In 2005, ten farmers joined him in an export venture and they went for insurance of grapes. Again, they were duped by middlemen and traders, but this time insurance helped them.

By 2009 this group of farmers led by

Today Sahyadri Farms is India's largest exporter of grapes with a 17 % of share in India's total export.

Shinde was exporting 163 containers every year. However, European Union once rejected Indian table grape consignments due to the excess traces of chlormequat chloride. Shinde paid compensation to farmers by selling his own farmland. This helped to build confidence among farmers and they came up with the idea of the Farmer producer company. Shinde had an Amul Model in mind and wanted to ensure that every shareholder has equal rights in the Company.

In 2010, Sahyadri Farms - a Farmer Producer Company - by the farmers, of the farmers, and for the farmers was established in Nashik. Within a few years, the Company set up its own infrastructure, agro advisory team, a world-class pack-house, and cold storage facility, and minimized post-harvest losses.

Sahyadri Success Saga

Today Sahyadri Farms is India's largest exporter of grapes with a 17 % of share in India's total export. Recently Sahyadri Farms exported 21,000 tonnes of grapes. The FPC is also importing and experimenting with other grape

varieties. Sahyadri Farms is developing a value chain for other horticulture crops, including mangoes, tomatoes, bananas, pomegranates, Citrus, Cashew nut, and sweetcorn.

Sahyadri Farms is also the largest producer and processor of tomatoes trading about 125000 MT of tomatoes per year. Almost 40% of all Hindustan Uniliver's Kissan tomato ketchup is produced by Sahyadri Farms.

The overall turnover of Sahyadri Farms was Rs 1007 crore in FY 2022-23. In the same year Sahyadri Farms Post Harvest Care Limited (SFPHCL), the subsidiary of Sahyadri Farms became India's first FPC subsidiary to raise overseas growth capital of Rs 310 crore. The investors include Incofin, Korys, FMO, and Proparco.

Sahyadri Farms has developed its own value chain 'seed to plate' and more than 20,000 farmers spread across 252 villages are its members cultivating over 30,000 acres of land. About 20,000 farmers provide produce to Sahyadri Farms and Shinde plans to increase this number to 25,000 by 2023.

"We focus on customer delight and ensure that they get value for

their money," says Shinde adding that Sahyadri Farms has reached in markets more than 42 countries.

Sahyadri Farms has also introduced its FMCG products including fruit drinks, juices, jam, kinds of ketchup, frozen, and IQF products in the over 10,000 retail outlets.

Helping Farmers

Sahyadri Farms has set up a Farmer facility Centre at Nashik where farmer members can receive all the agricultural inputs like quality seeds, fertilizers, pesticides, equipment, etc. The Centre also has a soil testing lab and grape nursery. Sahyadri Farms has also developed portable sensors cum weather stations for farmers. The Farm has started Skill Development Academy to train youth in various employable skills and have also launched FPC incubation and training center to strengthen FPO ecosystem in India.

Sahyadri Farms has established a system where farmers produce quality crop and Sahyadri Farms provides technical support, inputs, aggregates farm produce, grade, sort, and pack it. Also, Sahyadri Farms takes care of finance too. The other wing Sahyadri Farms Post Harvest Care Limited mentors other budding FPCs, creates infrastructure for post-harvest management, and is involved in distribution and marketing.

Efficient farm management, efficient post-harvest, and efficient marketing are the mantra of Sahyadri Farms's successful journey.

Towards Future

Sahyadri Farms is working towards developing the model of self-reliant villages. As of now, Sahyadri Farms is working in the Mohadi Rurban Cluster with 14 villages with a population of over 40,000. Projects are being implemented to transform the agri economy, skill development, village redevelopment, water distribution, health, and education.



FROM STADIUMS TO FARMS

We are all witness to the remarkable evolution of sports - athletes pushing boundaries of human performance and teams leveraging cutting-edge technologies, catapulting competitions to another stratosphere. From an era where a cricket team would collectively score 300 runs in a single match to individuals hitting equivalent numbers singlehandedly; young Haalands in their 20s scoring goals for fun, outnumbering goals scored by several bottom position teams in the English Premier League.

There is much to be



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learned and applied beyond the confines of stadiums. Imagine if we could channel the same drive, precision, and adaptability seen in the world of sports and direct it towards revolutionizing Agriculture - a paradigm shift it could bring to propel the agricultural industry into a new era of growth and sustainability.

Key Attributes of a Champion Team

- **Adaptability and Skillset:** The ability to adapt to different conditions and take on additional roles, even if they are outside of your primary skillset, when your teammates are struggling.
- **Team Formation and Role Dynamics:** This attribute is closely tied to the situation at hand. It involves the player's capability to intelligently fit into different formations based on the circumstances of the game.
- **Actionable Plan:** Sports teams

rely on well-defined game plans and strategies to achieve success. They constantly evolve and adjust their game plans based on their competitors, week in and week out.

- Data Intelligence: The use of data analytics and advanced technologies in sports has revolutionized performance analysis and strategy development.
- Passion: The world of sports is driven by passion, dedication, and an unwavering pursuit of excellence.

What attributes can Agri-tech leverage ?

Our powerful ally – innovation, has been around for long, with many good solutions developed by multiple start-ups, however, their deployment is a concern, ‘an actionable plan and an ecosystem missing for a long time.

Being in the Agritech space for a considerable number of years, I have learned that technology is going to play a critical role in transforming the Agri value chain. Like many of us, we have been trying to create the right ecosystem to benefit all the stakeholders.

How to scale up the experiments/ pilots to a reasonable figure and engage the large chunk of the farmers ?

While in Agri space, infusion of funds and tech innovation is happening but the players are not evolving accordingly, there is a lack in understanding and levelling up with respect to the modern gameplan. The great agriculture team needs to step up and take cue from familiar sports such as football and cricket.

While in sports, the evolution of players with advancements in technology enhances their understanding of their roles and their ability to exhibit adaptability and flexibility in dynamic conditions. They make informed decisions based on data, constantly upgrade their skillsets based on data and the evolving formats of the game. However, at the heart of it all, the success of the day is ultimately



Our powerful ally – innovation, has been around for long, with many good solutions developed by multiple start-ups, however, their deployment is a concern, ‘an actionable plan and an ecosystem missing for a long time

determined by the cohesion and performance of the team.

The Gameplan – Beyond Tradition

In cricket, simply being a good batsman is not enough. The ability to field well or bowl effectively enhances the team's chances of winning. Additionally, your flexibility to bat at different positions in the order and adapt your batting style based on the game's requirements, as well as understanding and executing the game plan, determine whether you play in a single format or across all formats. The more you play, the more you earn or grow.

Similarly, in the field of agriculture, having only technical knowledge is insufficient. Adding skills such as GIS, digital marketing, understanding IoT functionality, and proficiency in using business intelligence tools can help individuals play a pivotal role in tackling new challenges posed by climate change

and nutrition. It enables a more futuristic approach. Therefore, it is crucial to continuously refine your core skillset while actively acquiring additional sub-skillsets.

Approach taken by Coaches in Agri

- Defensive plan/ Effective Crop Protection: Majorly propagated by R&D teams, researchers, companies aligned to sustainability and environment
- Counter-attack play/ Responsive Adaptation: Majorly by input selling companies
- Attack / Optimized Crop Production: Modern data-driven companies.

All three approaches have worked well for respective organizations, but I believe the modern play is pivoted more towards ‘Attack / Optimized Crop Production’, it’s what woos the fans (clients/ farmers) more than anything and plays the additional 12th player role for you, technically outnumbering the opposition before even the game starts.

Ability of an organization in any industry to install above mentioned structure, commitment, passion, and courage in their ecosystem could be a differentiator and a proven ‘serial winner’, an organization everyone looks upto. That’s where we can find our Sachins and Kohlis of Agriculture.

PAVING THE WAY FOR A DATA-LED AGRICULTURE ECOSYSTEM

Building an ecosystem of digital agriculture with individual farmers is challenging due to low smartphone penetration or low digital literacy. Productivity and income enhancement efforts directed towards individual farmers will always be a challenge. Hence, farmer collectives or farmer producers' organisations (FPOs) are well poised to address some of these challenges. However, Farmer Producer Organizations (FPOs) are met with many significant obstacles and find it difficult to create a sustainable business.

Digitization for Negotiating Market

In order to create a sustainable business model, FPOs need farmer information and associated data points which can help them build a realistic business plan, one which is built keeping the customer (farmers in this case) at the core. The capacity building needs at FPO level entails various sub-components like communication structure, data identification needed for creating a business plan, data-based decision making, negotiation skills, compliance and governance. All this can only be achieved through digitization which helps in collecting, managing and building on data assets. These data assets will help them negotiate better with the market actors.

Data is power and the ownership of data should belong to farmers. FPOs are best suited to collectively build this data asset for a large group of farmers. Soil data is needed to plan optimised input requirements, weather/climate data is needed for creating a mitigation plan,



consolidated data of produce availability (crop, variety, quantity and dates of harvest) is needed to create a simplified communication channel with the market linkage actors. Only when the whole value chain is digitised can we adopt blockchain like technology to build on traceability of farm produce.

Placing the Farmer at the Centre of the Equation

Digital Green's program for farmer collectives is aimed at providing the FPOs with all the necessary skills, digital tools (mobile app) to organise farmer data, use these data points to build a reasonable and accurate business plan and also help them digitise their business. The capacity building exercise coupled with the digital tools enable the BODs/management of the FPOs to build and manage their business, establish simple & consistent communication channels between member farmers, and effectively negotiate with market players. Digital Green's program for farmer collective enables them to both own and initiate the data collection process. An

FPO, powered with data assets, can act as the interface between smallholder farmers and ecosystem players (both private and public). With a secure data sharing consent system (enabled by Farmstack, a digital public good technology developed by Digital Green) in place, FPOs will be able to share only those relevant data points of farmers with the market players, which will help in the exchange of products and services. This in turn will also help Agtech players in optimising their cost of operations, thus helping them focus their efforts and resources on improving the delivery of products and services to end farmers through the FPOs. This will be a win-win for all stakeholders.

D2FO app

Digital Green is offering its Digital products and training to FPOs for free and all its digital products are being developed as digital public goods. Characterised by a framework which can be customised to the requirements of individual users, the **D2FO app** enables farming communities to access better remuneration for their



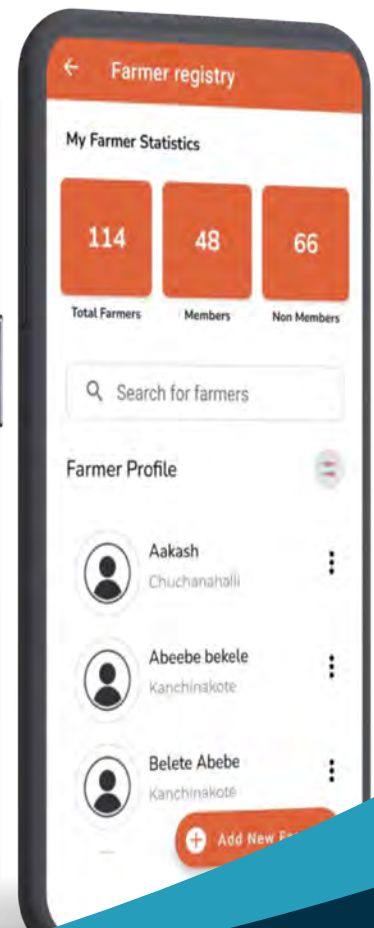
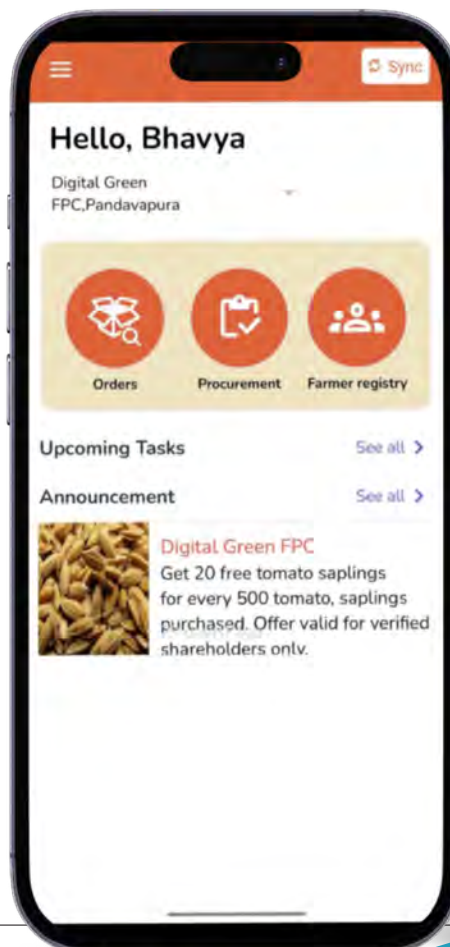
diversified intelligence which will equip decision-makers with critical insights on cropping patterns, resource gaps and overall vulnerability to climate events. FPOs can also give farming communities access to findings in emerging research in the ecosystem in the interest of fostering sustainable farming practices. The farmer collective app endeavours to make farmers partners and co-owners of the agricultural ecosystem by helping them realise their agency and power as stakeholders. It not only aims to play an enabler role in helping the national plan of creating 10,000 FPOs, but also play a critical role in building sustainable FPOs. The road towards achieving a fully digital agriculture sector will be paved one insight at a time through the vision of the farming community and the resourcefulness of the FPO infrastructure.

efforts. It works closely with farmers to understand requirements across knowledge management and upskilling, inputs, financing and even staffing. It streamlines communication between FPOs and farmers through its insight generation capabilities that form the basis of decision making. The inputs provided by farmers subsequently help FPOs and frontline workers coordinate input procurement, policy action or trade facilitation with the relevant private sector and public sector stakeholders in the ecosystem.

The success of 110 women pumpkin farmers from Odisha is a remarkable testament to the potential of agritech and data-driven decision making in increasing incomes and boosting growth within the local economy. Each of the women farmers was faced with losses in income as they manually routed the produce to the market. With support from the digital skilling, crop data aggregation, and market access functionalities of the **Digital Green Farmer collective app**, the all women's FPO was able to estimate the availability and quantity of produce. They were able to collectively negotiate and sell 4.8 metric tonnes of pumpkins at farm gate. This not only increased income levels by 18%, it also helped the community prevent logistical expenses as they were borne by the buyer.

Transforming FPOs into Engineers of Agricultural Microenterprises

As there is a pressing need for a centralised repository of agricultural intelligence from across the nation, FPOs can pave the way for its creation. Working closely with farming communities can sustain the creation of





SOLUTION FOR SUSTAINABILITY

In India, the countrywide decline in major crop yields between 2010 and 2039 due to climate change effects could be as high as Nine percent, worsening further with time. The loss can be up to 35 percent for rice, 20 percent for wheat, 50 percent for sorghum, 13 percent for barley and 60 percent for maize depending on the location and future climatic scenario.

This has heightened the need to embrace the notion of Climate Smart Agriculture (CSA) in the face of climatic vagaries to reduce the negative impacts on agricultural systems.

Silicon has been identified as a "Stress Reliever" for plants and thus offers a viable solution for sustainable productivity under prevailing scenario of climate change



About the AUTHOR

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Silicon for Sustainable Productivity

Privi Life Sciences (PLS) ventured into agribusiness with its patent process of stabilization of Ortho Silicic Acid (OSA). It is apt to say that Privi pioneered the use of Ortho Silicic Acid based formulations for agriculture purposes. Ortho Silicic Acid has been recognized as Beneficial Element by Government of India and included in FCO Gazette.

Silicon has been identified as a "Stress Reliever" for plants and thus offers a viable solution for sustainable productivity under prevailing scenario of climate change. Research studies conducted across 25 research institutes, according to NIASM, Baramati, found out that the foliar application of Ortho Silicic Acid (OSA) on wheat crop during its four stages of development, resulted in 15% greater crop proliferation whilst saving over 20,000 litres/acre of irrigation water.

A study was conducted at NARI

Lucknow to ascertain the impact of Ortho Silicic Acid formulation in reducing the accumulation of heavy metal (Arsenic, As) in grains of paddy. Foliar application of OSA had resulted in 47% and 41% reduction in Arsenic accumulation in grains and husk, respectively.

Ortho Silicic Acid Formulations in Improving Crop Health

In recent past there has been an increased awareness about use of natural and organic residue free products for sustainability. OSA has an inherent property of polymerization therefore, it deposits itself to form a “protective layer” within plant cells. The protective layer so formed improves the overall health of crop by reducing incidence of pest and diseases.

It is not always possible to have a healthy crop coupled with sustainable productivity using such alternative approaches. Sometimes use of synthetic molecules becomes inevitable. There is a range of softer molecules with “green triangle” label available now.

Use of microbial based products are also becoming popular for use in agriculture. These solutions can be inculcated in Integrated pest and disease management programmes for improving crop health. In nut shell, there is a need to strengthen our crop protection portfolio by introducing a range of safer and softer molecules to serve the requirements of our farmers.



OSA has an inherent property of polymerization therefore, it deposits itself to form a “protective layer” within plant cells

Privi Alliances

Privi has forged strategic alliances to expand its offerings and strengthen its market presence. One such collaboration is with UPL, a leading agricultural solutions provider. This partnership combines Privi's expertise in R&D with UPL's global reach and distribution network, enabling farmers to access high-quality liquid OSA for crop protection and yield enhancement.

Additionally, Privi has formed a partnership with Syngenta, a renowned agricultural company. This collaboration leverages Syngenta's strong marketing and distribution network and Privi's manufacturing excellence, providing farmers with innovative granular OSA solutions for sustainable agriculture

practices. These alliances highlight Privi's commitment to delivering cutting-edge solutions and meeting the evolving needs of the agriculture industry.

ReEarth

Lastly, but not the least, we have envisaged a vision of ReEarth, to alleviate deleterious impact of climate change by aiding in carbon sequestration and to prevent soil depletion, using our Climate Smart Agriculture solutions. We are committed to shift focus from “enough food” to “good food” through our innovations and technologies. With a missionary zeal it's time to “ReEarth”, for we have only one planet for our future generations. We reiterate our pledge to “ReEarth”.



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