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IDEA TO MARKET

Stimulating AgriTech Innovations



In association with knowledge partner
Biotechnology Industry Research Assistance Council (BIRAC)
A Government of India Enterprise

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Editor's Note



Agriculture is the primary source of livelihood for about 58 per cent of India's population. The sector and allied activities grew at 3.6 per cent at constant prices in fiscal 2020-21 (FY21). The total agricultural and allied products exports stood at \$41.25 billion in that fiscal. The country's agriculture exports are projected to reach \$60 billion by 2022 end.

Small and fragmented land holdings, lack of access to quality seeds; lower productivity; insufficient water supply and dependence on rain for irrigation; poor socioeconomic condition of farmers; illiteracy and lack of technical knowledge and awareness; slow penetration of mechanisation; soil erosion; lack of sound agricultural marketing; scarcity of capital; poor storage facilities; transportation issues; and natural disasters and human-induced environmental degradation have been some of the major problems faced by the sector.

Despite all these problems, India is the world's second-largest producer of rice, wheat, sugarcane, cotton, groundnuts and fruits and vegetables. The country's food and grocery market is the world's sixth largest, with retail contributing 70 per cent of the sales. The Indian food processing industry accounts for 32 per cent of the domestic food market, one of the largest industries in India and is ranked fifth in terms of production, consumption, export and expected growth.

The agriculture sector accounted for 18.8 per cent in the country's gross value added in fiscal 2021-22, registering a growth of 3.6 per cent in FY21 and 3.9 per cent in FY22. Growth in allied sectors, including livestock, dairy and fisheries, has been the major driver of the overall growth. According to the Economic Survey 2021-22, the allied sectors are steadily emerging to be high-growth sectors. The livestock sector grew at a compounded annual growth rate (CAGR) of 8.15 per cent over the five fiscals ending 2021-20.

Dairy is the single largest agricultural commodity contributing 5 per cent to the national economy and directly employing more than 8 crore farmers. India tops in world milk production, contributing 23 per cent of the total produce.

India is the second-largest fish-producing country in the world, contributing 7.56 per cent of global production. The Pradhan Mantri Matsya Sampada Yojana (PMMSY) was launched in 2020 to enhance production and productivity, modernising the value chain.

Under the Pradhan Mantri Kisan SAMPADA Yojana (PMKSY), projects on mega food parks; infrastructure for integrated cold chain, value addition and agro-processing clusters; creation of backward and forward linkages; and expansion of food processing and preservation capacity are being undertaken.

Keeping all these developments in view, it becomes imperative that the country keeps adopting new-age technological interventions in agriculture to boost productivity, reduce crop loss by controlling pests, improve access to data, expand marketing penetration and raise farmers' income.

This publication profiles 23 start-ups and companies that have developed products and services in the agritech domain with funding and assistance from the Biotechnology Industry Research Assistance Council (BIRAC) under the Department of Biotechnology (DBT).

The innovations are presented in five categories: sustainable agriculture, agri-biologicals, animal husbandry & allied, food processing & post-harvest technologies and agricultural supply chain.

The booklet also carries insights from key opinion leaders associated with the sector who throw light on the agritech landscape in the country, and discuss problems and potential solutions. Two articles discuss genomics solutions in agritech and the Indian innovation scenario in the sector.

We are indebted to Manish Diwan, PhD, Shilpy Kochhar and Utkarsh Mathur and the entire team from our knowledge partner BIRAC for their assistance and valued guidance. We also thank the key opinion leaders for their valuable inputs.

We look forward to feedback and suggestions from readers to improve similar ventures in other fields.

A handwritten signature in black ink that reads "Dipesh Satapathy".

Dipesh Kumar Satapathy
editor@vivifymedia.in

Start-ups Strengthening Innovation Ecosystem for Progressing 'Farm to Fork' Translations



Agriculture is one of the important pillars of India's economy engaging half of India's work force. India has been able to produce in quantities that are largely sufficient to address its basic food requirements. In certain areas, we are also able to export the surplus to the world. However, the efficiency of resource utilisation, crop production, post-harvest crop management and value-added produce manufacturing require a major upliftment for which technology interventions are needed across the value chain. We require diverse agri innovations that are simple, accessible, low-cost, dynamic and adaptable for rapid integration with the conventional practices catering to the different needs of large as well as marginal farmers.

Hundreds and thousands of solutions that may be local, regional are required. Local need identification aligned through the local ecosystem for faster, efficient and cost-effective deployment would yield greater acceptability and smoother adoption. Enablers would also need to be mindful of the fact that a cohesive improvement in the quality of life for a

farmer, access to basic amenities, dependence on the environmental uncertainties and financial security, are important for turning a humble individual farmer into a progressive entrepreneur.

The multi-faceted unmet needs of this magnitude can be addressed by the emerging start-up ecosystem. There are more than 65,000 registered start-ups in the country, out of which about 10 per cent is working in the agri domain. This is expected to improve further.

The talent pool of student scholars as budding entrepreneurs gets replenished every year and is nurtured across the nation, including in tier 2 and tier 3 cities and aspirational districts. This is a rich pipeline for seeding of the new start-ups.

Enabling agencies like DBT/BIRAC, ICAR, DST, CSIR and others have invested in capacity building, creating knowledge clusters that comprise academic research institutes. The agritech start-ups, entrepreneurs and the industry can lead the translation of knowledge base culminating into new products and technologies. Incubation centres like BIRAC's BioNEST Bio-incubators, DST's technology business incubators, NITI Ayog's Atal Innovation Centres, RKVY Raftaar agribusinesses incubators and others provide the breeding of innovative ideas through opportunities for funding, testing and mentorship for technology maturation from ideation to proof-of-concept, leading to development of final products. A well-established network of such incubation centres now exists across the country.

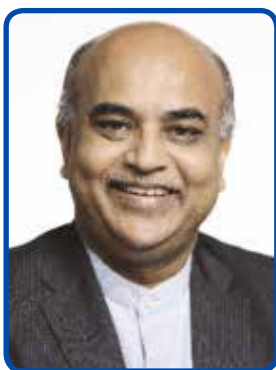
There is also an increase in private investment activity from angels and venture capitalists as seen through the increasing instances of follow-on funding raised by start-ups after initiation using public grants. Microfinancing at affordable cost is also important for the local, remotely-located small farmer's business activity to groom.

This i2M publication is an interesting compilation of a few representative agri-based biotech start-up innovations that have reached the market exemplifying the evolving ecosystem. Going forward, the growth in the innovation sector would pave way for Atmanirbhar Bharat.

Manish Diwan, PhD

Head, Strategic Partnership and Entrepreneurship Development & Make in India Facilitation Cell for Biotech Sector
Biotechnology Industry Research Assistance Council (BIRAC)
A Government of India Enterprise

Pragmatic Solutions Stimulating Agri-Innovation Landscape



Agriculture and its allied sectors in India have proved to be resilient even during apprehensive situations like COVID-19, registering 3.9 per cent growth in 2020-21. During the unprecedented pandemic that the world faced, people acknowledged India's prodigious potential to act and deliver in that rudderless situation and become *atmanirbhar* (self-reliant).

India, with a variable landscape and with a larger section of its workforce being directly or indirectly dependent on agriculture and related sectors, urgently needs smart solutions that can cost-effectively cover the necessities of such a fundamental and paramount segment.

Innovative, affordable and tech-driven solutions can potentially shape the agriculture sector as self-dependent for efficient and effective agricultural solutions. We need a combination of both latest technologies as well as cost-effective solutions to address the high unmet need of the country. Innovations in agriculture by start-ups can offer great hope as these can potentially make agriculture accessible, affordable and scalable, thereby making it export-oriented. India's growing innovation ecosystem has witnessed the addition of nearly 700-1,100 new biotech start-ups every year for the last five years. Among the more than 5,300 biotech start-ups present in the country, about 13 per cent share of the bioeconomy is contributed by the bio-agriculture sector.

DBT-BIRAC promotes the biotech innovation ecosystem in the country by nurturing and scaling biotech entrepreneurship and the start-up ecosystem. Support provisions like access to risk-funding; establishment of common infrastructure like BioNEST bioincubation centers; mobilisation of private investors and mentor networks; and showcasing opportunities have created a robust, vibrant and sustained pipeline of entrepreneurs, start-ups and supporting stakeholders' networks from the public sector, the industry, the academia and philanthropists representing India and the international community.

This Idea to the Market booklet is a compilation of the potential agricultural solutions that have facilitated both small- and large-scale communities.

BIRAC's effort is to empower the emerging biotech enterprises and work towards the development of innovation and entrepreneurship to position India as a global biotech innovation hub.

Shirshendu Mukherjee, PhD

Mission Director, Grand Challenge India
Biotechnology Industry Research Assistance Council (BIRAC)
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Genomics Solutions in Agritech

Is India Ready?

*From creating pest-resistant plants, increasing post-harvest shelf life and boosting plant-derived agri-biologicals to improving livestock breeding and targeting sustainable agriculture practices, genomics has the power to be a one-stop solution for most pressing needs in Indian agriculture, **Adita Joshi, PhD, Founder, Sansriti Foundation, writes.***

Genomics, the study of genomes, has the power to drive sustainable agricultural and livestock production to meet current challenges of food security in the wake of climate change, shrinking natural resources and changing abiotic and biotic stress factors. A genome is the total DNA (genetic information) present in cells of plants, animals, viruses, fungi, bacteria and all living forms. Next generation sequencing (NGS), a technology used to sequence genomes can identify genes for desirable agronomic traits and aid farmers and breeders take informed breeding decisions and produce nutrient-rich crop varieties with improved yield and grain quality.

Genomics is pervasively seeping into allied sectors in agriculture and transforming key areas like agri-biologicals, animal husbandry, sustainable agriculture, food processing and safety, post-harvest technologies and agricultural supply chain all over the globe.

Smart crops, desired traits & sustainable production

Genome can be edited at precise locations to produce designer plants that are resilient against stressors like viruses, bacteria, pests herbicides, temperature shifts and drought like conditions. Gene editing involves targeted and specific deletion or insertions of genes to confer or modify a particular trait in a stable and heritable manner. Classical breeding takes more than a decade to achieve desired traits.

However, with new-age technologies like CRISPR-Cas9 gene editing system, plant genomes are manipulated to achieve desired traits in much shorter time of three to five years. A recent example is the development of yellow coloured tomatoes with improved traits using CRISPR-Cas9 by AgriGenome Labs in Kochi.

As CRISPR-Cas9 is non-transgenic in nature, it is not subjected to rigorous regulatory compliances as with genetically-modified food crops. Therefore, leading agri-biosciences companies are slowly adapting this technology to produce healthy alternatives like gluten-free wheat, low glycemic index grains, low fat versions of oil-seeds like calyano oil, and a new gene-edited soybean oil developed by Calyxt Inc and launched in 2019. Gene editing has applications in biofortification of plant produce to meet micronutrient deficiency requirements. For example, Mohali-based National Agri-Food Biotechnology Institute has standardised the CRISPR-Cas9 technology for producing bananas fortified with vitamin A.

CRISPR-Cas9 has been successfully employed to cultivate drought-resistant maize, high-yield rice varieties with improved growth, generate pathogen-resistant plants like tomato resistant to powdery mildew, a fungal pathogen, and rice resistant to bacterial blight.

Translational genomics approaches have been used in India for developing pathogen-resistant and pearl millet with improved yield (15 per cent) and wilt- and drought-resistant chickpea (Pusa chickpea 4005).

India is home to a fortune of indigenous plant varieties. When combined with genomics, precision technology can open a gamut of possibilities to address key issues pertaining to food security, nutrient deprivation, yield of livestock products and to roll out need-based plant products.

A single change in DNA sequence is called single nucleotide polymorphism (SNP) and is often responsible for variability of traits across plants and organisms. SNPs linked to traits can be detected using a technique called genotyping. SNP genotyping arrays IndRA (rice genome) and IndiCA (chickpea) have been developed by the National Institute of Plant Genome Research in New Delhi. IndiCA and IndRA will facilitate genomics-assisted breeding for rice and chickpea, identification of traits of agronomic importance and development of stress-resistant varieties with higher yield.

Genomics and gene editing technology can be deployed to combine the resilient traits of landraces and wild relatives with those of the cultivated varieties. This will bring forth the best traits in terms of resistance to pest and pathogen, and tolerance to salt, temperature and drought. Smart crops ready to face the challenges posed by climate change are in the pipeline.

Soil metagenomics, personalised biofertilisers & precision agri-biologicals

Agri-biologicals are natural products derived from living organisms such as plants, microorganisms or animals and are used to either stimulate plant growth, protect against pests or enhance plant fertility by improving nutrients or fertiliser uptake. The market of agri-biologicals is expected to grow at 13 per cent CAGR globally, and at 4.5 per cent for India in the coming years. It is expected to reach \$21 billion by 2026.

Compared to chemical alternatives, agri-biologicals rapidly degrade over time and promote sustainable and green agricultural practices. Agri-biologicals have been used in integrated pest management strategy to maximise plant yield of fruits, vegetables and tree nuts. They have varied modes of action, and thus, do not pose a problem of resistance to pests.

Metagenome refers to the combined genomes of all microorganisms present in an environmental sample. Soil metagenomics is another promising area in research and development to uncover a new range of precision plant microbes that will disrupt the traditional chemical options and reduce environmental pollution risk. Not all



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soil microorganisms can be cultured and isolated in the laboratory by traditional techniques. However, most can be detected using metagenomic shotgun sequencing, sensitive enough to detect DNA from various microorganisms, insects and other organisms present in the soil.

Metagenomics is based on the understanding that a plant and its microenvironment are tightly interlinked and their association may be useful in many ways. There is a direct link between how soil microbiomes may interact with plants. An example would be response of the microbiome to stress conditions. As soon as a plant is exposed to stress conditions, certain molecular signalling pathways are activated in the soil organisms to enable heightened intake of soil nutrients by the plant and thus counter stress.

Microbial communities in soil may be affected by parameters like fertiliser, pest control chemicals, environmental changes and farm practices like crop-rotation. Companies like US-based Illumina and Perkin Elmer have developed fully-automated sequencing workflows to assess all diverse organisms into the microbiome environment and enable species identification. Switzerland-headquartered Syngenta and German multinational BASF are focussing on developing plant microbes by identifying and screening substances from microorganisms present in soil.

Personalised biofertilizers can be produced by identifying microorganisms living in the immediate environment of a plant or inside it. Metagenomics comes handy for identifying the original microbiome of the crops and helps in the development of personalised biologicals that may enhance the immunity of the crop, thereby reducing the need for other chemicals.

India is rich in agro-climatic zones, soil types and diversity of crops. A huge potential is waiting to be untapped for research on a large variety of agri-biologicals that are customised for local regions and crops to help farmers reduce fertiliser costs, promote sustainability and reduce runoff risks. Valuable insights may be obtained from combining biologicals with genomics precision technologies to develop precision agri-biologicals that aid in monitoring plant health, promote pest defence and increase nutrient value.

Minimising post-harvest losses & ensuring food safety

Genomics approaches are adopted for minimising post-harvest losses in vegetables, fruits and other horticultural and ornamental crops. The UN Sustainable Development Goal (SDG) 2, which strives to promote sustainable agriculture, end hunger and achieve food security, cannot be truly realised unless the global post-harvest losses (almost 33 per cent of the produce or 1.3 billion tonnes annually) are minimised. Long supply chains, perishable nature and short shelf life of fruits and vegetables results in losses and waste. The hardest hit are small farmers and populations in developing countries with meagre resources.

Genomics and gene editing technologies have been utilised for developing tomatoes with increased shelf-life, intact texture and flavour and even disease resistance in post-harvest stages. Similarly, potatoes and mushrooms that show less browning with improved cold-storage and processing traits, and flowers (petunia) with longer longevity traits have

been developed using translational genomics approaches. Grapes, citrus and chilli pepper genomes have been edited to confer resistance to post-harvest pathogens.

Further, there is a promising scope for undertaking genomic sequencing and identifying qualitative trait genes in many horticultural and ornamental plants as many genomes are not yet available. This will promote broader genome based applications.

As food products move around the world, there is a fair chance of them carrying contamination in the form of bacteria or other pathogens. Whole genome sequencing approaches like GenomeTrakr used by USFDA are utilised for profiling pathogens and related cases of food sickness and disease outbreaks due to pathogens transferred via food exports and imports. Genomic sequencing is also used in identification of transgenic products, a regulatory requirement in some countries.

Genotyping cattle & livestock

A genomic SNP chip—an array of 11,496 SNPs called 'Indigau', has been developed by Hyderabad-based National Institute of Animal Biotechnology (NAIB) to aid conservation of indigenous cattle varieties in India. These SNPs are related to traits like increased milk yield or disease resistance, and therefore, will help in selecting cows whose produce will positively affect farmers' revenue. The Indian dairy sector offers huge scope for future SNP chip development.

Genotyping will enable farmers to breed cows that are better adapted to changing climate conditions, yield economic efficiency and reduce cost of resources. Traditional breeding requires at least a few years and several lactations to assess the genetic potential of a cow. With genotyping, farmers can not only predict valuable traits at birth of the calf (potential mother), but also any genetic anomalies that may be passed on to the next generation.

Further, genotyping helps in selection of bulls with desired traits and the best IVF combinations for cattle breeding may be selected. It is not far when each calf will be sequenced at birth and receives a genotyping tag for a trait of importance—a simple step towards precision dairy farming.

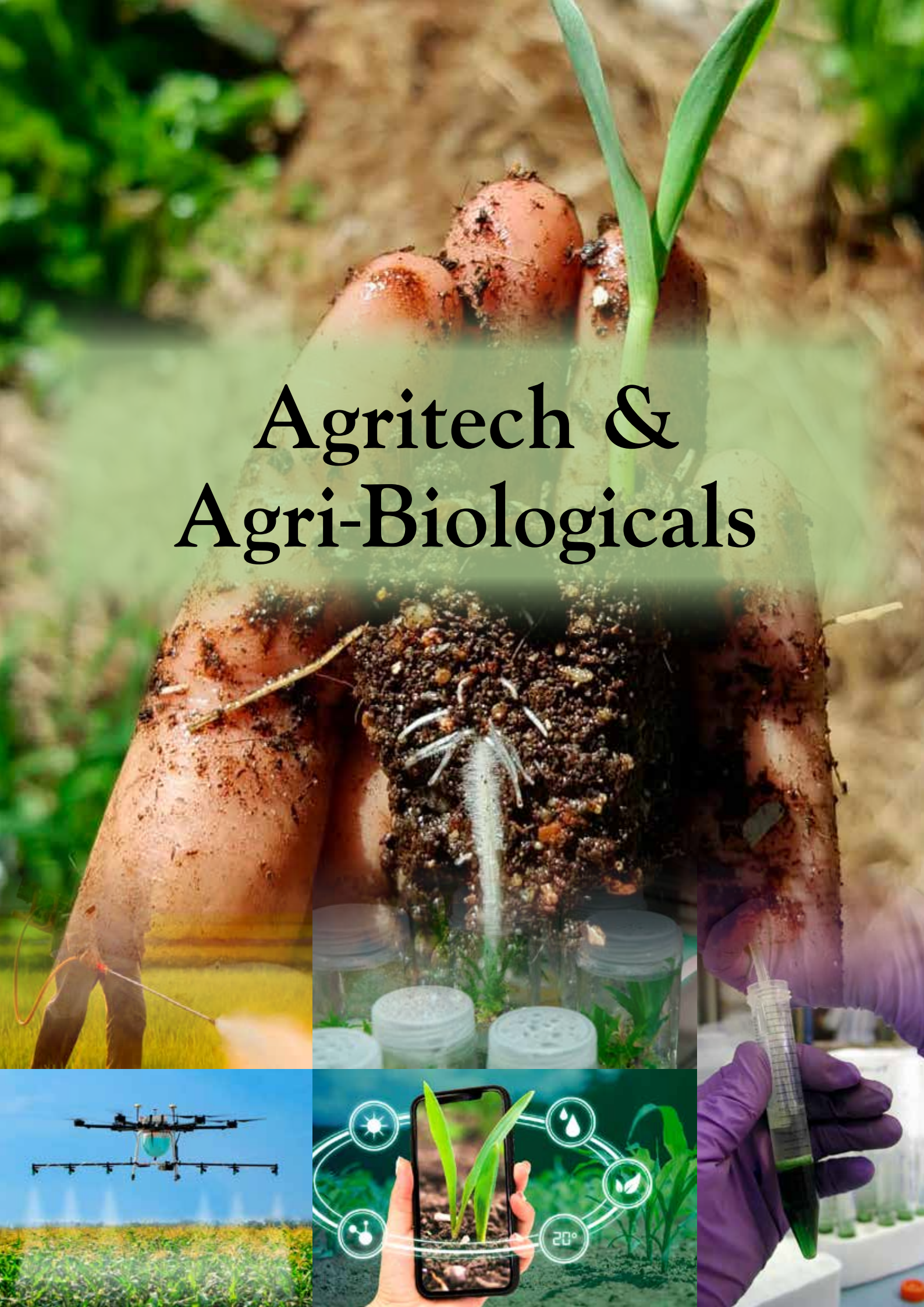
Further, infectious agents may be detected and disease surveilled in cattle using the metagenomics approach. Illumina's NGS technology is gradually finding application as a tool in screening and monitoring infections in animal populations.

While India has made decent strides in agrigenomics applications with a few poster stories like IndiGau, IndRA and IndiCA, there is a tremendous scope for strengthening its agrigenomics capabilities and developing an ecosystem where farmers, industries and researchers may work together to harness the benefits of translational genomics. ■



Adita Joshi is the founder of Sansriti Foundation, which provides consultancy on science education and communication. She also works as a scientific consultant with the CSIR Institute of Genomics and Integrative Biology in New Delhi.

Agritech & Agri-Biologicals



Croplytics: Advisory System for Farmers

A Masters degree holder in computer application, Rashi Verma has over 11 years of experience in e-governance and business development with companies like Fortuna Infotech India, Sify Technologies and NIIT GIS.

AgSmartic Technologies is a precision agriculture company founded in 2017 to improve crop yield by precise irrigation and pest-disease management through a data-driven approach by using artificial intelligence, Internet of Things and computer vision. Chief technical officer Abhishek Sinha is the other co-founder.



Rashi Verma

Co-founder-President
AgSmartic Technologies
New Delhi
agsmartic.com



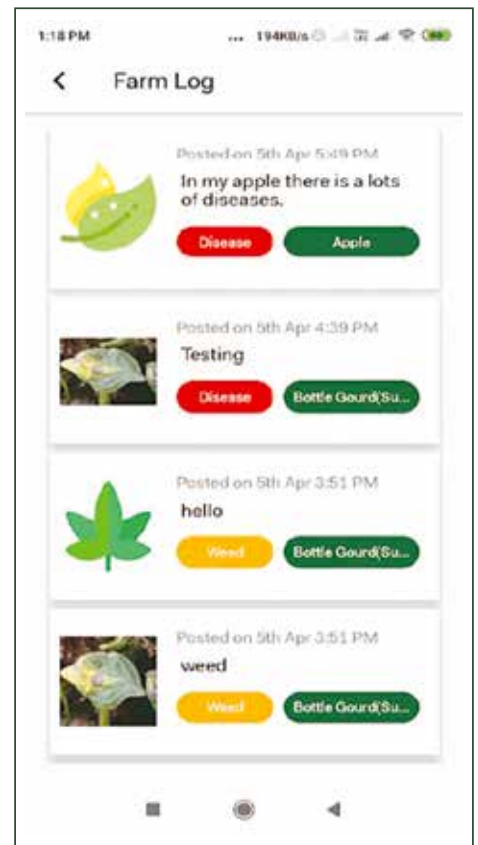
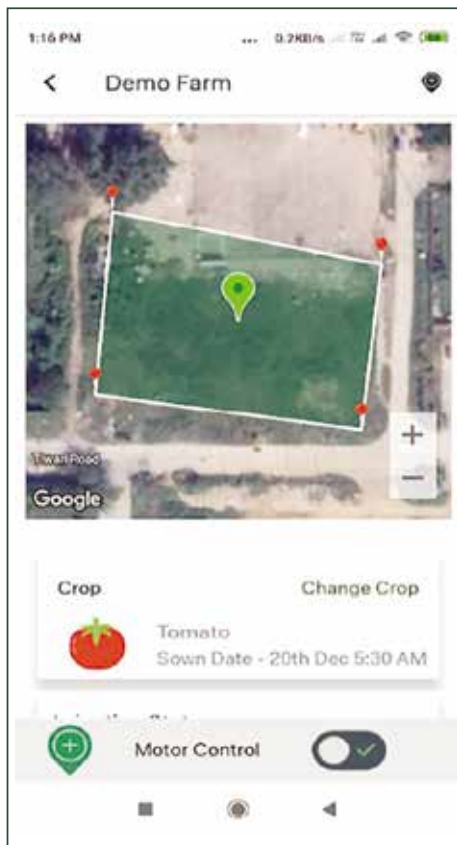
Product

Data-driven farming is the use of data to augment decision-making in farming systems and improve factors like crop yield, profit, environmental sustainability and food security. With the help of remote sensing of geo-tagged farm and weather data, fairly accurate information can be obtained that can help farmers identify efficiencies. That may lead to higher productivity and profitability, lower input costs and optimised fertiliser use. Apart from these, the data can be used by the government, insurance companies and other stakeholders.

Our product Croplytics is a combination of hardware and software solutions that integrates sensor data and satellite imagery to translate data into actionable information for creating a precise model for irrigation and pest detection. We have not filed any patent yet.

Our farm- and crop-specific advisory system requires no hardware. The process starts by registering farmers on the system, after which the geo-fencing of each individual farm is done by placing markers on the farm boundaries. Additionally, the farmers must also add other details related to crop to receive necessary advisories from sowing till harvest.

After successful registration of farms, our satellite-based system starts tracking and capturing images of the farm on a regular basis. It keeps track



of the vegetation index—both enhanced vegetation index (EVI) and normalised difference vegetation index (NDVI)—for crop growth and anomalies. It tracks the water index (NDWI) for changes in soil water balance; weather parameters like temperature, humidity, rainfall and wind speed; and crop stages.

Based on all these, the system provides necessary advisories like weather alerts; change in crop growth; water scarcity alerts; major change in pH; advisories based on temperature, humidity, season, crop stage and location; and necessary package of practices.

Notifications can be received on the mobile app and on www.croplytics.com. In case of FPOs, they can add

farmers and can monitor each farmer's farm through the dashboard.

Marketing strategy

We have collaborations with partners like FPOs and foundations at locations where we work so that customer acquisition cost can be reduced.

Revenue generation plans

We have two ways of generating revenue: subscription-based advisory services and one-time sale.

Challenges

Every geographical region has its own challenge, with each requiring a different kind of pump with varying phases, voltage and other requirements. To scale horizontally to different geographies, detailed understanding of the irrigation requirement is necessary.

Procuring components is a tedious process as well, and with a very limited set of vendor alternatives, manufacturing is often delayed.

Technology awareness among farmers is quite low. Though the outcome of providing real time guidance on pests and disease, weather advisory and soil moisture condition is helping farmers in reducing damage, but the number of farmers willing to use our technology is still not high as expected.

BIRAC support

BIRAC has immensely helped us in product development. Their acceleration programme helped us in understanding the essentials of business, including marketing, communication and finance. ■



Using AI to Protect Crops from PESTS

A Masters degree holder in microbiology, techno-commercial business development professional Shahnaz K Shaikh founded early-stage start-up AI-Genix International in 2019 along with Khalil J Shaikh, chief technology officer in the company now, after successfully running another start-up, Microbiz Network, which worked on artificially intelligent (AI) next-generation insect communication technology.

She has been studying insects' behaviour and their response to various kinds of signals since 2001 and working on artificially intelligent crop protection technology since then.



Shahnaz K Shaikh

Co-founder-CEO
AI-Genix International
Pvt Ltd, Mumbai
ai-genix.in

Focus area, stage of development

With crop protection being our focused area, we are inventing, manufacturing and selling second generation AI-enabled pest management devices—BraveHawk and eBionic—and plan to launch a third-generation technology in 2023-2024, for which field trials are under way in private farms.

Through our initial start-up Microbiz Network, we sold more than 4,000 devices in India and abroad between 2014 and 2020 and generated sales revenue worth ₹2.5 crore. Once we realised that the product was well

accepted by farmers, crop protection experts and agricultural scientist across the world, we set up AI-Genix International Pvt Ltd. to mass-produce these products.

Problem

Farmers and scientists across the world are struggling to protect crops from insect pests, most of which have developed resistance against pesticides. Day by day, the cost of pesticides is rising. Moreover, as governments are gradually banning toxic pesticides due to their harmful effects on human health, farmers are left with fewer options for crop protection. Therefore, growers get frustrated when they lose crop.

Product

We have successfully addressed the issues related to insect pest management by developing Bravehawk artificially intelligent pest management technology that does not use a single drop of chemical pesticide. The device exterminates more than 2,000 types of insect pests and safeguards beneficial insects like honey bees and predatory insects. It increases the yield by 40 per cent and farms produce residue-free organic. The devices are fully automatic and solar-powered, and farmers can achieve above 95 per cent pest control.





The patent for the BraveHawk series has been filed and for the eBionic series, the application process is under way. The BraveHawk series products can cover areas between 1 and 2.5 acre and can be used for three to seven years without maintenance. The products are cost effective, eco-friendly, efficient and portable. The eBionic series products too have similar features with three models for specific groups of insects: eBionic Fruit Star, eBionic FlyStar and eBionic WevStar.

The crop protection cost is reduced by 95 per cent and there is a 40 per cent increased in yield. Farmers earn more and there is no health or environmental hazard.

Challenges

Our challenges include customer acquisition from foreign and domestic markets; keeping sufficient inventory of components for manufacturing; generating working capital required to scale up the business; expenses on patent filling in foreign markets; and lack of professional experts in functions like finance, marketing, sales and business development.

Cost effectiveness, competition

Unlike other conventional methods for crop protection, our technology attracts over 1980 genus and species of herbivorous and omnivorous insects. Broad spectrum insect pest do not develop resistance against AI-enabled devices that support crop setting by nurturing the population of honey bees. Faulty components can be returned to the company for recycling.

Our indirect competitors are manufacturers of pesticides, light traps, pheromone traps and sticky trap. But light traps attract both beneficial as well as harmful insects, and the percentage of beneficial insect catch is high—around 30 per cent. The pheromone technique is available for only a few insects and not necessarily for all insects that damage crops and plants, and is only useful for specific species of male insects. Organic pesticides and biochemical pesticides are expensive, while synthetic chemical pesticides are both expensive and hazardous.

Marketing strategy

We are making effective use of social media networks to reach out to customers and have formed strategic alliance with non-competitive agri-input suppliers and manufacturers to leverage their distribution network in

the domestic and international markets. We are selling our products on business-to-business, business-to-consumer and business-to-government platforms.

We have already signed a memorandum of understanding with three distribution partners in India to sell our products through their network of 20,000 outlets and looking forward to partner with three more suppliers. We are expecting to generate revenues worth ₹20 crore in fiscal 2023-24.

BIRAC support

Our start-up is supported by the BIRAC-BioNEST Bioincubator network.

Key milestones to cover in next few years

We aim to raise our manufacturing capacity to 3,000 units per month by the end of the second quarter of 2023, to 10,000 units per month by the end of 2024, and 30,000 units per month by the end of 2025. We want to scale up business operations abroad in a phased manner, covering Brazil, Saudi Arabia, Indonesia, Malaysia, Latin America, the European Union and North America. The launch of our third-generation product is planned by the end of 2024. ■

Achievements

- Skoch Merit Award for top hundred projects in India (2016) from Skoch Foundation, New Delhi
- Best Indian Social Enterprise Award and Best Woman Entrepreneur Award (2019) from Action for India, IIT, Hyderabad
- AABI Torch Award for Promising Entrepreneur 2020 from Asian Association of Business Incubation, Shanghai
- TiE Sustainability Summit Women Social Entrepreneur Award 2021 from The Indus Entrepreneurs, Hyderabad
- Gold Medal on Indonesia Inventor Day at the World Inventions and Technology Expo 2021, Indonesia.

Affordable Next-Gen Agri-Biologicals

Make crops climate-resilient, improve yield

The agri-biotech start-up was founded by three scientist, Renuka Diwan, PhD; Amit Shinde, PhD, and Shekar Bhosle, PhD, with the vision of 'bringing back pride and profits' to farmers. The three met while pursuing their masters and PhD in plant sciences at the Savitribai Phule Pune University, Maharashtra.

Bioprime aims to transform the way crops are grown, making food more nutritious and wholesome using cutting-edge technologies, and always keeping sustainability at the core. Incubated at the Venture Centre, NCL Innovation Park, BIRAC support helped the company develop novel biologicals and establish Smart Nanomolecules Induced Physiological Response (SNIPR), its discovery platform.



Renuka Diwan, PhD

Co-founder
Bioprime Agrisolutions
Pvt. Ltd., Pune
bioprimeagri.com

Problem

Farmers' profits can be increased by focusing on three factors: reducing cost of cultivation, generating more produce and offering better market price. Each of this is directly linked to efficiency of plant's processes. Growth, stress tolerance, plant defence and yield depend on a series of complex processes that require plants to allocate valuable resources to them. Climate change, fluctuating temperatures, unseasonal rains, water scarcity and flooding affect the ability of plants to function at normal levels.

More severe are the impact from climate change and drop in the efficiency of these process. This means external mitigation methods like supplying more nutrients, fertilisers, hormones, amino acids, etc. cannot restore the efficiency of plant process back to normal levels. This needs special dedicated process modulation. It became obvious that this vicious cycle can only be broken if the internal process could be coaxed to perform to normal efficiencies despite adverse conditions.

Focus area

BioPrime is developing effective and affordable next-generation agri-biologicals that helps make crops climate-resilient—protecting yield and crops from fluctuation weather, untimely rains, temperature stress and water stress to name a few. These biologicals are based on small biomolecules that modulate plant processes for faster and targeted results on field. Products are

crop agnostic, certified residue free and organic, and can be adopted by farmers on 'as is where is' basis.

Products

The first-generation products are at early commercialisation stage. We have launched eight products in five states. **Prime Chiron** and **Prime Fast 10** are super boosters for improving yield and harvest quality; **Prime Verdant** is a bio-stimulant for stress tolerance and increased yield with unique blend of nutrients, minerals and anti-oxidants; **Prime Fortisea** is a formulation of fortified seaweed extracts for faster growth and stress resistance; **Prime 7525** is an advanced complex blend of naturally derived biomolecules that acts as a super charger along with seaweed extracts; **Prime Conquer** is a complex botanical bio-stimulant formulation that activates innate immunity of plants; and **PRIME CG Pro** is a growth booster granules with triple action formula that reduces flower and fruit drop and increases fruit setting. All products are completely biodegradable.

Verdant is a proprietary formulation with unique blend of essential micronutrients, minerals, organic carbon, amino acids and plant-based anti-oxidants for active growth and stress tolerance in crops. It increases germination, strengthens cell wall, enhances white root formation and chlorophyll content. It protects plants from transplantation stress; reduces flower and fruit drop; increases fruit setting; and is particularly beneficial under conditions of water stress, temperature extremes and high biotic pressure.

Chiron, a bioactive formulation of essential nutrients, minerals and stimulants, reduces flower and fruit drop; and increases fruit setting. **Fortisea** promotes vegetative growth; improves crop vigour; induces white roots with better nutrient absorption; and builds resistance against biotic and abiotic stress.

Prime 7525 helps raise foliage and induce more flowering and fruit conversion. It helps get uniform fruit size and weight with uniform harvesting every plucking. It improves nutrient uptake of the crop, enhances photosynthesis.



From left to right: Co-founders Shekhar Bhosale, Renuka Diwan and Amit Shinde.



Fast 10 contains photosynthetic intermediates and botanical bio-stimulants that are readily absorbable. It reduces flower and fruit drop and increases fruit setting.

Conquer modulates the innate and systemic immunity of crops, providing comprehensive protection against wide range of sap-sucking pests by breaking down resistance acquired by the pests. Fast acting botanical bioactives like phytoanticipins and phytoalexins in the formulation activate plants' defence system.

How does SNIPR help

BioPrime focuses on ensuring that plant's internal processes function at maximum possible efficiency using biomolecules that activate certain process in plants. This enables the farmer to close the yield gap- the difference between maximum possible yield versus the realised yield.

Challenges, hindrances

Lab-to-market, the most critical scale-up point in any tech start-up where it is essential to validate the technologies commercial feasibility, requires various infrastructure—from large bioreactors, mixing tanks, extractors to routine filling and packing set-up. It is very expensive for a start-up to set up the complete infrastructure by itself. Inability to scale quickly means start-ups may not achieve market-competent price points and that hinders adoption. Small dedicated production set-ups that can be used on a shared basis will prove a game changer for product based start-ups.

Compared to incubation support in terms of facility and funding for medical and pharmaceutical sector, there is lack of support and infrastructure for agri and life sciences start-ups. New products and molecules need laboratory, controlled conditions and green house testing facility complete with soil, moisture, temperature and spectral data to establish proof of concept.

Once product is developed, establishing farmers' trust and winning confidence was the main hurdle due to spurious products and companies. Lack of regulatory framework meant there was no uniformity in quality and pricing and no governance on the kind of products being sold.

Marketing strategy

BioPrime has a B2C as well as a B2B approach to quickly establish the technology across India. B2B also helps

faster adoption. We also co-develop products with multinational corporations that are then launched through those companies' distribution channel. Lack of clarity and clear regulatory guideline is a major barrier in launching products in the market.

BIRAC support

SNIPR was established with the proof-of-concept funding received from BIRAC's BIG grant. The product market fit was done with support from the BIRAC's Sustainable Entrepreneurship and Enterprise Development (SEED) equity funding, and the scale-up and commercialisation with the Launching Entrepreneurial-Driven Affordable Products (LEAP) equity funding. The LEAP fund helped us tide over the pandemic-induced lockdown. BIRAC also sent us to Judge Business School, Cambridge, under IGNITE, its intensive entrepreneurial boot-camp programme. That offered us international exposure and helped shape our strategy and business model.

Key milestones to cover

- Bioefficacy testing, toxicity studies, shelf life studies of eight products
- Get regulatory approval of these products
- Build India's largest plant-associated microbe library Bionexus
- Strengthen the discovery platform SNIPR and work on plant protection products

Achievements

- UnLtd India's Growth Challenge award (2018)
- Among Top 10 finalist in Future Food Asia Awards (2018)
- Tie-BIRAC Women in Entrepreneurial Research (WiNER) Award (2019)
- Finalist in the National Start up Awards 2020
- NITI Ayog's Atal New India Challenge (ANIC) grant-in-aid (2020)
- Social Alpha Agritech Challenge winner (2021)
- Best Agri Input Company, Agri Awards (2021)
- Cisco Agritech challenge, finalist with grant in aid (2021)

Using Insect Pheromones to Manage Pests

Works through new controlled release dissemination tech

ATGC Biotech Pvt. Ltd. manufactures high-quality insect pheromones and sustainable next-generation pest management solutions. The company was established by a group of scientists—all alumni of the University of Hyderabad—in 2011 with the aim of providing green technologies for pest management as an alternative to chemical pesticides in agriculture.

Vijaya Bhasker Reddy, PhD, the company's director of operations, and Sivarama Prasad, PhD, are the two other co-founders. The company is now developing sustainable technologies using nanotechnological approaches for controlled release pheromone dispensers for mating disruption.



Markandeya Gorantla, PhD

Co-founder-CMD
ATGC Biotech Pvt. Ltd.
Hyderabad
atgc.in



Challenges

Mating disruption technologies are limited to a few large plantation crops worldwide and new to India. We faced several challenges in developing technologies for row crops in India. The major one was to establish dossiers and application methods suitable for Indian climatic and farming system, which mostly consists of small and marginal farm holdings.

Elements capable of reducing or avoiding the use of chemical pesticides, besides increasing quality and yield, are safe molecules that do not kill insects, but are scheduled in the Insecticides Act, 1968, when these are developed for mating disruption technique.

Mating disruption products are new to the Indian insecticide regulatory system and our technology is the only and first of its kind in indigenous mating disruption category. Hence, the process of approvals caused significant delays in product commercialisation. Though insect pheromones are natural and known to be safe, the need for rigorous toxicology studies and dossiers required only in India delayed the registration process.

We also faced challenges in scaling up pheromone production in a cost-effective manner, ensuring the economics of the Indian farming system. Further, technology adoption requires extensive farmer education and awareness as part of go-to-market strategy, as the method, time and mechanism of action are completely different from the conventional practices of insect pest management (IPM).

This extension education requires farmers awareness programmes in rural India considering a village as a unit with on-farm demonstrations. Mass and social media reach and e-commerce is limited to a few educated and progressive farmers. The expenses incurred from product development to commercialisation are high in this process for a start-up.

Currently, these technologies are available across the globe for four major pests and those are mostly on plantation crops like apple, grape, almond. Deployment of mating disruption is taken up in large areas to be effective. Technologies developed by ATGC suit well to Indian small and marginal farmers with cost on par at or less than insecticides.

Focus area, stage of development

The expenditure for Indian pest management services in 2020 was nearly ₹232 billion. Due to indiscriminate use of insecticides, the residue levels in the food we eat are increasing—a major health concern. Alternative technologies for pest management are limited and are ineffective in current practices.

ATGC developed several insect pheromones and novel and effective dispensing technologies that are recognised as potential alternatives to chemical pesticides in reducing pre-harvest losses caused by pests. Insect pheromones are currently being used in India as monitoring and mass-trapping tools only and are not proved to be potential alternatives for chemical pesticides.



Our novel controlled release pheromone dissemination technologies helped develop a series of mating disruption products. We developed a product line that offers a solution to the unmet need for managing 50 different pests and three different prototypes for each pest, among which 10 are at the scale-up stage and three are in the process of commercialisation.

Product

Of these, CREMIT PBW for the management of pink bollworm (PBW) in cotton has now emerged as 'the only solution' approved for commercialisation with a green label from the Central Insecticide Board & Registration Committee. This product was licensed to Hyderabad-based Natco Pharma Ltd and commercialised with the brand name NATMATE PBW in 2021.

IPM mostly uses chemical pesticides that are hazardous and non-targeted in action, and cause imbalance in the natural ecosystem of the farm by eliminating farmer-friendly predators and parasitoids. Further, there is no chemical pesticide that has an approved product label claim for insect pest outbreaks like PBW in cotton.

The only safer alternative and greener solution for management of these devastating pests is CREMIT PBW. Its USP is it is species-specific to the target pests and highly effective, besides being easy in application and safe for farm workers and animals. Controlled release and long-lasting with a single application with a window of 30-45 days interval offers a greener solution. These innovative technologies are protected for their intellectual property at multiple levels through patents.

Marketing strategy

We have entered into licensing agreements with agro-chemical industries for quick dissemination of our technologies globally. We are exporting insect pheromones active ingredient for the last 11 years to the United States, Europe and the Middle East.

In India, we have an established network of distributors and dealers—both B2B and B2C—in Andhra Pradesh, Telangana and Karnataka. We are in the process of expanding our network to Kerala, Bihar, Maharashtra,

Uttar Pradesh, West Bengal, Gujarat, Tamil Nadu and Punjab.

We are also planning to establish a pan-India network by 2024. We have launched online sales on major e-commerce platforms besides launching an exclusive Android and iOS app for facilitating sale to new-age farmers.

BIRAC support

We received BIRAC funding for developing dossiers for four economically devastating pests—PBW in cotton, brinjal shoot and fruit borer, tomato leafminer and citrus leafminer—which significantly helped in the product development process. BIRAC supported the company in showcasing the technology in various agricultural forums as well.

The award helped us get not only industry recognition but credibility in reaching farmers and educating them about their use. BIRAC also helped us connect with the Ministry of Agriculture and Farmers Welfare.

Key milestones to cover in next few years

We are in the process of bioprospecting the pheromone synthesis, which is expected to reduce cost of synthesis significantly. Our efforts in successfully setting up of a molecular entomology division and dissection of pathways is expected to trigger another major growth phase in taking these technologies to every Indian farm. ■

Achievements

- Best Innovation Award in agriculture (2017)
- Aspirer Award by IKP Knowledge Park
- BioAsia's Top Start-up to look out for (2018)
- Agriculture Grand Challenge Award (2019) from Ministry of Agriculture and Farmers Welfare
- Best Start-up Award (2018) by Research and Innovation Council of Hyderabad

Gels, Fertiliser Carrying Membranes

Promote shift to organic farming

The company, incubated at the bio-incubator facility at the Indian Institute of Technology (IIT) Madras Research Park, develops nanofibre-based agricultural inputs. Its core team primarily comprises IITians with expertise in biochemistry, nanotechnology, microbiology and polymer science. Its products target farmer producer organisations (FPOs), distributors, plantations and aggregators. Some products are also targeted at improving sustainable agriculture among home and urban gardeners. Its manufacturing facility is located in Perungudi, Chennai.



Kavitha Sairam, PhD

Co-founder-CEO
FIB-SOL Life Technologies
Pvt. Ltd, Chennai
fibsol.com

Problem

India is an agricultural country and huge amount of fertilisers are imported. Despite government subsidies, fertilisers are a financial burden on small and medium farmers. The bulkiness of the fertilisers is another issue. As most farms are in remote areas and proper transport facilities are not available, a product that could cut down the logistics could be an excellent alternative.

The increasing global demand for soil treatment and the deleterious side effects of synthetic fertilisers is also an excellent opportunity for organic soil and plant formulations. The irrational use of chemical fertilisers not only pollutes the environment, but in due course has deprived the soil of its natural ecosystem.

The idea of entrapping agriculturally important microbes came to me a few years ago, when I had just completed my doctorate. I was working on stress signal transduction to improve secondary metabolite production in fungal systems. I was exploring ideas, including the development of assays for biomarkers. That is when my PhD guide and mentor Prof T S Chandra insisted that we should develop some technologies to address issues in agriculture.

Solution

Agricultural universities in the country have been supplying biofertilisers for long. However, these are supplied by mixing with inorganic carriers like lignite, peat and talc, which does not support their existence.

I realised that a method to stabilise these bacteria will be a solution. There were technologies like freeze drying, but those are quite expensive.

Hence I thought of exploring stress biology, where some stress stabilisers could be added in the bacterial media to stabilise them. Alternatively, electrospinning and encapsulation could be a solution. My junior and co-founder Anant Raheja was working on nanofibre technology, and we partnered to explore this further. We understood that besides stabilisation, we could also increase the payload of cells, or unit area, using this technology.

This would bring down the bulkiness of the material by reducing the carrier by a thousandth. The advantage would be huge savings on logistics for distributors and users. As the stability of the organism was improved, the efficiency in the field also rose substantially. The other advantage is that a wide variety of molecules—both organic and inorganic—can be entrapped.

Thus, the technology is a versatile platform available for the exploitation of variety of agri inputs. Although some research and development effort will be needed when new product pipelines are added, we believe that most of agri inputs someday will be redefined using this technology.

Product

Fertilizer carrying membranes (FCMs) are bio formulations encapsulated in biodegradable and bio-compatible polymers. Gels are products that consist of bacteria entrapped in a blend of natural and synthetic polymers.

Our product is a five-gram fibre that is soluble in water and can be applied on the field using conventional or modern irrigation practices. It addresses the demand for live bacteria that can rejuvenate the soil. It can also raise the nutrient utilisation efficiency, allowing plants to assimilate nutrients in a better way.



optimal production, removing bottlenecks.

Marketing challenges include educating farmers to raise their acceptance levels and cultivating a loyal customer base through rigorous product demonstrations and follow-up.

Marketing strategy

We have commercialised the gel technology and have a marketing license for the same. We are looking for partners for scaling up and commercialising the fibre technology.

FCMs and gels designed by us would bring down the financial burden on farmers. The logistics would also improve as an acre would require only 15 grams of FCM or 100 ml of gels. Our products are socially very relevant as they would promote the much essential shift to organic farming.

Our FCM is readily soluble in water and allows easy application with any existing irrigation facility. The carrier material of FCM is rapidly degraded by soil microbes and leaves no residues unlike chemical fertilisers.

Our products are cost effective and comparable with commercially available formulations.

Challenges

Among the technical challenges, a highly controlled and ambient environment related to humidity and temperature is mandatory. Technically skilled personnel are needed to impart the technology of manufacturing the fibres. The most important challenge for proof of concept was large-scale manufacturing of the product. Advanced concepts like multi-needle technology and centrifugal electrospinning need to be adopted for scaling up.

Although electrospinning and nanofibre technology have existed for the past four decades, these had not been explored on biologicals. In a market like agriculture, where the volumes are huge, there is a need for a technology that can be scaled up.

Electrospinning is now largely used for making filtration membranes. We pivoted it to produce biologicals, with some customisation to the existing methodology. We partnered with engineering companies and also hired an engineering team to focus on machinery development. The basic parameters needed to produce biological-entrapped nanofibres were extrapolated to the large-scale machinery.

Various conditions were optimised and the components needed for the process were built internally and assembled in such a way that we now have the largest scale for water-soluble nanofibres in the country.

Apart from indigenous machinery, we also identified methods to customise industrial-scale machinery for

At 179.9 million hectares, India holds the second largest agricultural land in the world. Out of that, 2.5 million hectares is under certified organic farming, and therefore, the market potential is quite high.

Through identified channels, we are currently having a potential of 30,000-40,000 acres, which if converted cent per cent, will lead to substantial revenue. With our products, we are targeting FPOs, distributors, plantations and aggregators. Apart from this, our technology remains open to research and collaborations from industries for developing a novel functional product addressing other problems.

BIRAC support

BIRAC's SBIRI grant set the ball rolling for our company. Through that initial grant money, much of the needed points of contact were established and many minor problems related to innovation and efficacy were refined.

Key milestones to cover in next few years

We want to build a robust sales structure and carry on vigorous marketing activities to reach potential acres. Capital expenditure will be upgraded to support upscaling. The scale of business will be accelerated by partnering with B2B clients. ■

Achievements

- Received grant-in-aid fund from Pusa Krishi Incubation Programme UPJA (2021)
- Winner of Swissnex Lift Labs' Liftathon series (December 2016); included a technological showcase in Geneva
- Won Open Innovation Challenge of India Innovation Growth Programme (IIGP) 2.0
- Core patent on using nanofibres for entrapment of microbes was selected for Sir J C Bose Patent Award from IIT Madras (July 2017)
- Winner in the National Bio-entrepreneurship Competition (December, 2017)

Breeding Hybrid Orchids

Rajkumar Kishor did his PhD in orchid breeding and micro-propagation at the Manipur University in between 1999 and 2003, after which he continued research on orchids in various roles at different institutions. In 2013, he founded the company with his wife Thoudam Kebisana with the help of BIRAC's BIG grant.



Rajkumar Kishor, PhD

Co-founder-Managing Director
Kwaklei and Khonggunmelei
Orchids Pvt. Ltd., Imphal
kwakleikhonggunmeleiorchids.com

Focus area, stage of development

We are focusing on the agri-biotech sector with orchids as the specific crop. We are at TRL-6, i.e, the pre-commercialisation stage.

Product

Despite having rich orchid resources, India has been importing orchids from other countries in Southeast Asia for commercial purposes. One of the reasons is the lack of elite indigenous commercial orchid breeds. The orchids developed in tropical Asia may not perform well in sub-tropical or temperate climates. Hence, there is a need to develop specific commercial orchid breeds for growers in different climatic regions of India. Therefore, this project shall result in development of, at least, some of the finest hybrid orchids that can form the backbone of commercial Indian orchid varieties. There is also a possibility of supplying elite planting material to all orchid cultivators as well as commercial orchid propagation units across India.

Hindrances & challenges

With funds provided by BIRAC, a small orchid tissue culture laboratory was established and we now possess more than 150 new hybrid orchids. However, we are facing problems in generating revenue as we are unable to upgrade to a full-fledged commercial laboratory. We require funds to the tune of ₹5-10 crore to meet the expenses, including those for infrastructure and working capital for five years or till the break-even point is reached. Orchid breeding is a long process and to launch a product in market requires at least 10 years. Moreover, skilled personnel are required for executing the process at different levels—from breeding to marketing.





The technologies we are using for the venture are already proven and verified. However, there still exists difficulty in establishment of tissue culture protocol for each and every new breed of orchid being developed. Therefore, some research work is needed to standardise culture protocol for every plant.

Every new orchid breed is a novel, priceless product. However for commercial purpose, we have to supply at a price competitive to those offered by foreign producers.

Marketing strategy

Our marketing strategy is both B2B and B2C. There is no barrier to enter the domestic or international market. The major challenge is to produce high quality orchid plants. The global orchid industry is a multi-billion-dollar business and Northeast India has a lot of scope to enter that market. We can generate revenue by selling copyright of the newly bred orchids, starter cultures of the orchids to other tissue culture laboratories, young plantlets to orchid

cultivators, and flowering plants to traders as well as end users.

BIRAC support

BIRAC has supported us by providing funds to the tune of ₹70.0 lakh under the BIG and SBIRI schemes. In 2017, BIRAC provided a follow up grant under SBIRI scheme.

Milestones to cover in next few years

Scaling up to commercial production in the next 2-3 years. ■

Achievements

Dr. Ibeyaima Innovation Award (2018) for hybrid orchids by the Manipur Science and Technology Council (MASTEC), sponsored by Ontario-based Manipuri Association of Canada.



Affordable Banana Planting Material

Sukhada Mohandas was a principal scientist at the Indian Institute of Horticultural Research (IIHR) in Bengaluru, with four national awards for research accomplishments. She has more than 30 years of research experience and founded the company in 2015.



Sukhada Mohandas, PhD

Founder, SM Plant Production Technologies Pvt. Ltd.
Bengaluru
smplantproductiontechnology.com



Focus area, stage of development

We are involved in producing healthy tissue-cultured planting material (banana) to supply to farmers throughout the year. Our product has already reached farmers.

Solution

We are addressing the non-availability of large number of quality planting material of banana cultivars Elakki bale (AAB) (also called Ney poovan) and Grand naine (AAA) (Pach bale) by using embryogenic cell suspension in bioreactors for mass production. This ensures the availability of healthy planting material throughout the year to farmers. The aim is to bridge the gap of around 2,000 million plantlets required to bring at least one third of the banana growing area under tissue culture-based cultivation.

We are under the processing of patenting our embryogenic cell suspension (ECS) technology.

Hindrances

We faced technical issues while designing the specification of bioreactors for large scale. Finally, we customised

the design for mass multiplication of embryogenic cells. We faced financial problems to set-up infrastructure for commercial production as well.

Marketing strategy

Initially, we were dealing directly with customers—face to face, but now we are engaged in online business as well, with IndiaMART as our partner.

BIRAC support

BIRAC played a major role in our journey. We got a BIG-III grant in 2014 for the proof of concept, which formed the base for start-up.

Key milestones to cover in next few years

To scale up production to 5 million plants per year and standardise commercial production protocol for other fruit and ornamental crops. ■

Achievements

Women Entrepreneur Award (2018)



India's Agritech Innovation Terrain

Hemendra Mathur, Venture Partner, Bharat Innovation Fund, and Chairman, FICCI Taskforce for Agri Start-ups, discusses opportunities and policy prescriptions for India's agritech start-up ecosystem.

Indian agriculture, which faces multiple challenges like climate change, water stress, deteriorating soil health, price volatility and farmer's lack of motivation to continue farming, needs to adapt innovations to become sustainable and profitable for farmers. Climate risks are more pronounced in the form of high temperatures, flash floods, delayed or erratic monsoon, shifting cropping patterns, depletion of water table and nutrient deficiency in the soil, adversely affecting productivity and farm incomes.

There are about 150 million farmers in India with more than 85 per cent of them owning less than two hectares of farmland. A farmer with an average land holding of about a hectare earns an annual gross income of about ₹120,000 to meet his personal, family and occupational needs. Hence, a farmer is often left with little surplus for productive investment into new-age solutions.

As demonstrated by about 1,500 plus agritech start-ups, innovations can go a long way in improving farm economics with improved yield, reduced cost of inputs and empowering farmers to de-risk against commodity price fluctuations and monsoon failures. The growing breed of agri-entrepreneurs is working towards improving farmer access to markets, quality inputs, institutional credit and insurance. Consumers also benefit in the process with improved access to safe, nutritious and affordable food. The industry and the government gain with access to reliable, timely and accurate data for taking decisions and formulating policies for farmers' welfare.

Indian agritech start-ups are trying to solve multi-dimensional problems in agriculture, including low productivity, sub-optimal efficiency in supply chain, and lack of access to markets, institutional credit, crop insurance, quality inputs and market linkages. The pandemic has improved digital adoption amongst farmers, thus accelerating many new agritech models where mode of delivery is digital, especially in advisory, financing and insurance.

The top nine emerging innovation opportunities in Indian agriculture, horticulture and livestock are as follows:

- 1. Demand-driven and tech-enabled aggregation and distribution of farm produce** from point of collection to consumption: Examples of these are Ninjacart, Jumbotail, Bigbasket, Kamatan, Desai Fruits Venture, Farmlink, WayCool, MeraKisan, Vegrow, DeHaat, ShopKirana, SuperZop, Crofarm, Agribolo, Kisan Network, MilkLane, Fresh to home, Licious, Captain Fresh, Numer8, AquaConnect, Mango Dairies, Krishikan, Chlorohemp,

ReshaMandi, Fraazo and Country Delight. Most of these models are business-to-business (B2B) targeted at institutional buyers, modern trade, and the hotel, restaurants and catering sector though direct to consumer models (D2C). These especially picked up during the pandemic.

- 2. Quality assaying of agricultural commodities** through image processing and digitisation of transactional data, price discovery and traceability: Examples of these are Intellolabs, Agricxlab, qZense, Raav Tech, InfyUlabs, Farmtrace from Innoterra, Occipetal, Amvicube, Nanopix, TraceX, Source Trace, Atsuya Technologies, Borlaug WebServices and Go4Life. Many of these models are pivoting to become marketplace.

- 3. Building near-farm storage, warehouse and processing units** with access to post harvest finance and market linkage through digital and physical modes: Examples are Our Foods, S4S Technologies, Agri Bazaar, Star Agri, Arya Collateral, Ecozen, Origo, Ergos, Sohan Lal Commodities, Promethean, Inficold and Whrrl. Micro-warehousing and farm level processing is likely to gain momentum with increasing demand for value-added foods.

- 4. Optimising the use of agricultural inputs and enabling delivery to farmers** based on farm and crop diagnostics: Examples are Agrostar, BigHaat, Behtar Zindagi, Unnati, Gramophone, Freshokartz, Plantix, Helicrofter, Hesa, EF Polymer, Frontier Markets, Bharat Rohan and Bharat Agri. The last-mile delivery and need for multiple compliances to store and sell agri inputs are some of the bottlenecks to scale.

- 5. Reducing labour cost through mechanisation** through the pay-per-use model and innovative mechanical tools: Examples are Sickle Innovations, Distinct Horizon, Kamal Kisan, Mera Tractor, Celestial Tractors, X-Machines, Tractor Junction, Khetibadi, Agrirain, Flybird and Toolsvilla. There is huge opportunity in building smart affordable multipurpose mechanical tools at one end and on the other end to build high end robotics and computer vision models to being efficiency in doing multiple farm operations.

- 6. Farmer advisory and data driven crop monitoring and precision farming:** Farm advisory using data collected from the farm on soil, crop and weather using artificial intelligence and machine learning tools is becoming mainstream, though monetisation models are still evolving.

Examples are CropIn, SatSure, RMSI, Mantle Labs, Stellapps, Krishi Tantra, Poultrymon, AgRisk and Skymet.

- 7. Agrifintech:** Data and digitisation are the precursor to innovative farmer, and value-chain financing models, which typically enable know-your-customer (KYC) processing, on-boarding and digital tools for risk assessment for farmers. Many of these models continue to be phygital. Examples are Samunnati, Greensat, Agrotech, FarMart, Jai-Kisan, PayAgri, Bijak and GrayMatter Technologies.
- 8. Controlled environment agriculture** using techniques such as vertical farming, hydroponics, aquaponics: Examples are Futurefarms, Urban Kisaan, Absolute Foods and Kaze Living.
- 9. Bioproducts,** including bio-fertilisers, stimulants to improve soil nutrition, plant immunity and growth: Examples are Bioprime, Kan Biosys, Barrix, Converte and EasyKrishi.

The innovation themes are at various stages of evolution. The market linkage, agri-input e-commerce and data-centric themes have picked up momentum and scale, whereas others are showing green shoots.

Changes needed

Here is 10-point policy prescription for Indian agritech:

- 1. Build sandbox for agri-fintech solutions:** The cost of capital in Indian agriculture is prohibitively high from farming to processing to distribution. Despite government's \$180-billion target for priority sector lending (PSL) to agriculture, about 70 per cent of farmers do not have access to institutional credit, paying interest of 24 per cent to 60 per cent per annum (against 7 per cent under PSL). Likewise, micro, small and medium enterprises, including warehousing companies, processors and distributors, which dominate the food supply chain, pay a high cost of working capital (15-18 per cent).

The high cost of capital makes farming and value chain businesses unviable. Digitisation of food supply can make the data available to bankers, which can reduce bankers' risk and cost of capital. Many agritech and fintech start-ups are working in digitising the supply chain to help bankers lend intelligently. We need a dedicated sandbox where both public and private sector banks can be offered incentives to work with start-ups for building and piloting innovative agritech and fintech solutions to scale them faster.

- 2. Develop climate-finance products:** India is amongst the most water-stressed and climate-vulnerable countries in the world. A large part of Indian arable land can go dry in next decade or so if we do not pay attention. Solving climate risks needs a holistic, collaborative approach through policy intervention, investment and innovation.

The Indian agri tech community in the last few years are trying to address climate change risks by building climate-predictive data-driven models and devising solutions for resource conservation and reducing carbon footprints. However, why would farmers adapt these practices? One option is to build credit and insurance products that offer incentives to farmers to adopt climate resilient solutions. The incentives could be in the form of interest subvention and reduction in premium on loan and insurance products respectively. Regulators need to work with banks, insurance companies and start-ups to conceive such products.

- 3. Dedicated cell for agritech start-ups:** Agritech startups often struggle to reach out to government officials and policymakers, specifically at the state level. For example, the current laws do not recognise agri-input e-commerce platforms for the purpose of distribution and storage of agri inputs like seeds, fertilisers and agrochemicals. Start-ups in this space often find it difficult to expand their footprint because of lack of regulatory clarity on agri input e-commerce.

A dedicated cell at the state level would go a long way in facilitating continual dialogue between the state governments and the start-ups. Likewise, there are many other areas where such dedicated cells under the aegis of central or state governments can play a proactive role to help agritech start-ups. Three such areas are:

- (a)** State governments through state agricultural universities and research centres can support start-ups for pilots and validation of technology. The validation from universities will help start-ups in course correction as well as in approaching the potential customers.
- (b)** State governments can also play an important role in training and capacity-building of village-level entrepreneurs who can act as channel partners for agritech start-ups to make their innovations accessible to farmers in the state.
- (c)** Another area that this cell can focus on is building high quality research papers related to innovations happening in India by agri start-ups. There are multiple areas that need in-depth research, for example:
 - How innovations are impacting the farmer's income?
 - What are the challenges in farmer adoption of new-age technologies?
 - What innovations in financing are needed to improve lending to small-holder farmers?
 - What are the challenges in creating a pan-India market for agri commodities?

There is a long list of research areas and many unproven hypotheses. Lack of well-researched data makes decision-making sub-optimal for policymakers, investors and entrepreneurs. The dissemination of research and knowledge can be

done through workshops, reports and events as appropriate.

- 4. Centre of excellence for data science applications in agriculture:** The secret sauce of data-centric models in agritech lies in building machine learning and artificial intelligence (AI) models, which can predict developments like weather, pest attack, harvest and crop yield, commodity prices, in advance with more accuracy. AI models also provide immediate, low cost, affordable, portable and accurate solutions for measuring soil moisture, nutrition, crop health and quality assessment.

One of the biggest challenges in scaling AI models is lack of access to quality data. Most start-ups spend disproportionate effort and time on data collection rather than on data modeling. The government can attempt to build a public data repository by collating already existing datasets that lie with government departments, research institutions and universities.

- 5. Piloting Agristack:** Agristack is conceptualised as a public digital platform for ready, authenticated and almost instant access to farmers. This platform can be the hotbed for driving disruptive innovations in agricultural sector. The government has already initiated work on AgriStack, under IndEA framework, called IndEA Digital Ecosystem in Agriculture (IDEA). The Ministry of Electronics and Information Technology along with the Ministry of Agriculture are working on it.

Building AgriStack has to be a collaborative effort involving governments at the centre and state levels and innovators. Use of technology in developing Agristack can optimise time and cost involved. There is clearly a one-time investment in building this and then there will be a recurring cost to maintain and continually update it. Unlike IndiaStack, AgriStack will have dynamicity, given multiple crop cycles and changes in farm boundaries over a period of time.

It is time for piloting multiple Agristack to formulate, test, design and build architecture; guidelines and modus operandi. Start-ups working on building digital tools like satellite imagery and drones for mapping farms can develop relevant tech models. Ground verification support for the purpose of identifying, validating and tagging cultivators to farm needs will be provided and validated by the state governments.

The utility of AgriStack, once developed, can be tested by inviting partners, including banks, insurance companies, agri input and output companies and anyone who wants to build first- and last-mile access to farmers. It is imperative that we need to make the platform open-source to maximise its utility. The extent of access needs to be discussed and decided jointly with the respective state governments.

- 6. Building incubation support for rural India:** The significance of agribusiness incubation centres in facilitating an ecosystem conducive for the growth of agribusiness enterprises is recognised worldwide. In India too, the work done by incubators such as CIIE.CO, Indigram Labs, A-Idea Naarm, Pusa Krishi, ICRISAT, Villgro and others is exemplary in nurturing hundreds of agri entrepreneurs. It is now time to build rural incubators to motivate and support rural youth in building their own entrepreneurial models.

The state agricultural universities and Krishi Vigyan Kendras can be roped in to build such incubators. The government should lay down guidelines for selection of incubators, locations and provide support for training the incubator managers with focus on rural areas. Rural incubation models will truly democratise the start-up ecosystem in India.

- 7. Catalytic funding for young agritech start-ups:** Though the government is already investing in multiple start-ups through government-backed incubators, we still need a high-velocity catalytic fund for investments at the seed stage. There is enough depth in the ecosystem to absorb seed funding to the tune of ₹100 crore per annum, supporting about 50 to 100 start-ups every year.

This will not just accelerate the proofing of concept, product and market development, but will also facilitate the pipeline for flow of capital into the agritech ecosystem for late-stage funds.

- 8. Incorporating agri entrepreneurship courses in agricultural education:** The agritech sector needs top quality talent for scaling the models. There is a need to nurture talent at the college and university levels. This can be made possible by incorporating courses on entrepreneurship in all agricultural streams.

Given huge application of data sciences in new age models, a few courses on data analytics and machine learning could also be made part of the curriculum. Internship with agritech start-ups could be another way to familiarise young graduates with start-up culture.

- 9. Platform for start-up—FPO-MSME connection:** Evolution of farmer producer organisations (FPOs) in India is at a nascent stage. FPOs are filling important gaps in the supply chain with focus on aggregation of farm produce and linking farmers to markets. There are about 7,000 FPOs in the country, but only few have reached scale and commercial viability. To be successful, FPOs need support in the form of financing, credit rating, capacity building, warehousing and primary processing.

Start-ups are best placed to build tailor-made solutions for FPOs in all these areas. We are

already seeing many start-ups orienting their business models to cater to the needs of FPOs. The handshake between farmers and agritech entrepreneurs will create unique win-win collaborative business models and FPOs have a huge role to play in making this happen.

Top institutions like the National Bank for Agriculture and Rural Development (NABARD) and the Small Farmers Agribusiness Consortium (SFAC) can take the lead for coordinating partnership between start-ups and FPOs.

Likewise, there is hardly any interface between MSMEs and start-ups despite the fact both agri input and post-harvest supply chains are dominated by MSMEs. Many MSMEs can optimise their cost of sourcing and improve value addition in partnership with agritech start-ups. Governments can facilitate dialogues and partnerships between FPOs, MSMEs and start-ups.

10. **Tech integration in export linked supply chains:**

India's exports of food and agricultural products are worth about \$30-35 billion per annum. For India to meet its export target of \$100 billion, it needs to integrate technologies related to quality assays, certification, traceability, food safety and price discovery for building access and trust among importers.

There are enough tech solutions developed by start-ups that can solve challenges faced by the exporters. Agencies like the Agricultural and Processed Food Products Export Development Authority (APEDA) can facilitate continuous interactions, dialogue and pilots between the start-ups and exporter of food products.

The above ten-point policy prescriptions can be a game changer for the Indian agritech sector, which in turn can benefit millions of farmers. It also complements government's agri reform agenda. The multiplier effect of scaling agritech on rural economy could be huge in terms of creating jobs and providing livelihoods to rural youth. Marriage between agri reforms and innovations is the perfect recipe for the longevity and sustainability of Indian agriculture.

Venture capital

Investors have pumped in close to \$2.5 billion in upstream agritech deals over the last decade and the momentum has started to pick up. In all probability, agritech will continue to attract venture capital in the range of \$500 million to \$1 billion on an annual basis in the foreseeable future.

Sector-agnostic investors are rapidly growing their participation, signifying the sector's attractiveness. There are many generalist funds entering the space. These include Arkam Ventures, Sequoia, Mirae Asset, Lightspeed Ventures, Elevation Capital, Avaana Capital, Prosus Ventures, ABC World Asia. The sector is also witnessing a new type of corporate strategic

investments from e-commerce giants like Walmart and Alibaba, which see food and grocery as a critical part of their business. Seed investment from incubators, angels and micro venture capitalists is also picking up.

Bottlenecks while serving rural communities

The pandemic reiterated the resilience of India's agricultural economy, which is demonstrating growth when other segments of economy faced turbulence. It also opened up multiple new business models of rural entrepreneurship.

Agri-tech offers hope and optimism in catalysing many unexplored models of rural entrepreneurship. There are at least 15 such models that can come alive on the growing agritech prowess. These models have the potential to create millions of jobs in villages, making rural economy robust and pandemic-agnostic. The models are the following.

1. **Farm-gate value-creators:** Farm gate value addition is a huge opportunity in waiting. Farmers are leaving too much in the fields for others to make money by selling crops as commodities rather than products or brands. The opportunity to value-add through simple processes like sorting, grading, packing, milling, extraction, pulverisation, dehydration, cooling, freezing can remunerate farmers 30-50 per cent over and above farm gate price.

This is demonstrated by multiple innovators through building farm-level infrastructure for sorting, grading packing of vegetables, fruits and staples. Examples are Farmlink (Innoterra group), Kamatan, Waycool, Ninjacart, DeHaat, Agribolo, Impagro and Agrowave. Some of them have demonstrated secondary processing innovations like S4S technologies (solar conduction drying of vegetables), Our Foods (micro processing units such as dal mill, flour mill) and Desai Fruit Ventures from Innoterra group (packhouses for bananas, other fruits).

Evidence exists of positive impact of such near-farm value addition on job creation. The success of packhouses and controlled atmosphere storages for apples from hilly areas of Himachal Pradesh, Jammu and Kashmir in creating local jobs is noteworthy.

The above models need investment in physical infrastructure, which can vary from a few hundred to few thousand dollars. Some of it can be funded by government schemes (like the recently-announced Agri Infra Fund) and some through private investment, which even village-level entrepreneurs are willing to make as long as there is demand visibility.

2. **Micro-warehousing:** A significant part of India's warehousing capacity is dominated by large warehouses, typically catering to traders and processors. The majority of farmers with a few tonnes of harvested produce finds it difficult get a warehouse and thus ends up selling the produce

immediately after harvest when prices are usually the lowest.

Decentralised, affordable and accessible warehousing for farmers coupled with the option for post-harvest financing is critical to improving farmers' income. It will also have a soothing effect on volatility of commodity prices to the benefit of farmers as well as MSMEs who are usually at the receiving end of price shocks.

The work done by the likes of Arya Collateral, Star Agri, Ergos, Apna Godam, Whrrl in enabling farmer access to warehouses along with creating post-harvest digital layer for facilitating financing and market linkages can create new models of rural entrepreneurship in warehouse management and allied services.

- 3. Digital soil doctors:** For a sustainable agri supply chain, the supply chain paradigm has to shift from 'farm-to-fork' to 'soil-to-stomach' continuum, with soil at the centerpiece. Indian soil health needs immediate attention to meet productivity challenges. India definitely needs more soil labs than path labs.

Soil diagnosis, usually done with innovative techniques like sensors, IoT devices and proprietary algorithms, can take soil labs to farmer fields. This can drive accurate and timely correction in NPK ratio and other micronutrients to keep soil healthy. Rural youth can become soil doctors by training themselves in using portable kits developed by Krishitantra, SenseGrass, Nordetect and EasyKrishi. They can buy, rent, lease or even work on revenue sharing models.

- 4. Drone-preneurs:** Drone application in Indian agriculture is still negligible. It is time to promote the use of drones in agriculture for data collection, pesticide spraying, weed detection and crop health monitoring.

Drone applications in agriculture present opportunities worth at least a few billion dollars, but the number of operators are quite limited (3thi, Thanos, IoTechworld, AgriCopter). For mainstreaming drone use, we need to train rural youth in flying drones. The certified drone-preneurs can, in turn, be employed by government agencies, agrochemical companies and banks.

- 5. Quality assaying as a service (QUAS):** Most emerging digital quality assaying models by companies like of Lateral Praxis, Agnext, Intellolabs, Agricx, qZense and InfyuLabs that use smartphones, spectrometers and optical cameras for commodities continue to be B2B, targeting aggregators and processors.

For directly providing quality assaying services to farmers, we need an army of trained QUAS-ians on the ground, who can collect commodity data using digital tools and provide almost-instant

reports to farmers for a fee. QUAS-ians can also provide these services to collection centres and aggregation points in mandis, warehouses and processing units in their catchment areas.

- 6. Silage stations:** Despite India being one of the largest producers of milk, the milk productivity level (at about 1,600 litres per year) continues to be low. One of the reasons is lack of proper cattle nutrition, specifically green and dry fodder. India is short by about 36 per cent in green fodder and by about 11 per cent in dry fodder. Fodder availability goes further down in summer, affecting milk production. This can be addressed by feeding silage (fermented fodder with moisture) to cattle. To meet the growing demand for quality cattle nutrition, India needs more silage stations.

Silage is prepared from corn, grass and cereals that are locally available. As silage is a bulky product, the production needs to be decentralised. Many dairy companies like MilkLane, Mango Dairies and organisations like BAIF are working on silage solutions.

- 7. Mobile picking stations:** Picking up agri produce at farms is still not common. Farmers go to the nearest market yard to sell the produce. Farmers incur the logistics cost and usually end up selling in the mandi at the prevailing price as the cost of bringing produce back to village is prohibitive.

Farm pick-up models are the need of the hour and typically require developing real-time communication channels with farmers, estimation of farm produce, harvest schedule, route scheduling and price forecasting. With government easing regulations for GIS mapping, rural roads can be mapped with much more accuracy, making farm pick-up solutions more feasible.

These models are still in process. Only a handful of start-ups like Agrowave, Apna Godam, Ergos have attempted these. Such models can scale with participation from local youth, who can be empowered with technology tools to work with farmers in enabling efficient pick-up and transportation from villages.

- 8. Water management specialists:** Efficient use of water for irrigation will be critical for sustainability of agriculture. Indian agriculture's ability to pass the 'water stress test' depends on the adoption of solutions for conserving water. Fortunately, there are enough tech tools developed by startups like Agsmartic, Fasal, SoilSense, Yuktix, Cultyvate, SatSure and Satyukt to estimate surface and root zone moisture, and accordingly, advise farmers on scheduling irrigation.

Solutions around irrigation controller (Flybird), irrigation guns (Agrirain), borewell charging (Urdhvam), hydrogel (EF Polymer) need to go mainstream to improve water use efficiency. Again, we

need trained manpower from the villages who can partner with innovators to take these solutions to the farmers.

9. Cooling as a Service (CAAS): Farm-level cooling solutions are needed for perishable products like vegetables, fruits, fish, flowers and milk. The fisheries sector was a major victim of last year's lockdown as fishermen could not get ice for ice-boxes in time. Affordable and distributed cold stores at the point of collection is the need of the hour, be it bulk milk coolers or cold rooms for vegetable, fruits, eggs and meat products.

Though many start-ups like Promethean, Ecozen, Tan90, Tessol, Rukart and New Leaf Dynamics are working on modular designs, the challenge is to fill the full capacity where the role of the local ecosystem, including FPOs and NGOs, becomes important as without their participation, utilising and maintaining cold chain facilities is not efficient. This opens up opportunity for village-level entrepreneurs (VLEs) and village organisations to provide cooling as a service to farmers. The investment could range from a few thousands to a few lakhs with a payback period of two to three years.

10. Pollination as a Service (PAAS): Bees play a critical role in cross pollination in horticulture, oilseeds, fodder and pulses crops. However, the density of bee population in Indian farms is declining due to climate change and pesticides. There is an opportunity to promote PAAS, not just for making honey but also to build bee boxes for renting. A trained beekeeper can easily maintain up to 500 bee boxes. Scientifically designed bee-boxes with sensors, optical cameras, IoT devices and GPS to monitor and track bee colonies can make the maintenance and monitoring of bee boxes easy for PAAS providers.

11. First and last mile hustlers: Many agribusinesses and agritech models need field support for first and last mile access the farmers. These include:

- Demand aggregation and doorstep delivery of agri-inputs for companies and e-commerce platforms.
- Farmer onboarding, KYC checks and loan recovery for banks as well as agrifintech firms.
- Ground verification of data to complement data collected from satellite imagery.

There is a growing breed of start-ups that are training people to connect with farmers. VLEs trained by Hesa (called Hesaathis), Frontier Markets (women entrepreneurs called sahelis) are providing the first- and last-mile access to farmers using 'digital assist' or 'phygital' models.

12. Insurance agents: While the government is pushing for deeper penetration of crop insurance under the Pradhan Mantri Fasal Bima Yojna, a huge opportunity awaits to provide micro or parametric insurance products to farmers. Weather

insurance, for example, is the obvious product specifically in the context of improving availability and sophistication of tools to provide accurate data for underwriting of insurance products.

The penetration can improve once the farmer starts trusting the product as well as insurance provider. The product has to be simple and easy to comprehend for the farmers. The expertise is needed in designing and distributing the product to rural communities. The work done by IBISA and Gramcover in distributing multiple insurance products through locally-hired channel partners is exemplary.

13. Vet services at farmer doorsteps: The quality of veterinarian services for cattle, poultry, fisheries and aquaculture has a lot to be desired. A typical farmer's needs include animal vaccination, disease management, artificial insemination, lactation management (in case of cattle), and managing dissolved oxygen (in case of aquaculture), temperature, humidity and carbon dioxide emission (in hatcheries and broiler farms).

Innovators like Milklane (Innoterra), Livestoc, Pashushala, Moofarms, Dvara Dairy are developing platforms that can empower local vets with tools for disease detection, artificial insemination and cattle insurance. For these models to scale, we need qualified and trained veterinarians, who are in short supply—less than a lakh vets are there in India. We have 300 million cattle population, and if we add the population of broilers, layer birds, goats and sheep, the number is overwhelming. We need not just vets, but a large number of para-vet staff to execute diagnostic tests and artificial insemination services. This opens up a huge opportunity for rural women and men, who can be trained to provide some of these services.

14. Farm equipment management services: Indian farms need mechanisation in the wake of disappearing and expensive labour. We need equipment for urea deep placement (Distinct Horizon), tools for weeding, spraying, tilling, seed treatment, soil pulverization, land leveler (VST Tillers, Shaktiman, Toolsvilla, Balwan, X-Machines); specialists for tractor and equipment repair; agents for sale, purchase and loans for first-hand as well used tractors (Tractor Junction, Mera Tractor).

These models need intensive training to build technical expertise in villages. Such expertise exists in the informal sector and in pockets like Karnal and Vadodara, which are famous for developing farm tools. The existing informal media can leverage digital media developed by agritech entrepreneurs for demand generation as well as efficient delivery of such services.

15. Management services for FPOs: The government has been promoting FPOs for many years now through various policy initiatives, but the

expertise needed to manage and scale FPOs is scarce. Talent for financial controls, governance, ERP development, human resources management, value addition, branding, sales and distribution for such rural-centric businesses needs to be developed in rural areas only.

It is unlikely that talent from places like Mumbai, Delhi or Bengaluru is going to move to places like Sangli, Saharanpur or Kolar. The only viable option is to train people from the local ecosystem through short-term courses. It is much easier now than it was a year ago with increased adoption of digital education models during the pandemic. The trained manpower can provide professional services to FPOs and other rural enterprises.

There are multiple other areas like quality milk collection and procurement (Milklane, Promethean); fruit picking, sorting and grading (Sickle Innovations); digitisation in value chains like silk (ReshaMandi), jute (Borlaug Web Services) and spices (Krishikan, Masala Market); waste to energy/food/feed models (String Bio, Krimanshi, Takachar). All these also can create job opportunities in villages.

Each of the 1,000 odd existing new-age innovative companies can create on an average 100 micro-entrepreneurs within three to five years of their scale-up journey and each micro entrepreneur can create about 10 direct or indirect jobs in villages. This adds up to creation of about a million livelihood opportunities in rural areas. More than the number, these opportunities can bring stability, learning, skills, pride and dignity to our rural youth.

As the number of agritech innovators multiply and go from 1,000 to 10,000 in the next 10 years, the number of new livelihood opportunities will balloon to more than 10 million. There are not too many sectors that have such multiplier effect on job creation.

Most of these opportunities will be driven by private capital from entrepreneurs, corporates and venture capitalists without putting pressure on public finances. Needless to say, the positive impact of innovations in terms of improving farmer income, climate resilience, reducing food loss and diversification from crop income to ancillary industries will further add to the resilience of rural economy. Public intervention through enabling policies for skilling rural youth, rural incubation, affordable debt and catalytic funding can further boost rural entrepreneurial models.

The marriage of agritech innovations with rural entrepreneurship will unlock the true value of rural economy, creating millions of jobs and help India realise the dream of \$1-trillion agrifood economy in not-so-distant future.

As far as fresh agriculture graduates are concerned, this is the best time to explore entrepreneurship in Indian agriculture, which is driven by improving public ecosystem and inflow of private funds. ■



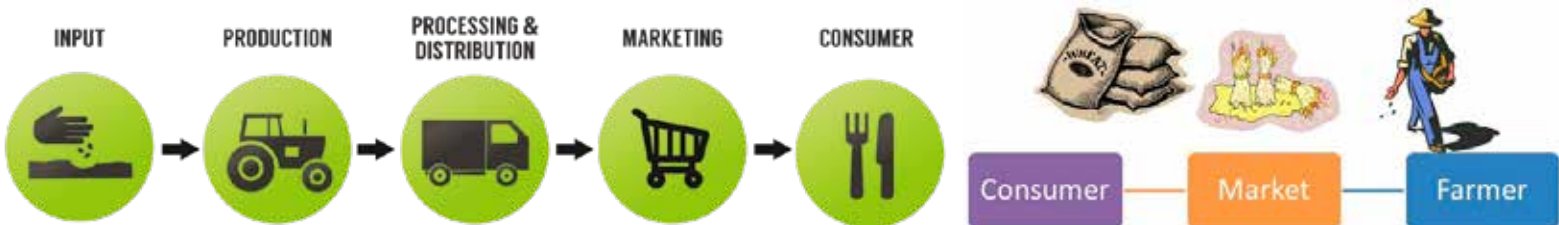
Hemendra Mathur has over 25 years of experience in venture capital, private equity, management consulting and investment banking in South Asia, Europe and the United States. He has supported over 200 agri start-ups in the last 10 years as mentor, advisor, investor and board member.



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Post-Harvest & Supply Chain Technology



Extending Shelf Life of Fruits, Veggies

Promoting shift to organic farming

An agriculture engineer with a masters degree in food science, Deepak Rajmohan worked as a food scientist in the United States, before quit job and moving back to India to work on solutions to the food waste problem. Co-founder Vijay Anand has over 13 years of experience.



Deepak Rajmohan

Co-founder
Greenpod Labs, Chennai
greenpodlabs.com

Challenges

We have been facing challenges in finding lab and equipment resources while building our R&D capabilities. While scaling up our operations, it has been hard to find the right contract manufacturers for large-scale production. Building a team and finding the right talent for R&D and operations have been quite hard.

Focus area, stage of development

Our product is focused on extending the shelf life of fruits and vegetables. We are in the pilot to commercialisation stage for our product for mangoes, tomatoes and strawberries. We are in early development for a few more crops.

Problem

Despite India being the second largest producer of fruits and vegetables, 40 per cent of it is lost before it reaches consumers. The economic loss of food waste costs the country \$12 billion annually. The primary causes of the loss are poor storage and transportation facilities.

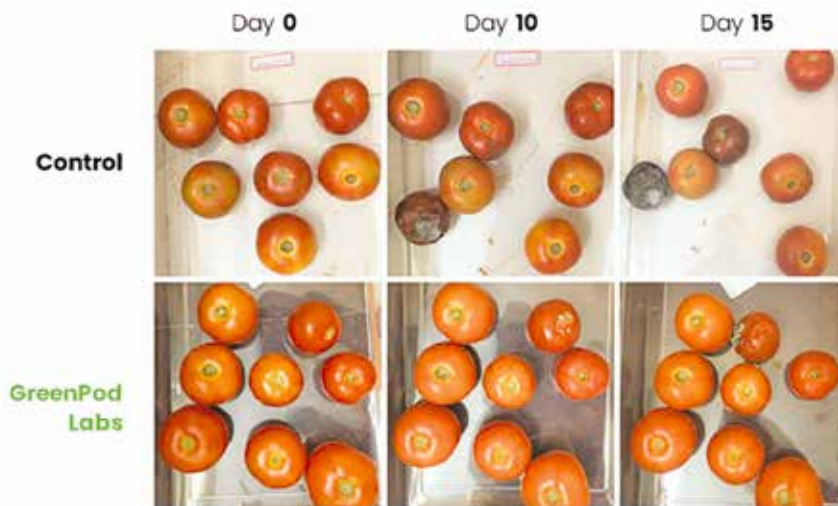
Product

We have developed an active packaging sachet that can extend the shelf life of fruits and vegetables. The product comprises nano-encapsulated plant extracts that can naturally activate a defense mechanism within a fruit or vegetable to slow down the ripening rate and minimise microbial attack. When the volatile active ingredient is released, it slows down the ethylene biosynthesis pathway and restricts microbial growth of fresh produce without any expensive technology like refrigeration and harmful chemicals.

Competitive advantage

- A proprietary formulation and delivery model
- Use of all-natural bio-active compounds to activate the defense mechanism
- A cost-effective solution with easy adoption throughout the supply chain
- Customisation based on volume, days, fruit/vegetable and variety





On an average 40% – 80% increase in shelf life at 35°C



On an average 30% – 60% increase in shelf life at 35°C

Hindrances

During early product development, we faced challenges in developing a solution that worked consistently and provided functionality both in a controlled environment and at the customer end. Developing a single product for one crop that can work across different varieties was also a challenge.

Marketing strategy

We are targeting B2B customer segments like farmers, farmer producer organisations, distributors, middleman, retailers and e-commerce channels. Our revenue generation plan is to work directly with these B2B customers.

Our distribution channels include direct sales to supply chain players and other stakeholders; packaging and crate distribution channel; and fruit and vegetable distributors and exporters associations.

BIRAC support

BIRAC has provided the opportunity to access its grant programmes. We also got connected with several mentors to help us with product development and scaling up.

Key milestones to cover in next few years

- Having an impact on smallholder farmers to raise their annual income by 30 per cent
- Cutting down post-harvest losses for fruits and vegetables by half in the next five years



Achievements

- Most Scalable Start-Up Award from C-Shark Tank
- Among 25 agritech start-ups under the CISCO Agritech Challenge
- Amongst 30 start-ups to watch by INC42 Media.
- Winner of Climate Launchpad, India Regional Finals
- First Runner up of Grand Idea Challenge of Indian School of Business, Hyderabad
- Winner of Agritech Innovation Challenge 2 organised by Indian Agriculture Innovation (IAN) Network and Social Alpha (Tata Trust and Bill Gates & Milinda Foundation)
- Milken Motsepe Prize finalist

Mandi on Web, SMARTPHONE

Saini has more than 13 years of experience in agriculture. MandiGate was started in 2016 to get better consumer quality and viewing prices for farmers, and to revolutionise sourcing and selling of fruits, vegetables and staples. It focuses on agricultural produce supply chain and is now at the minimum viable product (MVP) stage. It creates a mandi on the web and mobile marketplace for farmers, retailers and consumers.



Yogesh Saini
 Founder
 MandiGate Pvt. Ltd.
 New Delhi
 mandigate.com

Problem & solution

Problems in the trade of agricultural produce have remained underserved by technology so far because of the complexities of the trade, which includes long chain of intermediaries, perishability, opacity, price volatility, liquidity and lack of standardization; trade barriers of various kinds—trust and quality assurance apart from legal and regulatory aspects; insufficient information on product and service availability; infrastructure bottlenecks

and the lack of right knowledge at the right time at the right place.

Low availability of people who can understand the finer nuances of both fresh produce trade and modern technology platforms, and have the requisite match-making skillsets to build something new for such businesses using technology is also a problem.

Our aim is to link farmers to the market and consumers using technology to raise efficiency and cut down losses across the supply chain. Both farmers and our customers have access to the virtual marketplace with transparent pricing to get the best deal. Our vision is to emulate the Amul model to aggregate farm produce in India and help build a sustainable ecosystem benefiting both producers and consumers.

Operational since October 2018, our company started working to strengthen fruits and vegetables trade by offering producers, wholesalers and retailers with integrated supply that is efficient and responsive, and leads to a long-term partnership

MandigateFruits | Online Store

 <p>Banana ₹47.00 Buy Now</p>	 <p>Apple ₹135.00 Buy Now</p>	 <p>Orange ₹50.00 Buy Now</p>	 <p>Guava ₹230.00 Buy Now</p>
			



aimed at reduction in waste for fruits and vegetables. The vision had its origins when I was dealing with milk supply chains. If a milk producer is being entitled to get a pie of 75-85 per cent of the maximum retail price, why cannot this happen to farmers or wholesalers dealing with agricultural produce? The produce reaching buyers a higher rate leads to continual inflation.

Hindrances

The farmers and small-street vendors are not smart-phone savvy. Availability of channel credit service was another hindrance while developing technology. Convenient availability of funds is an issue as well.

Strategy

Technology has big role to play in our digitised supply chain.

Demand aggregation: An alternative to the wholesale markets where demand across multiple retail points is aggregated on a technology platform enabling large

volumes of produce to move across country at low costs.

Demand prediction: The system predicts demand for various stock keeping units on the basis of parameters like historical demand, season, day of the week, weather and price.

Trust: The system builds a trust rating of producers on the basis of their produce rejection rates. It generates a trust rating for retailers as well based on their payment schedule and produce rejection rates.

Produce improvement: Technology-enabled feedback to the grower allows faster product improvement cycles.

Remote view: Remote view of the produce allows the retailer to take buying decisions.

Fair price, quality consistency, produce assortment and convenience are the value proposition for retailers, while fair price, timely payments and business growth are the value propositions for growers. We just bridge the demand- and feedback-related information gap.

For backward integration, we want to map farmers and provide them the seeds plus consultancy for potato crop in the next season and while on harvesting time, we want to encourage them to store the goods in cold store and collateral financing will be facilitated to sell at an opportune time. For that we will engage in process harmonization, contract farming, and sorting, grading and processing of produce. We will also ensure a robust backend in logistics and distribution.

BIRAC support

BIRAC has offered us a platform to incubate us, and has provided us with networking support in the ecosystem.

Key milestones to cover in next few years

We are planning to appoint 50 more channel partners for distribution. We want to test the mobile app among the newer 2,000 retailers in fiscal 2022-23, and then expand to tier-II north Indian cities. ■

Achievements

- Finalist among Top 20 Start-ups in northern zone in English news channel ET NOW 'Leaders of Tomorrow' Season 8
- Among Top 10 Agri Start-ups in India in Indigram Lab Foundation's BioNest Cohort-1 (2021)
- Among Top 500 Global Start-ups in FTxSDG challenge by Financial Times
- Signed MoU with Haryana government's farmer producer organisations consortium for direct procurement from farmers

Non-Invasive Quality Analysis of Agri Produce

A biotechnologist and an agriculture enthusiast, Alphonse Dhas Antony has been working on portable sensory applications for the agricultural industry since his graduation days. He met the other founding team members of the company at the NIIT University, Neemrana, Rajasthan. Rahul Kumar and Abhinandan Bhargava have computer science and engineering background, while Varshnee Raj is an electronics and communications engineer.

They applied for grants that support ideas for solving problems faced by relevant industries. With support from technology business incubator iCreate, the start-up was incubated in Ahmedabad to bring out a proof of concept. The company has worked with some of the biggest agricultural conglomerates and similar stakeholders to streamline quality control processes.



Alphonse Dhas Antony

Co-founder-COO
Raav Techlabs
New Delhi
raav.in

Focus area, stage of development

Our solutions are for post-harvest quality management. These can be used by all stakeholders of the agricultural supply chain to enhance traceability, maximise sampling and ensure movement of good quality produce. We are currently at the scale-up stage where we are catering to orders for quality analysis of agricultural raw materials like wheat, grapes, apples and more.

Problem

The following are the interconnected problems of the agricultural value chain that we aim to solve:

- There is a lack of technology to access the internal quality of agricultural produce rapidly. Available technologies are expensive, consume time and use a lot of laboratory resources and manpower to analyse a small fraction of the sample.
- Rapid, non-invasive solutions to detect nutritional data and adulteration to curb problems are a need.
- Rejection rates in the export industry are rising as the commodities do not match expected quality standards in international markets.
- Food is being wasted due to poor logistics and storage management.
- Methods for farmers to access quality and approach alternate market opportunities for a better valuation of produce are absent.

Solution

We have developed non-invasive quality analysis solutions for various agricultural commodities like oilseeds, cereals, pulses, spices, fruits and vegetables. We leverage the technology of spectroscopy to quantify



Fruit analyser AoNIR

nutritional parameters like oil content, protein, sweetness and perishability by just scanning the sample and getting the results within seconds. Hence, the use of traditional laboratory practices that take hours and uses exhaustible chemicals for quality assessment is done away with.

Our solution offers remote access and multiple parameters in a single scan; detailed analytics of scanned or saved data on cloud; demographical representation; productivity management (assuming, our product is deployed at various stages of production); and sharing of monthly and annual reports in PDF and other formats.

AoNIR is a portable, non-invasive and non-destructive molecular scanner to check internal quality of fruits and vegetables. It can test parameters like brix, acidity, moisture, shelf life, optimum harvest time and ageing.

NIRSpec is a portable, non-invasive and non-destructive internal quality testing device for grains, pulses, oil seeds, etc. It can handle the task in under 30 seconds and requires zero consumables. It can test parameters like protein, gluten, moisture, shelf life, oil content and adulterants.

Challenges & hindrances

As most of our solutions are deployed at produce collection centres, which are remote locations across India, customer support and servicing is a challenge. We aim



The founding team. From left to right: Varshnee Raj, chief technology officer; Abhinandan Bhargava, chief marketing officer; Rahul Kumar, chief executive officer; Alphonse Dhas Antony, chief operations officer.

to maximise remote servicing and streamline our support by making specific hubs where the equipment can be shipped for reducing the time taken for fixing problems on field.

Developing remote sensing solutions is an iterative process. It involves developing multiple designs, electronics and algorithms essential for all hardware-based solutions. It took us three years of intensive research, including more than 20 designs and 15 printed circuit board iterations, for stabilising the product, which is economical, robust and easy to use.

Advantages

Comparing our value to conventional forms of quality analysis, we save up to 90 per cent of costs incurred by our clients on quality control management. Furthermore, we digitise the entire data platform that helps clients save on logistical and inventory losses.

BIRAC support

BIRAC's BioNest programme at Indigram Labs Foundation 2021 helped us improve our core business principles. Key insights on alternate pricing models, funding avenues and understanding of key customer problems were some of the highlights of the programme.

Key milestones to cover in next few years

In the next three years, we plan to cover more than 30 commodities, deploy over 1,000 devices and assure the quality of produce in more than a million farms. ■



Grain analyser
NIRSpec

Achievements

- Best product among two national and three international competitors tested and validated by a leading agricultural conglomerate
- Pitched our solution to Prime Minister Narendra Modi and Benjamin Netanyahu at the India-Israel Innovation Interaction held at iCreate, Ahmedabad, in 2017

Gramik on Smartphone, ERP Solution for FPOs

The company was founded by computer engineer Akshay Dixit, CEO; electronic and telecommunication engineer Sagnika Chakraborty, head of design; Ashish Mhalankar, head of mobile technology, who is pursuing a Master's degree in cloud computing; and software engineer Vaibhav Shelke.

It offers tech solutions to empower stakeholders in the rural agrarian ecosystem. It works closely with farmer producer organisations, agribusinesses and their associated smallholder farmers for optimising their procurement process and farm operations through web-based software solutions and smartphone-based platforms. 'Vesa' meaning 'small and marginal farmer' in Sanskrit and 'togo' means integration or aggregation in Japanese.



Akshay Dixit

Co-founder-CEO
Vesatogo Innovations
Nashik
vesatogo.com

Focus area, stage of development

We focus on software as a service (SaaS) in agritech. We are in the early traction phase. Our supporters and partners include Digital Impact Square, a TCS Foundation initiative, TATA Motors, UnLtd India, Indigram Labs Foundation, Sahyadri Farmers Producer Company Ltd., Pune International Centre, Y Combinator, Maharashtra State Innovation Society, Agri-Elevate by Samunnati and Cornell Maha60.

Products

Gramik is a smartphone-based market linkage and aggregated logistics platform. It shows market trends (rates, demand, etc.) to farmers, allowing them to take smart and informed decisions and ensuring higher profits. Aggregated logistics services (pay-per-use) ensure reduced post-harvest expenditure. Vehicle owners on board have scope of better business opportunities. Marketplaces also benefit as the process is more transparent, democratised and optimised.

For farmer producer organisations (FPOs) and agribusinesses, we offer **FPO (agribusiness) management system**, a customised SaaS-based enterprise resource planning (ERP) software solution. Day-to-day operations can be managed in three broad buckets: pre-harvest, post-harvest, and market linkage and sales

management. It offers an end-to-end solution to manage all activities from seed to plate. It is an integrated hyperlocal e-commerce platform to enable better reach to end customers.

Challenges

Challenges included adoption of technology by the agrarian community, lack of smartphone penetration and supporting infrastructure at the grassroots level, and difference in paying capacities and regional language barriers across geographies.

Marketing strategy

We offer our services on a subscription basis. We have a pay-per-use structure for FPOs and agribusinesses, a fixed, one-time deployment cost and recurring subscription costs. The billing cycles are adjusted depending on local situation. We have partnerships with FPO-supporting bodies like the Small Farmers Agribusiness Consortium (SFAC) and the National Bank for Agriculture and Rural Development (NABARD), and with the central government and states.





In fiscal 2021-22, we enabled movement of 2.5 lakh metric tonnes of produce amounting to ₹60 crore through the Gramik platform. There are over 3,500 farmers using the app. The FPO management system has enabled transactions worth over ₹650 crore and is deployed with renowned FPOs like Sahyadri Farms, India's largest farmer collective. We also plan to cover Maharashtra in its entirety and connect with the state government to implement our system under the State of Maharashtra Agribusiness and Rural Transformation (SMART) project in small and medium FPOs and enterprises. We have partnered up with FarmSetu Technologies, a startup working on pre-harvest management, to develop a full stack ag-tech platform.

BIRAC support

BIRAC support has offered us access to ecosystem partners and expert mentors.

Key milestones to cover in next few years

Fiscal	Revenue estimate	Gramik deployment/revenue target	FPO management system deployment/revenue target
2022-23	₹5 cr	10 partner organisations/ ₹2 cr	50 clients/₹3 cr
2023-24	₹15 cr	20 partner organisations/ ₹7 cr	150 clients/₹8 cr

In the current and next fiscals, we plan to integrate the agronomy platform with Gramik to provide allied services to the on-boarded farmers; increase geographical presence to adjoining states of Maharashtra and the rest of India; explore African and European markets; and deploy at least 5 systems overseas. ■

Achievements

- Akshay Dixit was amongst the 175 representatives from shortlisted start-ups to interact with Prime Minister Narendra Modi and Commerce and Industry Minister Piyush Goyal on 15 January 2022 at the first ever Start-up India Innovation Week
- National Start-up Award 2021 in the special category of agriculture post-harvest
- Emerging Social Enterprise 2021 Award by TiE Hyderabad, for contribution to the rural economy during the COVID-19 pandemic
- Best Indian Social Enterprise 2019 by Action for India
- Among Top 50 start-ups of India Innovation Growth Programme (IIGP) 2.0

Formulation to Remove Pesticides, Kill Microbes

The company was incubated at the NCL Innovation Park, Pune, based on the one of the patents of Asmita Prabhune, alumnus scientist at the National Chemical Laboratory (NCL). She has over 30 years of experience with over 125 international publications and 28 patents to her credit.



Asmita Prabhune, PhD

Co-founder-Director
Green Pyramid Biotech
Pvt. Ltd., Pune
greenpyramidbiotech.com

Problem

Most agriculture produce involves the use of large quantities of toxic and carcinogenic chemicals and pesticides that cannot be removed with water. Direct and indirect consumption of such products, i.e. fruits and vegetables, causes severe health problems. It is estimated that acute pesticide poisoning affects 3 million and accounts for 20,000 unintentional deaths per year around the world, with 99 per cent of the fatalities believed to be in developing countries. In addition, the unhygienic handling of agricultural produce introduces plant and human pathogens.

Apart from the health hazards caused by the consumption of such produce, there are economic implications as well. A short shelf life, unavailability of local cold storage and inadequate transportation facilities contribute to considerable loss of money as well as produce. The severity of these economic losses is further exacerbated due to the fact that pesticide residue above the maximum residue limit results in rejection of certain agriculture produce in export markets.

Solution

To address this problem, we developed a unique patented biosurfactant-based formulation called **SOPHAB** that solubilises and removes the pesticides and inhibits the growth of microorganisms present in agriculture produce. Its amphiphilic nature with emulsifying properties remove the hydrophobic pesticides and chemicals by making them soluble. Additionally, our formulation acts on microbes by disrupting their cellular membrane and inhibiting their growth, thus, reducing the stress of microbes on the surface of the agriculture produce.





Our potable formulation creates a thin coating that prevents the microbial attack and helps to avoid early shrinking. API gives a log reduction of bacteria within a few minutes that leads to an increase in the shelf life of the agriculture produce.

Our formulation is a patented organic solution for agriculture produce. It eliminates pathogens, pesticides, chemical residue and colouring agents. It doubles the shelf-life of agricultural produce, has a near neutral pH (skin-friendly), and is odourless, colourless, tasteless, non-sticky and non-oily. The formulation does not change the taste of the fruit or vegetable, and cleans it within a few minutes with no need for a rewash. It also does not cause skin and eye irritation.

Our product is available in the market and also on various online platforms.

Hindrances

A major bottleneck is the lack of awareness regarding health risks arising out of prolonged exposure of pesticides present in fruits and vegetables. Very few are aware that there is a scientific solution to remove pesticides from post-harvest produce. Those who are aware still prefer traditional methods like baking soda, hypochlorite, vinegar or just plain water. This hinders the product's acceptance by customers and affects our company's growth. That is why we want to focus on awareness during product promotions.

Pesticides are generally hydrophobic in nature, and hence, cannot be removed by these methods.

Instead, the produce gets contaminated with these chemicals. Additionally, these harsh methods spoil the taste and texture of the fruits and vegetables. To increase awareness and to market this product we need sales tools and promotional materials.

Marketing strategy

Our current revenue model targets B2C and B2B markets. Under B2C, households, small kitchens, retailers and vegetable and fruit vendors are being covered through different marketing strategies like online platforms, exhibitions and direct contacts.

Under B2B, the hotel and hospitality sector, big kitchens, food processing industries, exporters and distributors will be covered. The profit margin based on unit price will vary depending on the order size from customers. For each unit sold, we expect a 55-60 per cent profit margin.

BIRAC support

BIRAC's BIG Grant helped us develop our business at initial stage.

Key milestones to cover in next few years

We are in the process of getting the Eco Cert certification, which is the organic certification offered by the European Union. This will open up the export market for us. ■

Achievements

- AIT-Swissnex National Award (2017)
- ISO- and HACCP-certified
- The only product in the market with FSSAI approval and Green Cert certification governed by the Agricultural and Processed Food Products Export Development Authority and the National Programme for Organic Production



Gap in Connecting New Research with Field-Level Experimentation



Sudhir Kumar Sopory, PhD

Emeritus Senior Scientist
International Centre for Genetic
Engineering and Biotechnology
New Delhi

Sudhir K Sopory has been working on the mechanisms of abiotic stress tolerance in plants. His group at ICGEB has underscored the role of different genes and, more specifically, the glyoxalase pathway, in stress tolerance.

Evolution of Indian agri-tech start-up sector, future

I understand many start-ups have come up—in hundreds. However, only about 10 are doing well in terms of building market linkages, especially for small holder farmers. With some hope of allowing genome edited crops to be brought under testing and deploying, some specific companies may come up in future. However, in a price-sensitive market, profitability is not ensured.

Start-ups should look for alternate and new routes to get good and cheaper products with sustained productivity. Climate change, water availability and droughts will be very challenging area for future. New start-ups will have to focus on newer technologies and translate their ideas to benefit the sector.

Lacunae in Indian agri-tech innovation landscape

While at the basic scientific level, many labs have done quite well, there is a gap in connecting new research with field-level experimentation. However, there is lack of awareness on part of common consumers about the quality of the produce.

Upcoming fields or problems that need innovators' attention

Major problems will be posed by changing climate conditions and soil fertility. We require soil and water security, and water-use efficient and nitrogen-use efficient plants. We need to use artificial intelligence and machine learning in using vast database to identify good genotypes and also for predicting reliable long-term climate models. We need to bring

in molecular and genomic services and utilise agriculture waste.

Policies or support systems available

There are various programmes under different government agencies like DBT that support innovation and help set up start-ups. There is scope for more crop- or area-focused programmes under public-private partnership mode. We also need to develop agronomic platforms that offer product evaluation to both private as well as public sectors, and set up accredited seed certification companies near seed production centres that have all the infrastructural set-up to bring down the cost of data points.

Pandemic's impact

Yes, the pandemic has partly hit agri-tech innovation as the work in labs as well as on field got affected. Crop testing is season-based, and hence, if one misses that season, work can get delayed by six months to a year.

Stumbling blocks

The major hindrances for innovators are sound ideas, enabling environment, bio resources, skilled manpower, and above all, ensured funding. Any company has to see that profit can come only after four to five years and it should be prepared to sustain activity. This is possible only if it has full faith in its idea.

There is less linkage of innovators with farmers to identify their needs and with the consumers to find out their preferences. We need farmer-driven innovation using all the new knowledge and proper technology. Farm-to-table network and links need to be strengthened. ■

Pandemic Led to Digital Shift



Bindu Nishal, PhD

Vice President, Agri Innovation
Lead, International One Health Incubator
IKP Knowledge Park, Hyderabad

Agronomist and researcher Bindu Nishal earlier worked with the Centre for Cellular and Molecular Biology, Hyderabad, and DowDuPont.

Evolution of Indian agritech start-up sector, future potential

Agriculture is critical for a nation's growth and development as apart from producing food, it creates jobs and improves livelihoods. The Indian agritech start-up sector has seen remarkable growth these past few years. With only 43 agritech start-ups in 2013 (according to Tracxn) to 1,427 in 2022, this sector is poised for tremendous growth and is expected to continue to grow at a rate of 25 per cent per year, according to NASSCOM.

Gaps in innovation landscape, policy intervention

Fragmented and scattered information on farmers and landholdings, supply chain inefficiencies, and delayed adoption and adaptation of disruptive technologies that have the potential to change the landscape of Indian agriculture are potential lacunae in the Indian agritech innovation landscape.

Problems needing attention of innovators

Mechanisation of farm activities, automation of irrigation, innovations in precision agriculture space, especially catering to small and marginal landholding farmers, post-harvest loss management, data analytics, artificial intelligence, machine learning, digital tools to connect farmers across India and creating networks that connect all agriculture stakeholders from 'seed to sale' are some of the areas that need attention by agritech innovators.

Changes proposed for policies or support systems available

Funding plays a critical role in building a successful innovation ecosystem. The Indian government has launched

several initiatives like the Biotech Ignition Grant (BIG), Biotechnology Industry Partnership Programme (BIPP), Small Business Innovation Research Initiative (SBIRI) and Promoting Academic Research Conversion to Enterprise (PACE) to cater to innovators at different stages of product commercialisation. Several venture capital firms and philanthropic organisations have also contributed to building the agritech innovation ecosystem. The agritech sector has received \$1 billion in funding between 2017 and 2020, according to Bain & Company and is predicted to grow to \$30-35 billion by 2025.

The Indian government has revised policies for agriculture, especially during the pandemic, and we have initiatives like Digital India, Make in India, Start-up India and Skill India in place. However, agritech-specific funding opportunities, grand challenges and policies that directly impact a farmer at the farm level should be initiated.

Venture capital

From incubation support by science parks, funding support via various government programmes and venture capitalists to market access and commercialisation support, it has never been a better time to be an agritech innovator in India.

The most important aspect to attract funding is the solution that the start-up offers. Other factors include a thorough knowledge on the current market, USP of the solution being offered, gaps, competitive landscape, a competent team and a solid business strategy.

Effect of pandemic on agritech innovations

Like other sectors, the agricultural sector was also adversely hit by the pandemic. The beginning of the lockdown with restricted transportation saw local shortage of food supplies and price hikes. However, this changed quickly and the agriculture sector started showing a positive economic growth.

This change was brought about largely by the government and agritech start-ups, who played a vital role in the transition of the agriculture sector from being an analogue system to a digital one. As a result, more farmers could connect via digital platforms to mandis for selling produce and the genesis for a long-term adoption of digital supply chain was born. This will not end here as more and more solutions using blockchain to enhance transparency and traceability and SaaS (software as a service) technologies are emerging in the market today.

Bottlenecks while serving rural communities

Although Internet penetration has increased in rural areas in the past few years, lack of stable broadband

connections is still an issue. Agritech innovators need to keep this in mind and develop app-based technology solutions that are usable on phones with lower bandwidth. Additionally, these tech solutions should be made available in vernacular language, especially in rural areas.

Hindrances

Unclear business plans that may lead to early exhaustion of funding, inefficient team structure with no representation from business and marketing, and lack of awareness of the market could be some of the stumbling blocks faced by agritech start-ups in the country.

Advice for agriculture graduates

With the growing acceptance of digital agriculture, information on gaps in the agricultural supply chain, availability of various funding options, opportunities for agritech start-ups are immense. We need agriculture graduates to come forward, pick these areas and contribute towards sustainable and profitable agriculture and overall development of our nation. ■



COURTESY: ARS/USDA





Veterinary & Aquaculture

CowVuW

Video-aided artificial insemination device



Dr V Maroudam, PhD

Founder-Director, CisGEN Biotech Discoveries Pvt. Ltd., Chennai
cisgenbiotech.com

A graduate in veterinary science, Maroudam did her post-graduation in veterinary microbiology and pursued a PhD in biotechnology. She has more than 17 years of R&D experience in veterinary diagnostics and vaccine development.

Biotech Ignition Grant (BIG) propelled her journey from being a DBT scientist to an entrepreneur. CisGEN was selected by IIT Madras for incubating at its bio-incubator, IITM Research Park, Chennai, where the company is currently running its research and development lab.

Problem

In the Indian dairy sector, semen from elite bulls is collected, tested, formulated, packed and transported to villages to artificially introduce into female reproductive tract. Conventional artificial insemination (AI) guns have to cross through the small and tumultuous opening of cervix for depositing the semen in the uterus. This is done without direct visualisation and by guiding the gun by palpation through rectal wall. Therefore, depositing the semen exactly in the uterus is difficult using the conventional gun.

Additionally, the conventional technique can injure the rectal mucosa due to excess manipulation. Improper positioning can cause injury or pierce the cervix, stress the animal, reduce the probability of insemination and is a highly unhygienic practice.

Collaboration

Adiuvo's patented imaging technology enables users to visualise the biological structures within a bovine cervix for accurate and efficient deposition of semen. Owing to real-time visualisation of the bovine cervix and surrounding rectal mucosa through a camera, the need for palpation is eliminated, which aids in preventing unwanted mechanical damage to the animal's internal organs.

Therefore, both the companies joined hands to develop a video-aided artificial insemination device, called CowVuW or Smarteasy AI gun, with data visualisation, image storage and data retrieval capabilities.

COLLABORATOR

Geethanjali Radhakrishnan

Founder-CEO
Adiuvo Diagnostics Pvt. Ltd., Chennai
adiuvodiagnosics.com

Challenges

We faced difficulty in getting spare parts and consumables during the pandemic due to IC chip shortage. Creating a lean process for low-volume manufacturing and generating funds to rent space for upscaling are also challenges.

Mucous clouding on the camera (on the AI gun tip) can pose a problem, which can be tackled by removing the probe, clean it and re-inserting into the animal. The cow also needs a frame to be held firmly in place. In the initial design, constant usage of the device without knowing the level of battery was a hindrance. We added a battery indicator to the device.

Product

The CowVuW device can be guided into the cervical opening by direct visualisation combined with data retrievable video app for smartphones. It helps the field operator to exactly deposit the semen inside uterine horns by viewing the miniature HD camera. An app is also installed in operator's mobile to collect the data and monitor the animal's reproductive data. The device has been extensively validated in Indian cattle. Our validation data indicated that the conception rate had improved by 10 per cent using our device compared to the conventional AI method.

The device helps veterinarians detect and treat reproductive and fertility problems in bovines. Storage and retrieval of reproductive data shall be useful for policymakers to design region-specific animal husbandry guidelines. The data stored and analysed can be used for breeding programmes across India. Our product's design has been registered and patent applications have been filed.

CowVuW is cost-effective as all its components are sourced in India and are readily available, it has an easy-to-use maintenance protocol, its app interface is free, it is at least 30 per cent cheaper than its nearest competitor, and its consumable—the speculum sheath—is inexpensive as well.



The device will be best fit for all teaching and training institutions and veterinary centres. The data recorded in the app will be useful for national breeding programmes and progeny testing schemes. The device will naturally be a part of reproduction aids of organised farms. Overall, the innovation can help improve the economic status of farmers, especially women engaged in backyard farming, who can achieve the ideal economic objective of breeding programmes, which aim at one calf per cow per year. The product is presently in the scaling up stage.

The device will be sold on both business-to-business channels and through distributors.

BIRAC support

BIRAC's Small Business Innovation Research Initiative (SBIRI) grant awarded in March 2018 helped us develop the prototype design, validate and up-scale our device.

Key milestones to cover in next few years

We plan to try the product in four states—Gujarat, Kerala, Tamil Nadu and Karnataka by 2022-2023. In 2023-2024, it will be marketed in six other states, before we sell it across India. We have identified a certified third-party manufacturer for large-scale manufacturing of the device with quality control testing. We also plan to develop a similar redesigned device for small ruminants and dogs. ■

Achievements

- Start-up India Award for animal husbandry
- Grand Challenge Award (2020) from the Ministry of Animal Husbandry, Dairying and Fisheries in animal breed improvement category

In-Vitro Diagnostic Kits for Veterinary Health Care

Non-resident Indian Rathnagiri Polavarapu is an adjunct professor at Emory University in the United States. A PhD in biochemistry from Madras University, he has been engaged in biomedical research and has developed more than 100 diagnostic kits, vaccines and therapeutics for animal and human healthcare. He has worked on several projects funded by the DBT, the US Army, the US Centers of Disease Control and Prevention (CDC) and trained hundreds of young scientists worldwide. His present research focus is to help farmers at resource-limited areas to support livestock productivity through biotechnology and gene editing.



Rathnagiri Polavarapu, PhD

President-CEO
Genomix Biotech Inc., USA
Genomix Molecular Diagnostics Pvt. Ltd., Hyderabad
Genomix CARL Pvt. Ltd., Pulivendula
(a joint company with Andhra Pradesh government)
genomixbiotech.com

Focus area

Our company focuses on the development of in-vitro diagnostic kits for human and veterinary health care, specifically for resource-limited areas, which can be used at point-of-care settings with minimal technical expertise.

Most of our products are in the production stage and some are prototypes that need to be scaled up. The production stage products are having manufacturing license from India's Central Drugs Standard Control Organisation (CDSCO).

Challenge

Though many technologies work precisely at the lab level, they won't work to that extent when scaled up. This was the major challenge we faced while scaling up of our products. Difficulties included the standardisation of the process for the development of kits and their scale-up to the production stage.

Product

Even techniques like enzyme-linked immunoassay (ELISA) can be performed at pen side with hand-held instrumentation developed by us. Genomix is either holding patents for some of the technologies or our partner concerns are having the patents that were used by us.

Glanders antibody detection ELISA test kits and Equine Infectious Anemia (EIA) antibody detection ELISA test kits were developed by Genomix Molecular Diagnostics in collaboration with the National Research Centre on Equines (NRCE), Hisar.

Glanders is a contagious, short- or long-term, usually fatal disease of the horse family caused by the bacterium *Burkholderia mallei*. Horses develop ulcerating growths that are most commonly found in the upper respiratory tract, lungs and skin. EIA is a viral disease affecting only members of the equidae family—horses, ponies, zebras, mules and donkeys.





Genomix CARL developed the paratuberculosis indirect ELISA kit in collaboration with Amity University, Jaipur. Paratuberculosis, also known as Johne's disease, is a chronic, contagious bacterial disease of the intestinal tract that primarily affects sheep, goats, cattle and other ruminant species.

Our kits are highly cost effective compared to imported ones.

Marketing strategy

Being a R&D-driven manufacturing unit, we use a marketing partner. The major hurdle in the Indian market is the lack of direct or individual buyers for veterinary diagnostic kits most such kits are supplied by the state governments through their network of veterinary hospitals.

As we have a joint-venture with the Andhra Pradesh government, we expect a major part of our veterinary kits to be procured by that state government. We will get in touch with the veterinary departments in other states to boost our revenue. In addition, we offer services to organised and unorganised farms for screening of several diseases.

BIRAC support

BIRAC supported us for developing the above three products. It also supported us for developing novel diagnostics for COVID-19.

Key milestones to cover in next few years

We want to develop diagnostic kits for the re-emerging zoonotic diseases along with an in-house vaccine production facility with indigenous technology. ■



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INTEGRATED BIOREACTOR for Aquaculture

The company provides a patented solution for water quality and disease management in the aquaculture industry.



Mohan Kandaswamy

Founder-Director
Oriental Aquamarine Biotech
India Pvt. Ltd.
Coimbatore
www.nitrifying-bioreactor.com

Focus area

The underlying factor behind the problems facing the aquaculture industry in India is non-stable and poor water quality. This can be controlled by installing a Recirculatory Aquaculture System (RAS) with minimum water exchange with the following advantages: water dependence less than 90 per cent; no seasonal factors influencing growth; floods and rainfall do not affect production; significantly lower incidences of disease; possible to secure far superior feed conversion ratio (FCR); reduce feed waste; generally lower mortality; site flexibility as farms can be located near markets; traceability and bio-security; domestication of alternative species; brooder stocking and development in controlled conditions.

Product

The product offered is an integrated nitrifying and denitrifying bioreactor with a specific bacterial consortium that converts ammonia (NH_3) and

ammonium (NH_4^+) to nitrite (NO_2), nitrite to nitrate (NO_3), and nitrate reduced to molecular nitrogen (N_2).

The bioreactor can be used to remove the harmful ammonia, nitrite and nitrate in the water, and help continuously recirculate and reuse the water. The system helps maintain optimum water quality (reef-quality oligotrophic water) conditions in aquaculture tanks and can be used to develop a RAS.

The bacterial consortium is available at three different salinity levels and could be used for fresh (0 ppt), brackish (15 ppt) and seawater (30 ppt).

In aquaculture, organic matter accumulation takes place from leftover feed, faecal matter and other excretory products of fish, which invariably deteriorates the quality of water with enhanced output of ammonia. The industry currently practices regular water exchange to maintain water quality. This requires significantly large amounts of freshwater. For every tonne of fish, aquaculture operations produce about 50 kg of nitrogen waste and 10 kg of phosphorus. Though RAS systems were developed earlier to treat and reuse the water in a closed loop in tank-based aquaculture operations, they do not address the issue of efficient removal of ammonia.



Key capabilities of the system

- Nitrification and denitrification occurs in the same system, whereas conventional systems require two reactors
- Maintains optimum levels of nitrogenous compounds: $\text{NH}_3 < 0.2 \text{ ppm}$ | $\text{NO}_2 < 0.2 \text{ ppm}$ | $\text{NO}_3 < 1.16 \text{ ppm}$
- Operational at site within 2-3 days; conventional systems require 60 days for full activation
- Can be tailor-made to customer requirements
- Available in three different salinity levels (0 ppt, 15 ppt, and 30 ppt)

Two models were initially made available—ex situ packed bed bioreactor (PBBR) and in situ stringed bed suspended bioreactor (SBSBR).

A new product with higher water treatment and ammonia removal capacities has also been developed based on market feedback. The product has been patented in India. Patent applications have been submitted in Thailand, Japan, Philippines, Indonesia and South Korea.

Challenges

Lack of technical inputs in the aquaculture area, such as feed and disease management, as applicable to a RAS to help build a sustainable model in the Indian context was a big challenge. A commercial model for RAS has not yet been fully established.

A challenge for technicians was to overcome mental block after having worked for years in a different manner. Another challenge was diligently following the system protocol and proper maintenance of the reactors to ensure efficient operation.

Marketing strategy

Our prospective customers are large-scale indoor tank-based facilities to grow high-value species of shell fish and fin fish from small to marketable sizes. Fish include Asian sea bass fish from a 5 gm fingerling to 1,000 gm in about a year's time. In the beachhead segment, our customers are new indoor grow-out systems with specific operating conditions.

Adjacent markets include indoor grow-out of finfish (for example, tilapia) with low price but high growth rate, indoor finfish nurseries and maturation systems of crustaceans.

BIRAC support

BIRAC partially funded our product development, field testing and validation, specifically the second phase of the design modification and commercialisation of nitrifying bioreactor technology to establish organic recirculation prawn seed production system.

Key milestones to cover in next few years

The first steps would be to obtain an endorsement of the performance of our product from industry leaders. We also intend to present results of our studies and products at meetings of the World Aquaculture Society and the Nordic Network of Recirculating Aquaculture Systems (NordicRAS) so that the greater aquaculture community, including manufacturers, distributors and consultants, are aware of the product.



We first plan to establish RAS units in the beachhead segments in partnerships with turnkey RAS solution providers. We are in discussion with two parties and expect to conclude the agreements and work on project installation by the first quarter of fiscal 2022-23.

We then plan to establish the financial viability of the RAS projects and develop a financial model for the benefit of aquaculture farmers and the industry at large. Also planned are geographical expansion in the beachhead segments and exploring adjacent segments.

We are looking for strategic business partners for different geographical segments. ■

Achievements

- Technium International Challenge, UK, Award (2008)
- TED Fellow for the TED Fellowship (2009)
- Chosen as one of 7 finalists competing in the Business Plan Competition for Green Business by New Ventures India
- Winner of India-Wallonia Tech Programme (2011)
- Winner of the XLR8AP Programme conducted by IC2 Institute of University of Texas, Austin, FICCI and Government of Andhra Pradesh
- Semi-finalist at the Global Cleantech Innovation Programme (2017) for SMEs in India

Nutraceuticals from Silkworm Pupa Oil

An MBA in operations management, company founder Srinivas B V conceived the idea of utilising waste silkworm pupa as a cost-effective and novel source of omega-3 fatty acids and its conversion into high value nutraceutical products during his M.Tech course in biotechnology and biochemical engineering.

The company develops novel nutraceutical and cosmeceutical products for humans, animals and plants. Its research & development unit is certified by the Department of Scientific and Industrial Research (DSIR) and its production unit has certifications of good manufacturing practice from the World Health Organisation (WHO), the Indian Ministry of Ayurveda, Yoga, Naturopathy, Unani, Siddha, Sowa-Rigpa and Homoeopathy (AYUSH) and the International Standards Organisation.

An indigenous supercritical fluid extraction unit has been set up for the extraction of omega-3 fatty acids and other high value botanical extract for nutraceutical and cosmeceutical applications. The facility is utilised for the conversion of other industrial and agro wastes like grape seed, pomegranate seed and peel, sandalwood seed, etc. into high-value products.

This technology was extensively utilised during the pandemic to develop immunity-boosting products.



Srinivas B V

Founder-CEO
Aspartika Biotech Pvt. Ltd.
Bengaluru
aspartika.com

Challenges

A major challenge was to convince regulatory bodies about new technologies like supercritical fluid extraction. Government organisations still follow conventional techniques and require more convincing to approve newer technologies.

Problem

Silkworm pupa accounts for 80 per cent of raw silk produced. India annually produces 26,000 metric tonnes of silkworm pupa that is thrown in open as waste. This unscientific method of dumping results in bad odour and environmental hazards. Silkworm pupa is an untapped source of omega-3 fatty acids, and a richer and cheaper alternative to existing marine sources.

Existing sources of omega-3 fatty acids are krill, shrimp, etc., which are quite expensive. Therefore, the majority of Indian population is deficient in omega-3 fatty acids.

The WHO recommended dietary allowance of omega-3 fatty acids for infants is 0.5g/day. However, this is not being met due to lack of availability of the expensive marine sources.

Technology

We have developed a novel process of producing omega-3 fatty acids in its purest form for pharmaceutical and nutraceutical applications. The indigenous process using supercritical fluid-based technology and silkworm pupa is clean, environment-friendly and does not generate any waste.

Silkworm pupa is discarded from the sericulture industry and the other raw material, carbon dioxide, is a by-product of other industries. It is a completely renewable process where carbon dioxide is recovered after every process and there is less than 10 per cent loss.

If all silkworm pupa produced in India is reclaimed and converted to omega-3 fatty acids, it can cater to the requirement of 9 million infants for an entire year. The de-oiled cake is also a rich source of protein and a better alternative to soya protein for the poultry and aquaculture sectors.

Products

We produce omega-3 fatty acid-enriched silkworm pupa oil, which is enriched by up to 60 per cent through our technology. Supplementing egg layers' diet with YeggMore Omega, comprising omega-3 fatty acids from silkworm pupa, enriches omega-3 fatty acid content in table eggs from 40 mg/egg to 240mg/egg.

Asprogrow de-oiled cake after extraction of silkworm pupa oil is a rich source of protein. It is a growth promoter in poultry comprising synergistic combination of herbal mixture, de-oiled pupa cake and calcium linolenate. Growthmin Aqua is a silk protein-enriched aqua feed supplement. The last two are superior sources of protein compared to soya cake.



The products are free of odour. Omega-3 fatty acid from silkworm pupa is 50 per cent cheaper than popular sources. Our process is protected through an Indian patent application.

Marketing strategy

In the B2B category, we supply omega-3 fatty acids and protein cake as a raw material to feed animal nutrition manufacturers and poultry farm integrators. We supply premium quality natural extracts with richer bio-actives to cosmetic and nutrition industries, and immunity-boosting Indian flat bread and drops for military food and space food.

In the B2C category, we supply raw material to poultry and aquaculture farmers for production of omega eggs for increased yield and better growth. Our distribution channels are retail outlets, online portals and distributors. We are spreading across poultry farms through distributors and referrals by veterinary doctors.

BIRAC support

BIRAC has supported Aspartika from its nascent stage till successful commercialization of products. We initiated the project on producing omega-3 fatty acids from silkworm pupa through BIRAC support. Funding support has been received through the Biotechnology

Ignition Grant Scheme, the Biotechnology Industry Partnership Programme Scheme and the Project Commercialization Programme Fund.

Key milestones to cover in next few years

The company has a well-established animal nutrition market in south India. In the next three years, we aim to expand across India and the globe, scale up production and extraction facilities to meet demand, and establish common processing centres in various sericulture hubs in India to process the silkworm pupa produced and use the same facility to process other post-harvest produces like grape seeds, pomegranate seeds, etc.

Achievements

- Among the winners in the waste beneficiation category in the Global CleanTech Innovation Programme conducted by United Nations Industry Development Organisation, CleanTech Global and Institute for Design of Electrical Measuring Instruments
- Biotech Product, Process Development and Commercialisation Award (2020) in the private organisation category
- National Entrepreneurship Award 2019 under renewable energy and waste management category
- Emerging Star of the Year Award by Bangalore Chamber of Industry and Commerce (2021)
- Smart Bio Award (2019) for outstanding contribution in bio-industrial category given by the Karnataka government
- Winner of BIG PITCH Competition conducted by RBL Bank and 1Crowd



Vibrioshield

Anti-microbial to control vibriosis in aquaculture

With a Masters degree in veterinary science from Madras Veterinary College, Dr Subhashini has 25 years of experience in immunodiagnostics, bacteriophage therapy and molecular diagnostics in aquaculture.

Aristogene Biosciences, established in 2006, is recognised for its in-house research and development facility by the Department of Scientific and Industrial Research (DSIR). It has also been granted funds by the Department of Biotechnology (DBT) under the Small Business Innovation Research Initiative (SBIRI) scheme for development of molecular diagnostics for shrimp viruses and development of bacteriophage-based control of bacteria in aquaculture. These projects have been successfully completed, and the products are being commercialised. In addition, the company develops bacteriophage-based therapeutics for other bacterial infections in aquaculture and poultry. The company also provides reagents and kits in molecular biology, immunology and proteomics.



The founding team. From left to right: Vasudha B, C R Subhashini, L Sudha



Dr C R Subhashini

Director, R&D
Aristogene Biosciences
Bengaluru
aristogene.com

Problem

Asian countries like Indonesia, Thailand and India have emerged as global leaders in shrimp production. However, a major setback in aquaculture is the sudden outbreak of diseases, especially those caused by *Vibrio* sp., a group of common, gram-negative, rod-shaped bacteria that are natural constituents of freshwater, estuarine and marine environments and that are considered a significant problem to the development of the sector.

An intensive mode of culture with high stocking density became popular in different Southeast Asian countries. To maintain productivity of such intensive aquaculture, massive use of antibiotics has been employed. The spread of antibiotic resistance from aquaculture settings to the natural environment is increasing. About 70 per cent of the *Vibrio* isolated from aquaculture settings is multi-drug resistant.

Another concern associated with the use of antibiotics is the problem of residues, which has resulted in rejection by seafood importing countries of shrimp containing traces of antibiotics. Therefore, antibiotics are no longer the preferred treatment against vibriosis in shrimp culture and alternative methods are being sought.

Solution

Bacteriophage therapy will be a major breakthrough in the treatment of *Vibrio harveyi*. Its advantages are



a rise in shrimp production by avoiding loss due to vibriosis, thereby raising export revenue; increase in acceptance of the Indian shrimp in the global market due to lesser use of antibiotics; fall in production cost due to the avoidance of antibiotics; and prevention of spread of antibiotic resistant bacteria and residual antibiotics in the shrimp consumed by human—a major social advantage.

Product

Vibrioshield is an all-natural, non-chemical anti-microbial preparation for controlling vibriosis. Its active ingredients are high concentrations of naturally occurring bacteriophages that selectively and specifically kill Vibrios, ensuring higher yield and profits. The solution is quite effective in reducing the Vibrio count in ponds. It decreases shrimp larval mortality, reduces disease incidence and increases the survival rate of larvae. It does not damage routine beneficial bacteria, is safe and is easy to apply on field.

However, as the concept was new, it took a lot of time to teach farmers about the method. We market our products through distributors and dealers. BIRAC supported us by funding the project related to this. ■

Achievements

- Introduced the concept of bacteriophage therapy to the industry
- DSIR-recognized R&D centre
- Filed three patents for the products in aquaculture.
- Won 'BIRAC Innovator Award' for molecular diagnostic kits in aquaculture
- Vibrioshield has been selected by the Marine Products Export Development Authority (MPEDA) for its field trials on antibiotic-free post-larvae production
- Colishield, a cocktail of bacteriophages that can selectively kill pathogenic *E. coli* in poultry, and Vibrioshield and ELIXIR, all-natural, non-chemical anti-microbial preparations for controlling vibriosis have been in the market for the last two to three years

More Innovation Needed in on-field applications, non-crop sectors



Ram Kaundinya

Director General
Federation of Seed Industry
of India (FSII)

An author, strategic management consultant, teacher and an Indian agriculture policy analyst, Ram Kaundinya specialised in agriculture during his IIM Ahmedabad course, and worked for 22 years in the agrochemical industry with multinational companies. He is now on the boards of Axis Finance, AgriRain, Vasuhaika Software, CXWAI Tech India Pvt. Ltd. and NCDEX Institute of Commodity Markets and Research (NICR).

He serves on the expert review committee of Amsterdam-based Access to Seeds Foundation and on the independent steering committee of maize with the International Maize and Wheat Improvement Centre (CYMMIT), a member of CGIAR, a global research partnership. He has co-founded ThinkAg, a platform for the promotion of innovation and entrepreneurship in food and agriculture.

Evolution, future potential

The digital technology-based agritech start-up sector has developed quite rapidly in the last ten years. This picked up more speed during the COVID-19 pandemic. About 600 start-ups are operating in the ecosystem today in the country and it is estimated that more than 2 crore farmers are using the services of many of these.

Agri-tech start-ups are addressing the problems of farmers in three buckets now: issues before the crop is planted, issues that the farmer faces while cultivating the crop and post-harvest management of the produce. Farm mechanisation (like uberisation of machines, agronomic operations as a service, drones, etc.) is also receiving decent level of attention.

The presence of agricultural technology in crops is much more than in allied sectors like livestock, birds, fisheries, etc. Satellite data-based enterprises have also come up in a big way. This technology is developing very rapidly with reducing costs and has immense applications in assessment of crops, pest and diseases in future. The inter-connectivity of satellite data with drone imagery can be used for regional customisation of solutions, but such options are limited in spite of their critical need in view of climate change.

Innovation in life sciences space in agriculture is quite poor now. Not much work is going on in spite of the efforts of BIRAC. This area needs special attention.

Gaps in innovation landscape

Most of the upcoming digital innovations are coming from tech experts with no exposure to agriculture. Their understanding of the actual business opportunity, price paying ability of the farmer and the cash paying cycles of the farmer is quite low. They all need agri domain experts to help them so that they can make a business out of it. They need mentors with domain knowledge who can guide the enterprises through the critical early periods. The start-ups are now more concentrated in e-commerce of agri inputs and output. While this is an important area, we need more innovation in the on-field applications, non-crop sectors, financial services, insurance services and extension advice.

The power of machine learning and artificial intelligence remains untapped as intensive ground data collection is lacking. The analytics and interpretation of data requires pathologists for disease management, physiologist for crop health, and their involvement now is limited. This adversely impacts the quality of provided solutions.

Corporates, financial institutions, insurance companies and other stakeholders must come forward and engage with start-ups. They should collaborate in terms of providing space for pilot studies, helping them with infrastructure and technical advice, making small investments in equity and providing access to their customer farmers, so that they can guide the entrepreneur

through the journey. This will bring greater chances of success for these enterprises.

For biotech innovations, we need a good infrastructure support beyond a lab. These include growth chambers and culture rooms, testing facilities like polyhouses and greenhouses, enabling regulatory policy environment and funding support so that products reach the market without delay. These are some of the areas that need attention to enable innovation.

Problems that need innovators' attention

Livestock, poultry and fisheries or marine products need attention as this sector is assuming greater importance. It is growing faster than the crop sector. Practitioners in this sector have a different set of problems that need to be addressed. Formalising markets for livestock, animal health care, feed, processing, certification, financial services and market access will be important to address in this sector.

As far as crops are concerned, improving productivity in view of climate change will be the most critical problem we will face. High temperatures, weather uncertainties, water, soil and other natural resource management, large scale mechanisation of agriculture, value chain development, market access, financial services (farmer onboarding, credit rating of farmers, building close loop systems between farmers and contract farming companies, etc.) are some of the areas that need attention.

Plant-based food is emerging as a major area of business due to changing consumer preferences. Nutritionally-enhanced food and plant-based biofuels are other emerging areas that will see greater adoption in the future. This area needs much technology-backed innovation.

Biotech innovations that address creation of climate resilience in crops, natural resource conservation, reducing chemical usage in agriculture, improving the input use efficiency in crops and meeting challenges of emerging new pests and diseases are important for future. Such innovations need to be specifically prioritised and encouraged.

The focus towards sustainably-grown local food has increased during the pandemic. Technologies like hydroponics and aeroponics are being used to greater extent to grow soil free, sustainable food locally. These technologies decrease water usage, land use and increase productivity.

Policies or support systems needed

Indian agritech start-ups need government policy support in a few areas:

a) Funding support: The innovator spends most of his time trying to raise funds rather than focusing on his work in the lab or in his business. Unfortunately, venture capital intervention in agricultural innovation in India is minimal. This must be addressed through creation of a seed fund of ₹1,000 crore from which innovations or early enterprises meeting certain criteria should get between ₹1 crore to ₹4 crore as funding, either in one tranche or in two.

b) Working capital support: Banks should be encouraged to lend working capital facilities of ₹3-6 crore to such enterprises after they start generating revenue and break even. Lack of working capital cripples many of these enterprises. This bank facility should be free of collateral. The Reserve Bank of India will have to allow special norms for lending and non-performing assets for this.

c) Data support: An open access system of government data should be provided to agritech start-ups. Many of these spend time, effort and money in building or accessing data on farmers, land records and other parameters. This data is sitting in government records. If this is made available to start-ups on a payment basis, it would be a huge service to this sector.

d) Regulatory support: For biotech and life sciences innovations, a predictable, science-based and supportive regulatory environment will be most beneficial for start-ups.

Venture capital

The Indian agritech sector is quite attractive for investors because of the huge potential it offers: large cultivated area, a large number of small-holding farmers, a large population of consumers, emerging importance of food safety and traceability, lack of profits by farmers, opportunity for local-level value addition, providing market access to farmers, quality assessment of agri produce through digital means, reducing the length of supply chains.

Google predicts that by 2026, the number of Internet users in India will double and most of the growth will come from rural areas. This is a very encouraging sign for digital technology-based innovators and start-ups.

About \$2 billion of investment has come into agritech start-ups in the last five years. About 80 per cent of that has gone into the post-harvest market connect through e-commerce for farmers. Such a concentration in output marketing is happening because the farmer also gives importance to price discovery, quick disposal of produce, professional warehousing and credit on his stored produce.

It is worth noting that less than 5 per cent of the investment has come into biotech- and life sciences-based start-ups. This is mainly due to lack of such innovation and enterprises. This is a serious area to be addressed.

There are no unicorns in the Indian agri start-up space till now. There are no major exits that gave a huge return to the innovator or investor. Once such developments take place, the investment velocity in the sector will go up.

Pandemic's impact

The pandemic positively affected the uptake of the innovative enterprises and apps by farmers. Farmers and other stakeholders have become more amenable to technology interventions for improving productivity, farm management and market access. Innovators need to provide quality products and services to gain their confidence and encourage the new perspective.

During the pandemic, though the actual work by the innovators and start-ups did get affected, it has not upset the rhythm too much except during the second wave.

Bottlenecks

The major bottlenecks are:

- a. Seasonality of crops and cash flows of farmers: Enterprises that offer services during the cultivation of the crop have great difficulty in collecting their fees from farmers as the latter do not have cash during that period. So unless an enterprise has access to the output of the farmer, it does not have much chance of recovering money from farmers.
- b. Lack of access to data: The government has all the data of the farmers and land records and the innovators and enterprises struggle to create such a database or to access government's database as the government has not put in place any process for accessing its data. This data resides with state governments. A national policy acceptable to all states does not exist as of now.
- c. Lack of infrastructure in rural areas: Uninterrupted connectivity is an issue.
- d. Political uncertainty over farm related policies: Frequent changes in import and export policies and frequent crop loan waivers make this sector look very risky for innovators and funders. Business models that deal with these aspects are always nervous about such policy changes.
- e. Small-holding farmers and lack of collectivisation of land holdings creates an issue of scale and high cost of reaching farmers. This is being partly overcome through the farmer producer organisation

(FPO) movement. However, some reports say more than 60 per cent of FPOs are not functioning properly due to lack of financial viability.

Advice for fresh graduates

Agriculture graduates should look at innovation and agri-tech start-up as a career option. This decade will open up many opportunities in this space. There are some low-hanging fruits that can be picked by them, especially because they have domain knowledge. A few agriculture universities are providing trainings on operating small businesses and such trainings need to be more widespread and extensive.

However, no innovation or business model can succeed without a digital backbone. Agri graduates are not experts in digital technologies. So they should partner with a digital technology expert and start the enterprise. Such graduates are ideally suited to provide complete digital advisory and solutions.

Connecting farmers with digital services being offered by several start-ups; helping farmers in understanding and operating digital services without taking risks; opening custom service centres in rural areas; management of farm machinery and drones; providing aggregation facilities for agricultural output and connecting to markets through short supply chains; setting up local primary processing facilities and connecting with secondary processing enterprises; warehousing and logistics; financial and insurance services to farmers are some of the areas where agri graduates can focus on.

It is important to build a robust system and organisation, rather than trying to scale up too soon. Understanding nuances of business and financial management is important. They should also have a mentor to guide them through this system. ■



Sustainability Topmost Priority for Agritech Investors



Rajeev Aiyappa

Managing Director
Value Mark Pvt. Ltd., Bengaluru
CEO, Bestovo Foods Pvt. Ltd.

With 25 years of experience in diverse aspects of crop protection and the fertilizer industry, Rajeev Aiyappa mentors start-ups in the agriculture, food technology and clean technology sectors and a few sustainable healthcare businesses. He is involved with ten incubators and accelerators, including Start Up Oasis (IIM Ahmedabad), SINE Mumbai (IIT Mumbai), IIT Madras, IIT Hyderabad, IIT Delhi and C-CAMP in Bengaluru. Before Value Mark, founded recently, he was CEO and partner at Plataforma Asia.

Evolution of Indian agritech start-up sector, future potential

The number of agritech start-ups has mushroomed and policymaking and funding has caught up in a big way. We at Value Mark see this to be a well-funded area with sufficient skilled founders breaking new boundaries.

Gaps in innovation landscape, policy intervention

We believe that the agritech landscape is yet to be monetised effectively in a manner that benefits our large rural ecosystem. Geographically, it seems that agritech start-ups are concentrated in certain parts of the country while there seems to be a large vacuum in other parts.

Problems that need attention of innovators

The focus during the last few years has been on efficient use of resources like inputs. We believe the next wave will be about efficient substitution and utilisation of labour because of skilled and well-paid labour choosing not to spend longer periods in rural areas as well as large scale urban migration. This results in the need for precisely trained robots, especially for harvesting horticultural crops.

Probable changes in government policies

The changes that can be incorporated in government policies to make these more favourable would be focus on longer-term hand-holding of a start-up with an equity upside for both the start-up as well as the government institution, and active mentors who earn a living by

seeing the start-up through their journey, especially the 'valley of death' phase in product development as well as revenue building.

Venture capital

India has a diverse agricultural landscape in terms of soil types, crop types, weather conditions and consumption patterns, and this, coupled with a burgeoning number of skilled and technically-qualified graduates and post graduates, create a wonderful place to invest in. Institutions will typically see tremendous potential in India in terms of creating a working laboratory of sorts. Further, success of a few start-ups over the past decade in creating unicorns has led to a realisation that success can be replicated at scale in India.

It is fairly easy for start-ups to attract venture capital, especially if the ecosystem in agritech is robust.

Pandemic's impact on agritech innovations

The pandemic has squeezed out the best of frugal innovations, not only in products but also in evolving businesses into sustainable ones. There has also been a case of start-ups realising realistic value in fund-raising with investors during this period.

Bottlenecks

A common bottleneck is to generate business revenues while the cost of customer acquisition is managed efficiently in the initial phases of a start-up after product development is completed. This can be overcome by collaboration as well as partnerships.

Advice for agriculture graduates

They should start early and think more from a business success perspective rather than a production or product development process. Failures early on are an important part of successfully establishing oneself.

Specific fields picked up for funding innovations

I see potential in combining various parts of the value chain with focus on impact on climate change. Examples include smarter production of inputs, extension of shelf life by tapping in the value chain of finished products and renewables with a source where crop residues are efficiently used.

Agritech start-ups funded

We have directly or indirectly supported or funded over two dozen start-ups and the main impact has

been a focus on their sustainability, wherein the ecosystem that they are a part of benefits as much as they do.

Priorities from investor's perspective

I believe that the topmost priority is sustainability of the enterprise that they invest in as well as the development of the ecosystem in which they operate.

Attention to needs of small marginal farmers

Indian agritech innovations do take into account the needs of small and marginal farmers but the ones that are well funded are the ones that service larger institutional farms due to effort by the start-up per rupee of revenue earned as well as the revenue potential involved. ■



COURTESY: CIMMYT/CGIAR



Waste to Value



Green Fodder Forever from Agri Waste

The company was founded by botanist Randhir Singh Gajraj, who has expertise in algal biotechnology; his wife Sabita R Gajraj, a physics graduate; and Kranti Vij, who has decades of experience in marketing, finance, logistics and business development. Its sister concern is Bioentri Canada Inc. based in Toronto.



Randhir Singh Gajraj, PhD

Co-founder-Managing Director
Sabran Bioentri Pvt. Ltd.
Mumbai & Jaipur
bioentricanada.com

Problem

Agriculture waste is available in plenty, paddy straw and sugarcane leaves are a big nuisance. Both are normally burnt on field and generate enormous smoke and smog problems, especially in the Delhi National Capital Region and the surrounding regions in north India and elsewhere in Indian continent and globally as well.

Milk and meat delivery often fall short in green rich bio-nutritious feed. Paddy, wheat or maize straw are mostly made to silage to raise nutritional value.

Focus area, stage of development

We are in the field of innovative feed and green fodder making and delivery with agri-waste as a base and multiple algae biomass as nutritive add-on.

We offer an eco-friendly and sustainable touch to

waste paddy straw (*parali* in Hindi) and other edible agri-waste available on field, at agri-industry units and also at sugarcane-based bio-refineries.

Solution

Green Fodder Forever (GF2) is a fully-scaled and commercially available bio-product that caters to the needs of cattle and other ruminant animals. Our multiple fresh and marine water bio-units for algal growth and cultivation systems are based on sustainable carbon sequestration via utmost carbon dioxide consumption and no waste delivery bio-modules.



We have developed a proprietary and innovative technology via amalgamation of the varied nutritional algal biomass to avoid burning of paddy straw and leftover sugarcane leaves and make them an edible cattle feed, GF2. We have developed several other feed supplements as well.

GF2 is produced by an all ecological and able carbon sequestration process wherein many a nutritive and high-end algal bio-systems and biomass incorporation into agri-waste make valuable and nutritive feed and fodder lines like Cattlact, Cattcal, PCUP, blue curd and beta carotene rich ghee, etc.

GF2 helps increase milk yield in dairy cattle with enhanced fat and corrected solids-not-fat (SNF) by about 20 per cent. It also provides immunity and better-quality calf and dung production in dairy animals. GF2, if fed to goat and sheep, can duly help increase milk, meat and wool quantities.

Algae cultivated and used in GF2 making and its delivery are the fresh and marine water algae strains of *Spirulina*, *Dunaliella*, *Chlorella*, *Nanochloropsis* and *Tetraselmis*. We filed for an Indian patent in 2016 and the process is under way.

Challenges

Putting up a unique and innovative low-cost, solar power-driven freshwater and marine water bio-system for multiple algae R7D, growth and cultivation at a place near the Sambhar lake in Rajasthan was a challenge. Getting rid of the silica problem from paddy straw to make GF2 was another. Standardisation of GF2 and its bio-making process, giving an innovative touch in the form of GF2 bread, and marketing of the product and technology as a package was yet another.

Paddy straw is rich in silica, and getting rid of it in an eco-friendly manner and its reuse in a sustainable manner was a major hindrance. But it was removed with intervention by a bio-alkali touch module. The algae-based fodder inherits a sea weed-type smell as add-on; cattle are made to eat that by masking the smell by combining wheat powder and molasses.



Mrs. Sabita R Gajraj
Co-founder

Mr. Kranti Vij
Co-founder

The green fodder had a low shelf life, and therefore, we researched to deliver it by embedding it in chapatis (Indian bread) as it can be easily packed and stored for longer periods.

The product had an add-on cost, but still matches in final financials compared to normal green fodder available in market like Alfa-Alfa. Marketing and acceptance of our green fodder is still a major challenge.

Marketing strategy

The base material for making GF2 is available as animal fodder and for feed making companies in India, Canada, the United States and Europe. Our customers include those from the agriculture sector; dairy, wool and meat producers; central and provincial governments; and trusts and non-governmental organisations.

The global feed and fodder industry is projected to reach close to a trillion dollars by 2030. We have strategic tie-ups with cattle feed chains in states of India and North America. Dealer delivery worth of CAD 100 million sized and due diligence on in Canada alone.

Our revenue generation strategy involves direct sales of ready-to-use product as whole GF2 or as concentrate to make GF2, and a licencing model in which customers can produce their own GF2 by learning our algae cultivation method and processing.

BIRAC support

BIRAC's BIG grant in 2018 worth ₹30.8 lakhs helped us develop and scale up the GF2 bio-module and shift from pilot to commercial scale.

Key milestones to cover in next few years

We would like to standardise the fodder product based on other available dry fodders like soybean and pulse husk, dry leaves of edible plants and animals and leaves of roses, etc. We plan to replicate and popularise this fodder across India, North America, South America, Asia, the Middle East, Africa, Australia and New Zealand. We also want to make innovative and eco-friendly products and by-products like out of GF2-based enhanced milk; eco-cheese, blue curd and beta-ghee to offer health benefits to people. ■

Achievements

- Among 100 Best Emerging Start-ups (2017)
- Process under way to start a unique and proprietary bio-module AADAT—Agri, Algae and Dairy Amalgamation Technologies—under the Sustainable Urban Rural Area Technologies (SURAT) venture in Gujarat state

Products from Banana Plant Fibres

Company founder P M Murugesan, a farmer from Melakkal village who studied up to Std VIII, owns coconut and banana gardens covering 2 acres and cultivates additional 4 acres on lease basis. His wife Malarkodi, who studied till Std X, supports the venture. Farmers in Melakkal and nearby villages situated in the Vaigai river basin cultivate banana.



P M Murugesan

Founder
Rope Production Centre
Melakkal, Madurai
Tamil Nadu
www.banaropemdu.com

Products

Fibres from banana plants are used to make ropes, mats, woven fabrics as well as hand-made paper. The affordable and health hazard-free products are eco-friendly alternatives to disposable ones made from plastic. Our products have been introduced in the market and are in the scale-up stage.

The company made innovations in cutting and rope-making machines—both automatic and semi-automatic, and the rope winding machine. Patents have been registered for the machine innovations. The banana rope is used to make products like handbags, floor mats, curtains, pouches, bed sheets and small baskets.

The raw material, i.e., banana plant waste, is procured cheap—at ₹5 per bark. The average profit margin is 30 per cent.

Challenges

Initially, only I and my wife were involved in manually separating fibre from banana sheath and wove a few hundred metres. I was able to sell the banana fibre products by myself, but found it tedious. We both were fed up with that activity and reached a stage where we decided to stop in 2002.

During manual production, the fibre broke due to incorrect moisture and we faced difficulties in finding the correct level of wetness. When machines were introduced to our production process, the fibre broke with irregular revolutions per minute (RPM). The correct RPM was found with a number of trial runs.

Marketing strategy

Products are already being supplied to an export agency in Bengaluru. We also sell products through stalls in Tamil Nadu and other states.

BIRAC support

BIRAC funded us for machinery innovation and product development.



Key milestones to cover in next few years

- To employ more than 1,000 rural women.
- As banana plant waste are abundantly burnt by farmers, we plan to procure all such waste and increase production to meet demand.
- To expand the geography of our exports.
- To make sanitary napkins and gift papers using banana fibre.

Achievements

- Prime Minister Narendra Modi commended the company in his 'Mann Ki Baat' radio programme in June 2021
- Best Agri Businessman Award, ICAR

Edible Cutlery

The company was founded in 2020 by chairman and managing director Vinayakumar Balakrishnan, director of finance Indira Nair and Rohit V Menon, director of research. Balakrishnan is a post graduate in geology with more than 27 years of experience in sales, human resources, banking, insurance and start-ups. Nair is a post graduate in physics, with more than 15 years of experience in operations, administration, banking and finance. Menon is pursuing integrated MS at Indian Institutes of Science Education and Research, Thiruvananthapuram.

It was incubated at IIT-Kanpur, the Kerala Agricultural University and Indigram Lab Foundation, New Delhi.



Vinayakumar Balakrishnan

CMD, Vir Naturals Pvt. Ltd.
Kochi
thooshan.com

Focus area, stage of development

The focus of the project was on creating fully biodegradable tableware, such as single-use plates, cups, take away boxes, cutlery and glasses. The product consists of agriculture by-product (wheat bran or rice bran), other natural ingredients coated with natural binders.

Research work had commenced long before the company was founded. Three years of research led to the soft launch of commercial production of biodegradable tableware in a fully automated robotic plant at Angamaly, Kochi, in August 2021.

We have started commercial production at Kochi. We started the THOOSHAN brand to provide a replacement for the current disposable plastic utensils in the market. Our mission is to start a cutlery revolution. Millions of single-use cutleries end up in landfills every year.

Product

Through our initiative, we hope to put an end to this behavior and increase public awareness. THOOSHAN makes a range of plates, bowls made from natural wheat bran. THOOSHAN's dishware has a longer shelf life (a year) and is resistant to fungus and bacteria. These are completely biodegradable in 30 days and partially edible. However, you don't always have to eat the plate; if you throw it away, it decomposes into organic manure for the plants. After its use, these tableware can be used as cattle feed, fish feed or poultry feed. The use of single-use plastic could be reduced to large extent by this novel concept. The product can generate additional income for farmers and local mill owners. We have not filed a patent yet.

Currently, our products cater to the premium segment and with scaling up, this can be priced similar to areca or bagasse plates.

Marketing strategy

As single use plastic ban is gaining momentum, there is tremendous scope for our sustainable and eco-friendly product, including its export. It is capable of taking over from plastic as it is affordable, edible, microwave friendly and biodegradable.

Our endeavor is to accelerate research on other biodegradable

products to ensure a sustainable earth, for future generations. We market our products now only in Kerala through a B2B model and through distributors. We are targeting caterers, events, weddings, public functions, resorts, etc for bulk sales. We will enter the retail market through Amazon soon.

Challenges

The main challenge was the technology and was addressed through participation with our technology partner, the National Institute for Interdisciplinary Science and Technology in Thiruvananthapuram under the Council of Scientific and Industrial Research.

As we were second in the world to have this technology, machine customisation was a huge challenge. Right now, production is in low volumes, but the output has quality. Scaling up is the biggest challenge now due to lack of funding opportunities.

Pricing is also a main hindrance as its premium-priced due to low volumes. Our trial plant has a capacity of only 1,000 plates per day and this needs to be scaled up to at least 50,000 plates per day through contract manufacturing.

BIRAC support

Supported through BIRAC's BioNEST Bio-incubation programme. ■

Achievements

- UNDP Green Innovation Fund Award, instituted by Kerala Start-up Mission and Haritha Kerala Mission, 2021
- National winner from Kerala for RAFFSTAR ABI for innovation in agricultural products, 2021
- Received idea and start-up grant in 2021 from the Kerala Start Up Mission



Stay Farmer-Centric While Innovating



S Sivakumar

Group Head, Agri & IT Businesses
ITC Limited, Secunderabad

S Sivakumar holds responsibility for ITC's Social Investments Programme as well. He is the chairman of Technico Agri Sciences Limited and vice chairman of ITC Infotech India Limited and its UK and US subsidiaries. He was earlier a member on the boards of NABARD and the Institute of Rural Management, Anand.

He serves on the advisory council to the Ministry of Rural Development on National Rural Livelihoods Mission, the Commodity Derivatives Advisory Committee of SEBI and on the Management Committee of National Agricultural Higher Education Project of the Ministry of Agriculture & Farmers Welfare.

Evolution

The evolution has been phenomenal, I would say. In the recent past, India's agritech start-up sector evolved rapidly across multiple dimensions. From less than 50 in 2013, the number of agritech start-ups is now well over 1,000.

More importantly, the range of problems these start-ups are trying to solve is pretty wide now—from delivering basic information on weather and prices at one end to hand-holding individual farmers through personalised agronomy advisory services at the other end; from smart irrigation to precision farming; from real-time remote monitoring of crops to rapid quality assaying of the produce; from fintech and other farm input marketplaces to linking farm output to institutional customers as well as household consumers; from scientific storage of grains to managing traceability along the supply chains of perishables.

You name it, and it's some start-up's business! The technologies deployed are also quite diverse: artificial intelligence, automation, hyperspectral imaging, IoT-enabled sensors, remote sensing and GIS, drones, robots and block chain.

These digital technologies are in addition to the advanced agriculture technologies like gene editing and precision biologicals, or the back-to-basics organic and natural farming technologies that are becoming popular again. These start-ups have

attracted nearly a billion dollars of investment in the last five years, with half of that amount just in the last year alone.

What we have seen so far is only a hint of the possibilities. The real potential will be unleashed over the next few years. Solutions of a large number of these start-ups will mature and be ready to scale up and spread wide. Buoyed by the increasing investments in the sector, and the improving chances of success because of the fuller ecosystem that's getting shaped, the influx of new start-ups will further accelerate.

Just as this past decade has seen significant disruption through consumer e-commerce and edu-tech, the next decade will witness the transformational impact of agritech on the lives of the billion rural Indians.

Gaps in agritech innovation landscape

There are certainly a couple of gaps that need to be plugged to enable agritech start-ups reach the next phase quicker. A large majority of the exciting innovations by the agritech start-ups are point solutions to specific problems. While they do solve the chosen problems very well, often by themselves, these solutions don't translate into more money in the hands of the farmers. Therefore, scaling them in isolation is a challenge for the respective start-ups.

For instance, a precision agriculture start-up can provide enormously impactful advisory to the farmers

through IoT-enabled sensors and AI/ML models, but without a coordinated access to the recommended inputs and seamless linkages to the output markets, farmers cannot profit from the advisory services alone. This makes it difficult for the start-up to craft a monetisation model.

As it is, the costs involved in taking the offerings to farmers across the vast agri landscape of India are substantial, as to be effective, a part of the activity in most solutions has to be physical. Given the low-ticket size of individual transaction due to very small land holdings in India, the high customer acquisition costs and the time taken to scale, most start-ups stare at long periods of cash losses despite technical robustness of their specific innovations.

Solution integrators with digital platforms and on-ground delivery infrastructure can solve this problem by empowering multiple start-ups to simply plug in to the ecosystem and offer their innovations to farmers at marginal costs. By assembling the multiple start-ups that 'together' offer end-to-end solutions to the farmers, the solution integrators aid in creating value for the farmer, and in turn monetisation opportunity for every stakeholder.

One such solution integrator in the making is ITC-MAARS Super App, riding on the e-Choupal rural infrastructure built over 20 years, and further supported by FPOs being set up across the country.

The other gap that must get filled for such platforms and the ecosystems to scale up is data sharing and interoperability of the systems. While today's technologies make such sharing and interoperability easy, the government has a big role to play through suitable policy framework, as also by giving access to the data available with the government. Fortunately, the governments at the centre as well as several states are taking proactive steps in this regard.

Areas that need attention of innovators

At a macro level, the topmost priority must be given to building climate resilience of agriculture, not just in India, but across the world. In recent times, if there's one problem that has hurt everyone from the farmer to the consumer, that is climate change.

Extreme weather episodes have become more frequent, adversely affecting farm yields and damaging crop quality, resulting in income losses for the farmer, increased prices for the consumer and uncertain business environment for all players along the value chain. Big data and analytics must be fully leveraged to arm the farmers with actionable forecasts on climate.

Alarming depletion of natural resources is another major problem, especially of water and top soil. While there are some solutions in pockets on climate-smart and precision farming, they must be contextualised and upscaled to deal with the size and complexity of the challenge.

At an operating level, volatility in prices is another big problem. Farmers often make decisions on which crops

to plant based on the previous season's prices. This is like driving with only a rear-view mirror to guide. Akin to the agronomy advisory based on weather forecasts, technology must aid the farmers with price predictions based on anticipated supply and demand conditions.

As no forecast can be cent per cent accurate, given the number of variables at play, access to derivative markets is key in certain crops to manage the inherent price risks. Technology has a vital role as well in connecting small farmers to these markets.

Over the past several decades, India has built a food and agricultural system that is production-centric, as our first goal was attaining self-sufficiency in food. Now that we have achieved that for all practical purposes, the focus should shift to raising incomes of farmers. The best route to do it is by serving the evolving needs of the consumers in terms of quality, safety, variety and convenience through value addition near farm or along the value chain.

There is also a large opportunity in exporting high value products to the world. Transforming our food and agriculture system into demand-responsive value chains is the best way to capitalise on both these opportunities. In other words, our farmers must be enabled to competitively produce the crops in demand with desired attributes.

Technology can be at the core of this transformation too, in transmitting demand signals, in production support and in linking to the markets. This effort will also deal with one of our other big problems—post-harvest wastage—by aligning production with demand instead of attempting to sell whatever is produced, but of course within the flexibility allowed by the agroclimatic conditions and the biological processes.

Support systems available

In addition to the ecosystem being developed to support start-ups in the country, the Indian government has also been proactive in designing and implementing multiple policies and schemes for start-ups venturing in the agriculture sector.

These include the scheme for 10,000 FPOs, the Agriculture Infrastructure Fund, the Pradhan Mantri MUDRA Yojana, the Pradhan Mantri Jan-Dhan Yojana and the Prime Minister Wi-Fi Access Network Interface scheme. These help create infrastructure, financial inclusion and internet connectivity for rural India.

Further, the recent budget announced support for use of drones in agriculture, a dedicated fund for investing in agritech start-ups and delivery of digital and hi-tech services to farmers in the public-private partnership mode. Another important announcement was a fund with blended capital to finance start-ups relevant for farm produce value chain.

Venture capital

The reason for strong tailwinds in the sector is pretty simple. It is the confidence that technology can solve many of the large problems that have been frustrating Indian agriculture for long.

The agriculture sector contributes to less than a fifth of India's gross domestic product, while employing nearly half of all workforce. This imbalance results in very low farmer incomes and emphasises the imperative of raising their incomes, as such a large number of people are involved.

On top of that, agriculture also deploys half of all the land and more than four-fifths of the country's fresh water, signaling that the solutions may actually lie in improving productivity. Evolving consumer preferences are creating demand for food-safe agri value chains, supported by quality systems and traceable supply chains. But our agri-food system is more production-centric and is not geared to service this evolving demand.

The emerging digital technologies have the potential to overcome many of the traditional barriers like lack of personalised solutions to deal with the heterogeneous contexts of the millions of small farmers and raise productivity, uneconomic costs of servicing these small farmers directly due to inadequate infrastructure, complex challenge of building demand-responsive value chains from fragmented farms dispersed across 600,000 villages connecting the domestic urban and attractive global markets.

On the other hand, digital penetration in rural India is increasing manifold on the back of increasing household penetration of smartphones and reduction in data prices.

In essence, the sector offers a mega business opportunity with a huge positive impact on social and environmental fronts.

Given these trends, it is very apparent that there has never been a better time for attracting venture capital into agritech sector and this is poised to further accelerate in the coming years.

From what I have seen, attracting seed capital hasn't been difficult if a start-up has a good idea to solve an important problem, and there is no difficulty to raise funds for growth stage, once the proof of concept is established and the business model is validated.

Where I have seen start-ups struggle is when they have to raise follow-on funding to iterate their solution a few times or pivot their business model after an adverse on-ground experience. This is where the blended capital idea I mentioned might come in handy.

Pandemic's impact

The pandemic has irreversibly accelerated the adoption of digital tools and innovations offered by

agritech. The need to operate without physical contact led to widespread adoption of digital tools to access information and interactive advisory services, and e-commerce in farm inputs and produce marketing. Farmers have experienced the benefits of these tools and are now willing to trust and enthused to invest in them.

Bottlenecks & challenges

Earlier in the conversation, I talked about the limitations of the point solutions and the need for solution integrators with physical on-ground delivery infrastructure.

Let me talk about another challenge here. The enormous diversity of India and the significant variations in the dynamics of different crop value chains mean that agritech innovators cannot assume that they can simply scale up their proven solutions around the country in their original form. Instead they should build problem-solving frameworks and construct tool-kits to adapt their solutions to multiple local contexts.

Traditionally, it is the government that delivered most of these services to the farmers, and almost always without charging any fee. So the biggest challenge the agritech start-ups face while marketing their solutions to the end-users can be termed as 'competing with free'.

They need to be as creative in designing their monetisation models as they are with solving the problems of the end-users. The inefficiency in the value chain and the new demands of the consumers do offer plenty of opportunities in doing so.

Advice for fresh graduates

Very clearly, this is a sun-rise sector. Agriculture graduates can feel encouraged with the realisation that there has never been a more exciting time to enter and build a promising career in this space than now.

Technology is poised to transform the sector over the next few decades and new graduates can leverage their fresh thinking and energy to lead the charge.

While a sound understanding of the scientific principles of agriculture and willingness to work in the field with farmers will remain critical, appreciation of the power of data sciences as a force multiplier will be equally important.

"Stay farmer-centric while innovating, and think collaboratively while executing" is my advice to the budding entrepreneurs in this field. ■

Demand for Solutions Addressing Climate Change to Rise



Srinivas Ramanujam

CEO
Villgro Innovations Foundation
Bengaluru

A computer science engineer and an IIM Calcutta alumnus, Srinivas Ramanujam is passionate about social entrepreneurship and for-profit models that are innovative, scalable and financially self-sustaining. He works with visionary and innovative social enterprises in agriculture, healthcare and climate action sectors.

Prior to moving to the impact sector, he spent 15 years in the corporate world across financial services, consumer goods, industrials and agribusiness segments.

Evolution, future potential

The last five years have seen significant investor support for demand aggregation models. BIRAC and the Department of Science and Technology have ramped up their support for technology and sciences-based start-ups. However, investor interest is only now beginning to focus on such breakthrough technologies.

The next half a decade will see increased overlap between climate action and agriculture. There could be increased focus on agri-allied sectors and that can help build resilience in farmer income and livelihoods.

Gaps in agritech innovation landscape

There are several opportunities that can be addressed through technologies that reduce crop loss at the farm gate or solutions that ensure quality and safety of produce across the value chain, in technologies and sciences that create value of agri-waste; and in enabling financial inclusion for agricultural activities.

Problems that need attention of innovators

There will be increased demand for solutions that address climate change—those that can help farmers mitigate risks, help them adapt to climate change and increase resilience in livelihoods and their community.

Policies & support systems available

Multiple departments and ministries have facilitating policies and financial and technical support schemes. There is also a benign regulatory and compliance regime for start-ups. However, the pace of deployment could be faster and there could be better integration with the private sector.

Venture capital

Only a few business models are witnessing enhanced interest, primarily for the 'urban' demand aggregation model. Other areas that are more B2B, B2G or focused on farmers as beneficiaries do not see an equivalent amount of traction.

Pandemic's impact

The pandemic slowed start-ups down because of restrictions on supply chains. But after aligning with the essential services ruling, agri-tech start-ups that were already present in the market could operate easily. However, start-ups in product development or pilot stage struggled.

Bottlenecks

The two biggest bottlenecks are that channels to access rural communities are fragmented and innovators struggle to replicate or scale what has worked in smaller geographies. These could potentially be overcome by connecting and integrating better with existing FPO and self-help group networks. The private sector could also play a role by being willing to accept more innovations in their products, market solutions and distribution networks.

Start-ups consistently struggle with reaching their end-users or beneficiaries in an efficient and low-cost manner. The second big bottleneck is in start-ups figuring out their business models, primarily in price or value discovery for their solutions.

Advice for fresh graduates

I would advise agriculture graduates to be clear about who will use their solution and who would pay for it. These are often different from each other. Second, start-up founders need to strengthen understanding of their markets and ought to have stronger insights. ■



Nutraceuticals & Fortified Agriproducts



Vitamin D-Fortified MUSHROOMS

Biotechnologist Priyangshu Manab Sarma has 20 years of experience at the National Chemical Laboratory, Pune; The Energy Research Institute, New Delhi; and the Oil and Natural Gas Commission. He quit job in 2016 to form Innotech Agropostikam, which focuses on fortification of mushrooms with vitamin D. He was joined by researcher Hamen Das.



Priyangshu Manab Sarma, PhD

Co-founder
Innotech Agropostikam
Pvt. Ltd., Guwahati
woodberryin.com

Challenges & Hindrances

Major problems included back-end integration and the high cost in analysis of vitamin D present in our samples. Initially we were supported by BIRAC, but during our commercialisation stage, we had to spend a lot on such analysis. We initially contacted individual farmers to take our technology and give us the produce. However, there were a lot of issues working with individual farmers. Currently, we are tying up with farmer producer organisations (FPOs) and farmer clusters. The second challenge is cultivating channel partners. As our product is a slightly premium and niche one, we are contacting

high-end stores for B2B2C options. However, the listing fees are high.

Focus area, stage of development

There are over two lakh small and marginal farmers in Assam trained in mushroom production. However, there are no market linkages or consistency in quality and supply. There is a huge population deficient in vitamin D that relies on synthetic formulations. There is also a programme on vitamin fortification in food products. Unfortunately, with no natural supplements of vitamin D, all such products use chemically synthesised vitamin D. Mushrooms can be a common linkage to solve all the above issues.

We are currently in the early revenue stage and in the process of scaling up our back-end integration operations as well as market linkages. We provide a platform for mushroom growers, training, spawns to ensure quality, add vitamin D to the produce through an Internet of Things-based patented process, assure buy-back by creating market linkages and mitigate perishability-related losses by converting to dried and powdered products. We are working on commoditising mushrooms, and with sustainable packaging, we ensure traceability with integration of QR codes, follow Food Safety and Standards Authority of India guidelines, and thus, enhance accountability of the farmers.

Product

Clean, organic, chemical free, plant-based nutrients in our food system are being increasingly accepted by consumers. This sector has also witnessed a surge in investment portfolios of several organisations. Therefore, we were encouraged to initiate work focussed



on a wonder food, mushrooms, as they have the potential to provide a base for a complete vegan protein and most importantly as a natural source of vitamin D.

With over 80 per cent of our population suffering from vitamin D deficiency, we wanted to position mushrooms as the natural source of vitamin D. With no natural alternatives, people are forced to take artificial and synthetic formulations of this vitamin. Thus, vitamin D-enhanced mushrooms can be a prophylactic option as a natural supplementation as part of the diet or the dried and powdered form can be used to fortify other food products. We developed and patented a process to enhance vitamin D in mushrooms. Our mushrooms contain 3,000-4,000 international units (IU) of vitamin D per 100 gm and can meet the daily recommended dose as suggested by the World Health Organisation (WHO).

Our focus was then to leverage this opportunity of value addition in mushrooms with the mushroom farmers of the region. We also realised that for scaling up of mushroom production, we need to get associated with farmers groups. However, even though there are several initiatives, with over two lakh beneficiaries being trained for mushroom production in Assam, we could not be assured of committed and consistent quality and quantity of mushrooms for procurement. This led to our focus on providing an IoT-based platform to maintain quality as well as provision of spawns from our captive unit to ensure consistency.

We thus provide our technology to the farmers now and ensure a buy back guarantee to them so that they don't have to worry about selling their produce. For back-end integration, we started associating with FPOs through organisations like E&Y and Samunnati to make the interaction more professional.

We were granted a process patent last year.

Cost

We are currently selling our product at a premium. Normal button mushrooms are available at around ₹50 to ₹60 per 200 gm; ours is priced at ₹99.

Marketing strategy

We have three sources of revenue: one from licensing the technology to farmer clusters; the second through sale of spawns; and the major revenue is from sale of products and produce. At present, we have 600 farmers with us and 30 channel partners through which we sell our produce.

Thus, starting with retail and aggregators, we are now focussing on B2C sales of our produce through our website. We also aim at making vitamin D-enhanced mushroom powder a natural source for fortification in soup, noodles and other dehydrated foods (B2B). Our focus is to move towards meat- and animal ingredient-free protein. With mushrooms as a base, we would move into other sources of protein like hemp and would apply the same model for vitamin C-rich pomello, star fruit and other selected agricultural produce.

BIRAC support

BIRAC supported us to establish the proof of concept and to carry out all studies required to take forward the concept to the commercial stage.

Key milestones to cover in next few years

- Scale up of production and procurement to 1,000 kg per day
- Setting up a production unit of button mushroom in Assam
- Scaling up of our associations with farmers to 5,000
- Scaling up of spawn production to 1,000 kg per month
- Use of mushrooms as a base material for vitamin D and protein supplement
- Integration of mushrooms in the Mid-day Meal Scheme
- To turn the largest exporter of vegan protein in the next two years

Achievements

- Winner of MANAGE-Samunnati Agri-Start-up Awards (2021)
- Revenue generated of over ₹60 lakhs in last 18 months



Nutraceutical, Cosmeceutical Products from Cordyceps

A researcher on nutraceutical product development, Mousumi Mondal started as a scientist working on artificial diet for silkworm at Central Sericultural Research & Training Institute (CSTRI), Mysuru. She received a BIRAC BIG grant to establish the proof of concept on cultivation of the world's most endangered medicinal mushrooms called cordyceps.

The women-led start-up was set up in 2016 after she finished the project to ensure that the magical medicinal properties of cordyceps reach all at an affordable price. The company has validated the process to develop high value nutraceutical products through biotechnological interventions. It is registered with Start-up India and Start-up Karnataka Cell.



Mousumi Mondal, PhD

Founder-CEO
Mallipathra Nutraceutical
Pvt. Ltd.
Bengaluru
mallipathra.com

Focus area, stage of development

Cordyceps are medicinal mushroom having high nutraceutical and cosmeceutical value. These are naturally found in mountains of Korea, Japan and China. These are consumed as functional health food in those countries. Traditional Chinese medicine accepts its medicinal properties.

Our focus areas are nutraceutical products and cosmeceuticals. The former include cordyceps fruiting body, cordyceps powder, cordyceps capsules, health drinks, etc. Our nutraceuticals target the geriatric population; immune-suppressed patients of HIV, cancer, diabetic; patients in post-recovery phase from kidney, liver or lung ailments; and sports nutrition enthusiasts.

Our cosmeceuticals include a cream with anti-aging, skin whitening and antioxidant properties.

Our animal nutrition products are for poultry and cattle.

Problem & solution

The mushroom grows only in specific high-altitude areas; is seasonal—grows once a year from July to September; is highly expensive due to limited availability and huge demand; and grows on unidentified hosts and hence highly inconsistent in quality. Its high value and demand has led to over exploitation of natural resources.

Our solutions included growing the mushroom in-house at any capacity, which takes care of biodiversity issues; growing it throughout the year in an artificial environment; reducing its cost through our patented



Cordyceps fruiting body



technology; and growing it on consistent hosts—both vegetarian and non-vegetarian substrates as per the requirement.

Compared to 365 days in nature, cordyceps are cultivated within 60 days through a new process. The novel non-vegetarian substrate comprises selectively-bred silkworm larvae imparting synergistic medicinal properties. The products of cordyceps (fruiting body and substrate) consist of cordycepin, cordycepic acid, essential fatty acids, phenolic compound and antioxidants.

Cordyceps-based nutraceutical supplements can be given to the geriatric population; these can boost immunity of patients recovering from immune-suppressed conditions; help prevent ailments of kidney, liver and lungs; can be a natural alternative to chemotherapy; and enhance stamina of sports enthusiasts. These are natural aphrodisiac as well.

Our products are synergistic in nature comprising bio-active ingredients from silkworm (1-DNJ, GABA) and cordyceps. The higher active components are cordycepic and cordycepic acid. We have filed a patent.

The price of cordyceps fluctuates based on availability. Our product is affordable for all at ₹75,000-₹100,000 per kg compared to similar products offered by competitors.

Challenges

Finance was the main problem when we started pilot-scale production. The difficulty in standardisation of cordyceps cultivation protocols mimicking the

Himalayan conditions was overcome by the company with novel biotechnological interventions.

Marketing strategy

The global cordyceps market size was valued at \$473.4 million in 2018, and is expected to grow at a compounded annual growth rate of 10.4 per cent by 2026 and reach \$2.84 billion by 2028.

We are establishing our brand through online marketing portals and making potential consumers aware through referrals by health experts, nutritionists and doctors. Our products like cordyceps fruiting body, cordyceps powder and cordyceps capsules are being launched on organic marts. We are also approaching medical stores, gyms and fitness and nutrition stores.

BIRAC support

The company was initiated through a grant-in aid support from BIRAC. It was further supported by BIRAC's BIPP scheme for pilot scale validation of the technology and developmental activities later.

Key milestones to cover in next few years

- To capture the pan-India cordyceps market in the next fiscal
- Establish a large-scale cordyceps cultivation facility complying with WHO GMP, FSSAI and ISO 9001:2015 standards
- Establish a niche global market for cordyceps-based products and capture 1 per cent of the global market in the next two years

Achievements

- TiE-Biotech Women in Entrepreneurial Research (WInER) Award (2021)
- BIRAC Innovator Award (2020)
- Immunity Champions of India Award under the immunity start-up category by Heal Foundation and the Indian Coalition for the Control of Iodine Deficiency Disorders. (2020) for products developed to combat COVID-19
- Smart Bio Award (2019) for outstanding contribution to agriculture sector from Karnataka state government

Gamma Oryzanol Nutraceutical

Rice bran derivative

AR Sharma, a first-generation entrepreneur from a business family based in Dhuri, Punjab, has over 35 years of expertise in the production and processing of rice bran oil.

The Ricela Group was established in 1992 at Dhuri to sustainably produce health-promoting value-added products from derivatives of rice. Group company A.P. Organics Ltd. is the highest producer and exporter of refined rice bran oil from India and exports to over 30 countries. It claims to be the first company in India to produce gamma oryzanol capsules at economical prices.



A R Sharma, PhD

Founder-Chairman
A.P. Organics Ltd., Ludhiana
A Ricela Group company
www.ricela.com,
www.oryanol.in

Product

In India, paddy occupies the first place both in area and production. This provides us with ample opportunity for the production of value-added products from the derivatives of rice. Rice bran along with the germ is an inherent part of whole grain, which consists of phytonutrients like oryzanol, tocopherols, tocotrienols, phytosterols, etc., and importantly, dietary fibres.

The complete exploitation of its potential has not been realised due to problems associated with rancidity. However, owing to numerous stabilization procedures, it has been possible to derive an array of health-promoting value-added products and we have moved towards that direction.

Rice bran oil was conventionally being used in India for manufacturing soaps and detergents, whereas in countries like Japan, Korea, Taiwan and Thailand, this oil was being used as a premium edible oil due to its scientifically proven cholesterol lowering properties.

Gamma oryzanol is a natural alternative for cholesterol management, for which generally statins are consumed. A number of in-vivo as well as human

intervention studies conducted around the world have indicated that our product has anti-dyslipidemic (dyslipidemia refers to abnormally elevated cholesterol or fats in the blood) and cholesterol management properties; anti-diabetic, anti-stress, sleep promoting and anti-hypertension properties; immunity boosting, anti-cancer, anti-allergy, anti-inflammatory and anti-oxidant properties; and liver-protective properties.

It is also a gastric trouble reliever; acts against hypothyroidism; protects the nervous system and its cells; reduces obesity; strengthens muscles; and prevents osteoporosis, cardiorenal metabolic syndrome and retinal damage.

Focus area, stage of development

The Food Safety and Standards Authority of India (FSSAI) has classified gamma oryzanol in the list of approved nutraceuticals. The product has been successfully commercialised and further developmental work based on market feedback is under way.

Hindrances

The technology for producing gamma oryzanol was new, and therefore, scaling up from pilot to commercial level was a challenging task. The difficulties included technical training to staff as manufacturing process was upgraded during commercialisation of this technology.

The biggest challenge was technology development starting from raw material to the final product. This involved preservation of gamma oryzanol in raw material during processing; development of a completely new technology for extraction of gamma oryzanol; continuous upgradation of process depending on market feedback; and manufacturing as per international



Rice Bran



Gamma Oryzanol

quality standards. To overcome these, guidance was sought from the Indian Institute of Chemical Technology, Hyderabad.

Marketing strategy

The product is currently distributed through tie-ups with multi-level marketing companies as well as directly through online market places. As the product is new in the Indian Market, the biggest barrier to enter the market is consumer awareness about gamma oryzanol and its health benefits. The company is already generating revenue to make the unit self sustainable and is planning to increase revenue by raising production capacity and

by associating with established private Indian brands in the field of health supplements.

Compared to prices in the global market, the cost of our product is quite economical.

BIRAC support

BIRAC has supported us financially through grants and soft loan and provided technical assistance as well, especially through monitoring and an expert committee during various phases of the project.

Key milestones to cover in next few years

- To clinically prove the health benefits of our brand of gamma oryzanol
- To explore the utilisation of gamma oryzanol in various food and non-food applications
- To enhance our production capacity meeting new requirements
- To explore the international market for our product



Achievements

- Top rank among winners of National Award for R&D (2007) by the Ministry of Micro, Small and Medium Enterprises (MSME)
- National Award by the Ministry of Science and Technology (2009) for successful commercialisation of indigenous technology of enzymatic degumming of rice bran oil
- Top rank among winners of National Award for outstanding efforts in entrepreneurship (2009) by the Ministry of MSME
- Top rank among winners of National Award for innovation (2012) by the Ministry of MSME
- International Award for Rice Bran Oil Research (2016) instituted by the International Association of Rice Bran Oil

Centralised, Integrated Agri-Data Platform Needed

Can offer data to start-ups, industry, academia



Ashish Jangale

Head of Precision Farming
Farm Division
Mahindra & Mahindra

Ashish Jangale works on identifying and establishing new revenue streams in digital agriculture through artificial intelligence (AI), drones, robots, Internet of Things (IoT) and autonomous machinery. He has close to 20 years of global experience with companies like John Deere, Ford and Caterpillar. His area of expertise is digital agriculture, technology strategy and industry platform conception.

Evolution of Indian agritech start-up sector, future potential

The Indian agri-tech space has witnessed tremendous growth in last five years, with more than 500 start-ups operating now. From investments worth \$20 million in 2015 to \$409 million in 2020, the sector is at the cusp of transformation. Start-ups in digital supply chain and output market linkage are leading the journey due to easier and quicker margins. Precision farming and agri-fintech start-ups have comparatively slower adoption due to significant groundwork required in developing solutions.

Most such start-ups in the Indian space started their journey with technological interventions in the input-output market linkages and established strong farmer base for growth. Those that started their journey as pure digital play had to change it to a 'phygital' model to ensure sustainable growth. Although the Indian agri-tech space is currently dominated by market linkage start-ups, the next leg of growth will come from precision farming, traceability solutions and agri-fintech segments.

The Indian agri-tech market potential is estimated at \$24 billion. The current penetration is only close to 1 per cent. A large agriculture base, several government initiatives, a dedicated 'digital agriculture' budget of ₹600 million and a plethora of incubators

and accelerators will ensure continued global and domestic investments and multifold growth of the space in future.

Growth, investment opportunities

More and more food will be needed to nourish India's increasing population. Farm productivity in our country is lower than the world average for some of our staple crops like rice, sugarcane and cotton. The fertilizer use efficiency is low. Farming consumes 80 per cent of water and the water tables in many states have dropped significantly in the last decade. The availability of water for farming is becoming increasingly difficult.

So there is tremendous scope to improve farm yield and productivity. There is significant migration of rural population to cities resulting in shortage of farm labour. This will only promote mechanisation, automation and use of technologies to reduce drudgery and for decision making.

On the other hand, there is a strong educational system in India that produces engineering, agricultural talent necessary for start-up growth. There are 1.1 billion mobile phone users in India and smart phone penetration will grow faster. 4G penetration is close to 86 per cent and 5G network, when available, will be the primary driver to communicate information to farmers.

Various government initiatives like doubling farmers' income by 2022, the Pradhan Mantri Fasal Bima Yojana and the recent relaxation of drone-flying regulations will further enable the development of the agri-tech ecosystem.

The magnitude of the problems in Indian agriculture and the conducive ecosystem make it easy to attract investments in this sector.

Problems that need attention of innovators

Indian agriculture is ripe with problems. Every crop is unique and each stage of crop growth cycle (land preparation, seeding, spraying, weeding, harvesting and post-harvest) poses a unique opportunity to develop tech solutions. For example, producing a kilogram of rice needs around 4,000 litres of water. Seventy per cent of production cost of grapes is attributed to chemicals. Spraying in sugarcane becomes extremely challenging after three months. Weeds in vegetables are a big issue. Post-harvest assessment of the quality of cereals or fruits is critical for e-trading.

There is a whole range of sector agnostic technologies—IoT, drones, AI, big data analytics, robotics—available to develop specific solutions to identify nutrient deficiencies in crop, deliver zone-specific fertilizer doses, detect hotspots of diseases in farms and estimate of harvest readiness.

Gaps in innovation landscape, policy intervention

Many public institutions acquire, collect, buy and generate farm data like satellite images (from Indian Space Research Organisation), weather information (from Indian Meteorological Department), soil properties (from the ministry of agriculture) and seed characteristics. These datasets are available in a siloed manner.

The value of these datasets can significantly increase if the datasets are integrated on a centralised agri-data platform and made accessible to start-ups, the industry and the academia.

Dedicate sandbox or pilot areas for major crops (100-200 acres) assigned by the government or the agriculture ministry can greatly facilitate such data capture, algorithm development and validation.

Krishi Vigyan Kendras, state agricultural universities and central institutes should be mobilised to help accelerate the adoption of new technology solutions in their focus crops or geographies. India also needs tax incentives for agri-tech start-ups working on sustainable, regenerative agriculture initiatives.

A 'precision farming pilot fund' needs to be created to subsidise pilot studies and crop risk during data collection. This would greatly trigger the sector's development and mitigate risks for nascent start-ups.

Subsidy assistance for high-end and precision farm equipment and implements could be directly routed to manufacturers. This will reduce the burden of high initial capital costs for farmers and improve the sale of the precision machinery.

Effect of pandemic on agri-tech innovations

The pandemic has altered everything, not merely agri-tech. For every digital intervention, the pandemic has been a blessing in disguise, accelerating its adoption and penetration to a great extent. Moreover, it has changed the mindset of the people and made them more receptive to new technologies.

Agri-tech start-ups working in the digital market space witnessed exponential growth during the pandemic. Indian farmers, traditionally considered the most technology-averse, started virtually connecting and accepting advisory from subject matter experts from far-off locations.

As *mandis* were initially closed, orders began to be sourced digitally and digital payments started. Greater penetration of smartphones, cheaper Internet and increased use of social media platforms during the pandemic opened up new avenues for such start-ups to reach the target audience.

Bottlenecks for innovators, start-ups

Given that the new-age solutions will leverage the combinatorial power of disruptive technologies, these will be inherently expensive. Farmers believe what they see; they buy what they trust. Innovators should try to intimately understand this mindset of farmers.

The innovations should be affordable for farmers; these can be offered to farmers on service basis (per acre, per season). These should be easy to use, with simple user interfaces and facilitate decision-making rather than confusing farmers with disparate data, price discovery and other parameters. The innovators should provide an opportunity to farmers to observe products in action and use the solution for a certain period or crop cycle to gain confidence in the product and reap profits.

Advice for innovators

I believe producing sufficient food for our population is going to be one of the biggest problems to solve in the next few decades, given the challenges of soil health, water scarcity and climate change. To solve these complex problems, multi-disciplinary teams are needed. Serious talent from engineering, agriculture—agronomy, pathology, nutrition—and business is needed to address that.

Decent start-ups should focus on the core issues in agriculture and should have multidisciplinary teams to solve them. Working in such start-ups would offer an accelerated and experiential learning for young graduates. ■

BIRAC Promoting Sustainable Agri Innovation Ecosystem

Agriculture contributes to about 17 per cent to India's GDP, and with its allied sectors, is the largest source of livelihood in India. Up to 70 per cent of rural households still depend primarily on agriculture for their livelihoods. The sector shows high vulnerability, variability and losses and low efficiency. Dependency on climate, weather, soil conditions; limited availability of seeds, fertilisers, disease-resistant and high-yield varieties; inefficient storage, shipping and handling of perishable and non-perishable crops; limited capacities in food processing and value addition in post-harvest produce are prominent gaps. Then there can be unannounced exigencies like COVID-19 that affected procurement, labour availability, retail and supply chain, access to debt and cash flow, all of

which impacted the agriculture sector without giving any time to recoup.

Therefore, any improvement in efficiency of resource utilisation, output, post-harvest management of sales, distribution, can have immense and immediate impact on the outcome and growth of the sector. Technology intervention supported through strategic funding, inter-linking, policy framework and prioritisation can provide the desired impetus.

Recognising this gap, unmet needs and potential opportunity, BIRAC is providing multifaceted support to start-ups, academia and the industry to innovate and develop affordable, accessible and scalable technology-led solutions.

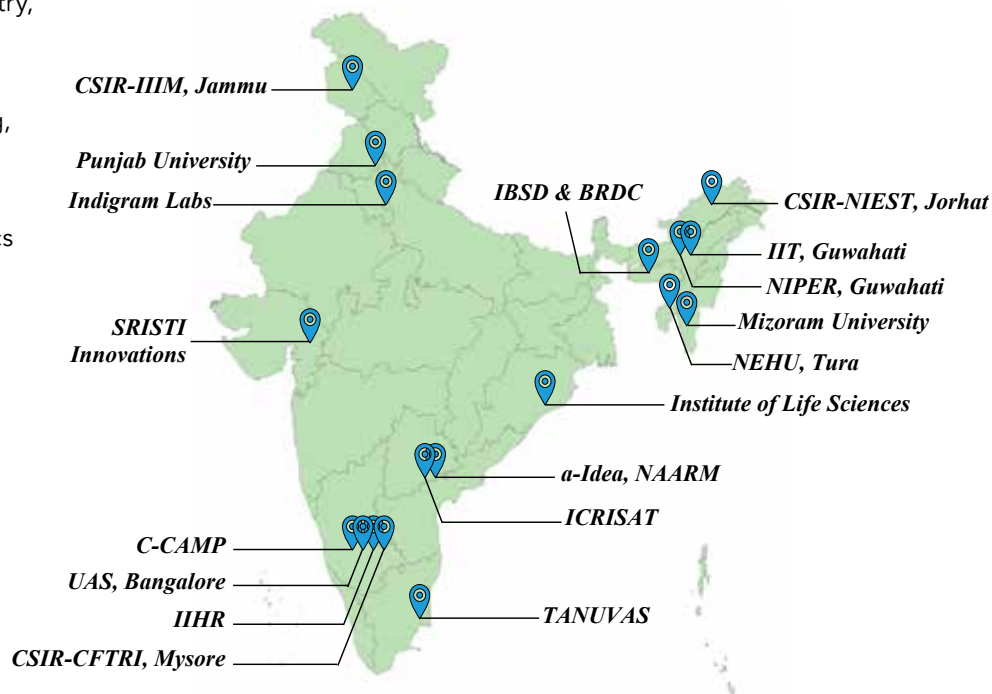


Bio-incubation

BIRAC has created a specialised network of 74 common access bio-incubation centres across 21 states and union territories. Out of these, there are 18 BioNEST incubation centres that are specifically focused on promoting start-ups and entrepreneurs in agriculture and allied areas. The sub-sectors they address include:

- Animal husbandry, poultry, sericulture, fisheries
- Food technology
- Secondary agriculture, including manufacturing, waste-to-value
- Veterinary, including breeding, selections, therapeutics, diagnostics

These incubation centres provide access to high-end facilities that range from tissue culture, greenhouse and aeroponics facilities, pilot processing for product development, food testing labs for analytical studies to product analysis, shelf-life studies, food packaging and field validation. This is besides the basic biotechnology laboratories for wet work and incubation space for start-ups and entrepreneurs to run their operations.



BIRAC's BioNEST Agri-Focused Bioincubation Centres

Technology Accelerator

Innovation and networking are integral to enhance the business competitiveness and gain success in the global market. This is particularly significant in case of agricultural technologies, as most of the research in the domain is carried out by public R&D institutions. BIRAC has supported a technology accelerator implemented

by our BioNEST partner, Indigram Labs Foundation in Delhi, which offers start-ups business mentoring and connections, including market linkages, FPOs, aggregators, B2B links and investors with customised mentoring assistance. The accelerator runs a batch of top 10 start-ups selected from across the country in each cohort.







BIRAC's BioNEST ACCELERATION PROGRAM

AT INDIGRAM LABS FOUNDATION (ILF)

(KRISHI UTTAN INCUBATION CENTRE)






Inviting Agritech & Foodtech start-ups at TRL 8 (Pre-Commercialization) Level to avail the Business Acceleration opportunity at one of the best Agri-Food focused TBIs in India.

North Eastern Region Network

The North East region of India is a recognised biodiversity hotspots in the world. Rich bioresources spread across the region's diverse ecosystems and nurtured by indigenous communities provide ample opportunities for furthering economic development of the region. To promote innovation and entrepreneurship in the region, BIRAC has established seven BioNEST Bio-incubation Centres in the region. These incubators are housed within universities and research institutes and are spread across Assam, Mizoram, Tripura and Meghalaya. These capacity-building bio-incubators are nurturing a local pipeline of biotech entrepreneurship in the region. The bio-incubators support start-ups and entrepreneurs in areas like natural product chemistry, phytopharmaceuticals, nutritional foods, plant technology, agro-technologies, floriculture, traditional medicines, ecology and environmental solutions, social entrepreneurship and women entrepreneurship. This is also complemented with a special biotech ignition grant (BIG NER) for the start-ups and a regional centre BRTC-BIRAC Regional Techno Entrepreneurship Centre for East & North East at KIIT BioNEST, Bhubaneswar, to promote entrepreneurship, handhold start-ups and incubators in the region.

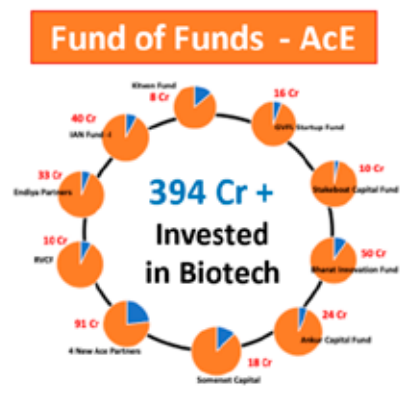
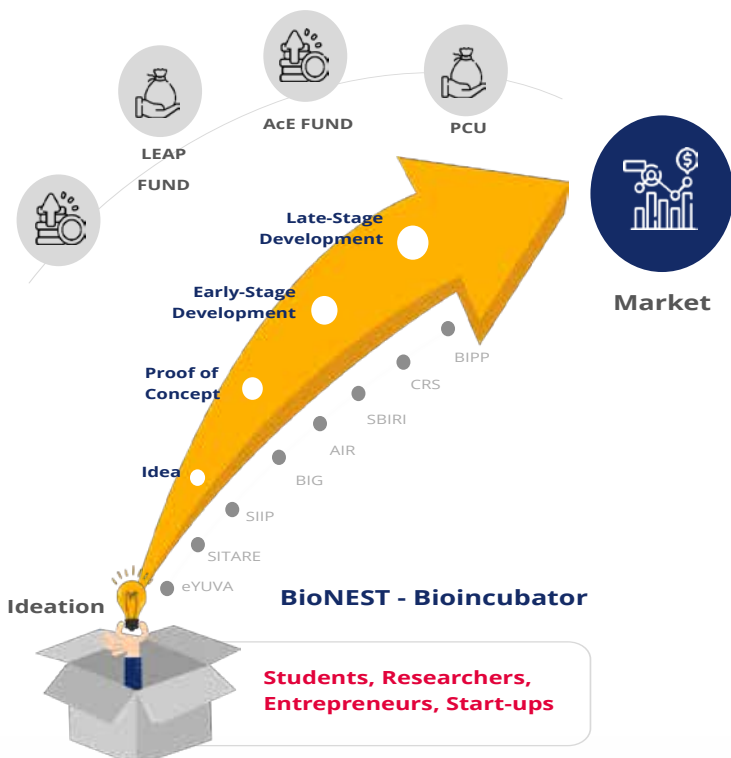


BioNEST incubators in the North East

Risk Investments in Agri projects

BIRAC provides funding support of up to ₹7 crore to start-up projects at various stages of product development through its various schemes and programmes. The support is provided in the form of grant-in-aid and equity-based investments. Through these initiatives, BIRAC has funded projects in various areas of agriculture, including:

- Agro climatic challenges
- Biotic and abiotic stress
- Higher and sustainable yield
- Enhanced nutritional value
- Environment-friendly processes
- Disease & pest resistance
- Special trait integration through transgenics, RNAi
- Biocontrol/plant health
- Tissue culture
- Decision support systems
- Precision farming
- Drone-based surveillance
- Innovations in post-harvest technologies for quality testing, storage, preservation, residue management
- Value addition and enhancement of nutritional value
- Logistic support to farmers



Biotech Angels Network

bioangels
Powered by IAN
350 Cr + Target

The Way Forward

“When tillage begins, other arts follow,” said American lawyer and statesman Daniel Webster. As agriculture forms the cornerstone of human civilization, it is vital for a heavily populated country like India to accord priority to this sector. Research shows that every rupee spent on agricultural R&D yields better returns compared to those on money spent on subsidies or other expenditure on inputs.

Initiatives, targets & projections

The Indian agricultural sector is predicted to increase to \$24 billion by 2025, according to Inc42, a portal covering Indian start-ups and entrepreneurs. By 2025, Indian agritech companies are likely to witness investments worth \$30-35 billion.

The organic food segment in India is expected to grow at a CAGR of 10 per cent during 2015-25 and is estimated to reach ₹75,000 crore (\$10.73 billion) by 2025.

In April last year, the government approved a Production Linked Incentive Scheme for the food processing sector with an incentive outlay of ₹10,900 crore (\$1,484 million) over a period of six years starting fiscal 2021-22. The aim is to develop global food manufacturing champions commensurate with India's natural resource endowment and to support Indian food brands in international markets.

The processed food market in India is expected to grow to ₹3,451,352.5 crore (\$470 billion) by 2025 on the back of government initiatives, such as planned infrastructure worth \$1 trillion and the Pradhan Mantri Kisan Sampada Yojna.

In September last year, Prime Minister Narendra Modi launched 35 crop varieties with special traits like climate resilience and higher nutrient content. The government has initiated the Digital Agriculture Mission for 2021-25 for projects based on new technologies like artificial intelligence, block chain, remote sensing and GIS technology, drones and robots.

In September last year, the Ministry of Agriculture and Farmers Welfare signed five MoUs with CISCO, Ninjacart, Jio Platforms Limited, ITC Limited and NCDEX e-Markets Limited for five pilot projects that will help farmers take decisions on the kind of crops to grow, variety of seeds to use and best practices to adopt to maximise yield.

In the next five years, the government targets \$9 billion in investments in the fisheries sector under the PM Matsya Sampada Yojana. It aims to raise fish production to 220 lakh tonnes by 2024-25.

Recognising the increasing importance of allied sectors, the Committee on Doubling Farmers' Income

(DFI, 2018) considers dairy, livestock, poultry, fisheries and horticulture as engines of high growth and has recommended a focused policy with a concomitant support system.

On the logistics front, the government came out with the Transport and Marketing Assistance scheme to provide financial assistance for transport and marketing of agriculture products to boost exports. The Ministry of Civil Aviation launched the Krishi UDAN 2.0 scheme in October last year to offer assistance and incentives for movement of agri-produce by air. It is being implemented at 53 airports, largely focusing on the Northeast and tribal regions, and is expected to benefit farmers, freight forwarders and airlines.

Issues & suggestions to boost the sector

Low fertiliser use efficiency, mechanisation of farm activities, automation of irrigation, precision agriculture, post-harvest loss management, data analytics, application of digital tools and creating networks that connect all stakeholders are areas that need attention by innovators.

With farming consuming 80 per cent of water, water tables in many states have significantly dropped in the last decade, and therefore, the availability of water for farming is becoming increasingly difficult.

The siloed data regarding weather, soil, seed characteristics, etc. available with government institutions need to be integrated on a centralised agri-data platform and made accessible to start-ups, the industry and the academia. A 'precision farming pilot fund' needs to be created to subsidise pilot studies and crop risk during data collection. Subsidy assistance for high-tech and precision farm equipment and implements could be directly routed to manufacturers.

App-based tech solutions should be developed with vernacular language interface and for lower bandwidth, typical of rural areas. The power of machine learning and artificial intelligence is yet to be fully tapped in the absence of intensive ground data.

As start-ups are now more concentrated in e-commerce of agri inputs and output, more innovation in on-field applications, non-crop sectors, financial services, nutritionally-enhanced food, plant-based biofuels, insurance services and extension advice are needed. Technology should also aid farmers with price predictions based on anticipated supply and demand conditions.

From 43 agritech start-ups in 2013 to 1,427 in 2022, NASSCOM says the sector is poised for tremendous growth and is expected to continue to grow at a rate of 25 per cent annually. Having achieved self-sufficiency in food production, India should now shift focus to raising incomes of farmers using technology, making farming convenient and reducing hassles. ■



IDEA TO MARKET

