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From the President's Desk

ICT for Sustainable Agriculture

Agricultural practices during the 20th century were based on substantial use of fertilizer, pesticides, and irrigation, but their indiscriminate use had an adverse impact on the environment. These technologies were part of the Green Revolution that helped achieve food security for the millions. However, the challenges of the 21st century are different, and in the light of limited land and water resources, agricultural intensification is a compulsion which has to be executed without adversely impacting climate change. In this endeavour, Sustainable Agriculture (SA), next-generation cropping systems that couple biologically-based technologies (plant-beneficial microbes, cover crops), Precision Agriculture (PA) and Conservation Agriculture (CA) need to be developed to optimise inputs use while increasing conservation effectiveness to maintain sustainable production. Crop cultivars with enhanced nutritional content and enhanced tolerance to abiotic (drought, salinity, heat, etc.) and/or biotic (disease) stresses need to be developed using advanced breeding and biotechnological approaches. The development of these cropping systems must be based on the concept of PA and CA and use of technology with the capacity to manage and disseminate accurate data and information at all levels of the agricultural ecosystem. For these systems, the major emphasis is on information systems and their ability to support a variety of characteristics of precision and conservation agriculture.

In view of complexity of the above agricultural production systems, there is a need to manage data spatially, which has traditionally been in the domain of Geographic Information Systems (GIS). For example, for correct application of fertilizers, water, and pesticides; manage drainage and water runoff; reduce movement of agrochemicals; and the right management practices at on-farm and off-farm level, the use of geospatial data and sensors for maximising crop yield is required. The precision and conservation agriculture practices, in fact, guide the farmer to treat the production field as the heterogeneous surface on account of fertility, water, plant pathogens, slope, surface runoff, drainage, etc., which are all highly variable throughout the field instead of as a homogeneous surface as it was treated in the past. With increased adoption of precision and conservation agriculture by farmers, demand will come for increased development and marketing of tools for the adoption of technology. Advanced sensors and systems that deliver decision support tools directly to the farmers will be required, allowing real-time decisions on the delivery of appropriate rate of inputs (water, fertilizers, pesticides). All this needs to be done on priority with adoption of scientific technology. In other words, the emphasis will be on recognition of the ecosystem services provided instead of food production (provisioning services) only.

For the last several decades, Information Technology (IT) has been used extensively in industries for eliminating out market inefficiencies through automation and better decision support tools that require the inclusion of both the producers and consumers in the process. Like industries, IT has also been used in agriculture but not at the pace it is required. There are some examples in the use of agricultural machinery, tractors and concepts of precision and conservation agriculture. However, recent advances in computing infrastructure, sensor technology, big data, and advanced algorithms suggest that a major disruption and paradigm shift is on the horizon, leading to opportunities for precision agriculture entering the mainstream in a smart way. IT also holds the key for accelerating knowledge transfer from the lab to the farmer. Eventually, a system based on these new technologies will be needed for mass transfer of genomic and other genetic data for the development of these advanced crop cultivars, management of agronomic data, and development of these next-generation production systems. Data generated from these production systems are inherently geospatial in nature. Agricultural field crop production inputs and conservation management to achieve sustainable systems can vary considerably over space and time. Therefore, monitoring crop and environmental performance will depend greatly not only on traditional methods of Earth Observation (EO), but also data generated in situ (i.e., ground truth). Hence, geospatial solutions based on imagery from EO at all scales integrated with sensor networks will increasingly become critical for the operation of precision agriculture systems where resource inputs are applied at precise geo-specific field locations based on crop needs. To accomplish this, we need a "system of systems" approach for building a scientific network that integrates the scientific and farming communities, based on a common, global IT platform (i.e., the cloud).

As smart machines and sensors crop up on farms and farm data grow in quantity and scope, farming processes will become increasingly data driven and data enabled. Rapid developments in the Internet of Things (IoT) and cloud computing will lead to Smart Farming (SF). While precision agriculture is just taking in-field variability into account, smart farming goes beyond that by using management tasks not only on location but also on data enhanced by context and situation awareness, triggered by real time events. With many technological innovations in mind, it is possible to bring significant changes by application of Big data techniques in smart farming through use-adapt mechanism. Use - because there is a need for new technology to achieve sustainable agriculture. Adapt - because new technology enables farmers or organisations to achieve higher or new goals. From the income point of view, farmers are seeking ways to improve profitability and efficiency on the one hand looking for ways to reduce their costs and on the other hand obtaining better prices for their produce. Therefore, they need to take better, more optimal decisions and improve management control. Future development has to be centered on the Internet of Things (IoT) in which all kinds of devices – smart objects- are connected and interact with each other through local and global, often wireless network infrastructure. Precision agriculture can be considered as an exponent of this development and is often mentioned as an important driver of Big Data. This is expected to lead to radical changes in farm management because of access to explicit information and decision making capabilities that were previously not possible either technically or economically.

Although precision agriculture has been talked about for long time but the adoption of the technology has been slow. The reason for poor adoption is due to the "growing complexity of adoption in the use of information technology" and the fact that "incomes in agriculture are generally low and young generations seek their prosperity in cities," implying that those with technical prowess are heading to the cities for hi-tech jobs that pay better. As precision agriculture is expensive, it is mostly implemented on larger farms which can afford the complex and changing technology. There are several reasons for limited adoption including culture in the farm community, skills, current information management processes, etc. Perhaps the biggest reason, until recently, has been the limitations of both the technologies and agricultural systems models used to support precision and conservation agriculture. It is further visualised that "many advances in data, information and communication technology of the past decade have not been fully exploited, because of the under investment in agricultural research, particularly in non-proprietary public good research, and in research aiming to improve the well-being of poor, smallholder farm households."

The other reasons for limited use of IT industry in agriculture are lack of standards, non-scalable systems, cost of sensors, and limited support from governments. Although there was some adoptions of remote sensing in agriculture through various programs but it has not served the bigger objectives. Effective farm management decisions, such as weed detection and management, require imagery with a spatial resolution in the order of centimetres and, for emergent situations (such as to monitor nutrient stress and disease), a temporal resolution of <24 h are required. The moderate resolution satellites, which were primarily designed for answering scientific questions, haven't always focused on the appropriate spectral bands (e.g., red edge band) for agriculture or frequency of data acquisition to make it easy to monitor crop growth during the growing season. These satellite networks are however recognized as the original generators of big data and represented a compromise or trade-off between spatial resolution and storage capacity. In recent years, commercial satellites, which serve a variety of markets beyond agriculture, have promised to fill the gaps made from the public-sponsored platforms. However, the cost and complexity of using these data have been limiting factors at the farmer level. As a result much of the use of remote sensing data has come in the past from aerial platforms and now from drones carrying small sensors focused on frequent observations over the growing season.

In addition to the difficulty arising from a variety of remote sensing data from multiple sensors, the lack of a comprehensive backbone for high-bandwidth transmission of data to remote farm areas has limited the ability of the exchange of data between the farm and value-added services. This will also be a very costly proposition for small farm operations in low-income countries and will have to rely on alternative architectures that utilize local sensor networks. It is felt that "The realization of 'Big Data's' value will not happen until the data transfer bandwidth barrier is overcome." Given the variety of data and limitations of bandwidth in many farming communities, it's not surprising that data management has also been an issue. The systems, while good at disseminating data, still require extensive and complex knowledge of a variety of satellites and sensors, file formats, meta data standards, physics, etc. In short, it still does require considerable expertise to gain any significant agricultural benefits from these systems. While data silos are not inherently a problem per se, techniques including those from analytics, AI and Machine Learning, require that quality data be readily accessible, coherent, and consistent before these algorithms can provide any value. In the end, the variety of data formats, speed of data coming off of a variety of platforms, and volume of data generated have led to a fragmented and siloed data management infrastructure for agriculture. In other words, this is a Big Data problem, which is formally defined as a combination of variety, speed and quantum of data. Given the inherently spatial nature of agriculture and remotely sensed data, GIS offers the opportunity to minimize data silos by providing spatial context (i.e., maps) around data. These challenges made it difficult to apply analytic techniques comprehensively such as yield forecasting and all the other advanced techniques tried in the scientific literature.

For incorporating the increasing impact of climate change, the next revolution in precision agriculture and conservation agriculture in general will be driven by technologies combined with Big Data analytics. To accomplish this transition, automation and the use of Artificial Intelligence (AI), Internet of Things (IoT), drones, robots, and Big Data will serve as a basis for the development of site-specific conservation and management practices that will increase incomes, reduce cost, and enhance the sustainability of agricultural systems in an eco-friendly manner.

Panjab Singh
President

109th Executive Council Meeting

The 109th meeting of the Executive Council (EC) was held on September 13, 2019 under the Chairmanship of Prof Panjab Singh, President, NAAS, New Delhi. After a brief welcome by the President, agenda items were discussed and approval accorded wherever necessary. The EC agreed to hold XV ASC 2021 at BHU, Varanasi during February 20-22, 2021 on the theme 'Energy and Agriculture: Challenges in 21st Century'. Dr A.K. Srivastava, Vice-President of the Academy and Chairman, Conveners' Group presented the recommendations of the Sectional Committees that were endorsed by EC after detailed deliberations. Similarly, the recommendations on Pravasi and Foreign Fellowship for the year 2020 were also accepted. The Executive Council also approved the selection of 11 young scientists working in agriculture related disciplines as Associates of the Academy with effect from 1 January 2020. After examination of suggestions received from Fellowships for various vacant positions in EC w.e.f. 1.1.2020, EC shortlisted the names for seeking votes from the entire Fellowship of the Academy to fill the vacancies as per NAAS guidelines. EC also gave its approval to revise expenditure norms on brain storming sessions, grant to regional chapters, payment of DA to sectional committee members and rates for catering services.

Programmes Held

Brain Storming Session (BSS) on "Zero Budget Natural Farming-Myth or Reality" (Convener: Dr H.S. Gupta)

Taking note of the recent concerns from various corners on the issue of promoting Zero Budget Natural Farming (ZBNF) as a new/alternate technology for sustainable agriculture growth and also climate change management, the National Academy of Agricultural Sciences (NAAS), New Delhi organised on August, 21 2019 a Brain Storming Session on the subject,

chaired by Prof Panjab Singh, President, National Academy of Agricultural Sciences, New Delhi. About 70 experts representing scientists across disciplines and organisations, policy makers, industrialists (fertilizer, chemicals and pesticide, seeds), Govt. Departments, NGOs, Farmers and other stakeholders participated. After day long marathon deliberations, the following recommendations emerged:

1. The Academy endorses that India will have to prevent overuse and promote efficient use of chemicals as well as integrated nutrients (chemical and non-chemical based fertilizers) or pesticides (bio-pesticides) for minimising pollution and soil degradation for productive agriculture.
2. The Academy recognizes that the concept of Natural Farming is very old. It is to be realized that Indian food grain requirement cannot be supplemented through technologies which do not have the productivity potential, already achieved. There is no rationale in compromising in the name of unproven eco-safe claims on promoting or evaluating a technology that is bound to reduce productivity of food grains below the current level and jeopardising the nation's hard earned food security.
3. Agricultural production is based on the natural resources and balanced nutrient inputs along with plant protection technologies against biotic and abiotic stresses as required by a crop based on location and production system. There cannot be a single recommendation, ZBNF notwithstanding, which fits every location and production system in agriculture belying the science-led differentiated and disaggregated approach.
4. The Academy has reviewed the protocols and the claims of the ZBNF methodology and it was concluded that scientifically the protocol had no logical explanation or a technically definable basis for it to be considered as a feasible technological option in current agriculture. The scope of feeding the plants their requirements to maintain current productivity does not exist through the protocol of ZBNF/SPNF being proposed.
5. The data points measured during the validation process of the ZBNF technology being carried out by Indian Council of Agricultural Research and State Agricultural University have shown up that it is a non-starter for better farm income per unit area.
6. The survey in Karnataka among already established ZBNF farmers by ICAR has brought out that the farmers have already adopted the use of farm yard manure / compost/vermicompost, etc., all of which are prohibited in the protocol, and consequently, cannot be considered a validation of adoption of ZBNF.

7. India's agricultural success has essentially been due to the quality seed of new improved varieties replaced periodically as and when newer varieties are bred. Therefore, in crops like rice, wheat, bajra, maize, mustard, chick pea, arhar, mung, etc., the productivity increment has been more than doubled over the traditional varieties. The ZBNF bans the high yielding new varieties and only recommends traditional varieties or land races. The Academy recognizes that this shall be the biggest undoing of the phenomenal success achieved by Indian Agriculture, if all the production zones of the country were to adopt ZBNF with traditional varieties (whose genuine quality seeds are not available in bulk). This is likely to result into a significant drop down of the national food grain production over the years, and with increasing pressures of climate change may even drop below the half mark, landing the nation into scenarios of severe food shortages.

8. While the current projects by the *NITI Aayog* on validation of the technology or survey of impact on agriculture may be taken to its logical conclusion, it is the firm opinion of the Academy that promoting technologies which essentially rely on crop varieties that have inherently low yield potential would be detrimental to the India's resolve of meeting the SDGs, especially 1 and 2, as well as meeting the aim of doubling farmers' income.

9. The food grain produced from traditional varieties, that too under low nutrient inputs, will be characterized by low nutrient uptake-led low productivity per unit area. For example, the protein harvested from the crop will be directly affected because of low nitrogen availability under ZBNF, further reducing the already low grain protein content in the traditional varieties as can be visualized in the case of wheat. A traditional wheat variety with less than 2 tons/ha potential will provide less than 200-250 kgs of protein per hectare under ZBNF, while the improved wheat varieties under recommended fertilizer dose shall be producing 450-700 kgs/ha of protein. The country cannot afford to compromise on the nutrient supply needed to overcome the silent hunger and the unethical perpetuation of high concentration of stunted and wasted children and anaemic mothers.

10. In conclusion, the Academy is of the considered opinion that there is no scope for an incremental value gained by the farmer or the consumer through ZBNF that represents one of the many such practices followed in India prior to the 1960s when no more than 60 million tons of food grains were produced, making ZBNF a technology that lacks rationale or acceptability as a production technology. Therefore, it is recommended that the Government of India should not needlessly invest capital, efforts, time and human resources towards promoting the ZBNF on the grounds of technical infeasibility for India to explore this unproven and unscientifically proposed technology.

Brain Storming Session (BSS) on "Tropical Wilt Race-4 Affecting Banana Cultivation" (Convener: Dr (Ms) Rashmi Aggarwal / Co-conveners: Dr S. Uma and Dr R.K. Jain)

The Academy organized a BSS Chaired by Prof Panjab Singh, President of the Academy, on September 25, 2019 at NAAS, New Delhi on the topic "Tropical Race 4 Affecting Banana Cultivation" to understand the etiology and devise suitable management strategies against the virulent strain of Fusarium wilt of banana. The session was Convened by Dr Rashmi Aggarwal with Dr S. Uma and Dr Rakesh Kumar Jain as Co-convenors.

Dr Jain while presenting the genesis of the BSS, mentioned about a few silent intruders or invasive pests in the recent past affecting field and horticultural crops. He expressed his concern about the sudden epidemic of Fusarium wilt of banana in parts of UP and Bihar in 2017, which has been attributed to tropical race 4 (TR 4) that needs further confirmation. Dr Rashmi Aggarwal presented the global status of Fusarium wilt of banana encompassing history of Fusarium wilt, race profiling and their distribution, epidemiology and management including global initiatives. Subsequently, Dr R. Thangvelu from NRCB presented the status report on TR4 distribution in India and its characterization. Prof Panjab Singh in his concluding remarks expressed the need for detailed studies on various aspects of Fusarium wilt of banana for devising suitable management strategy.

During the session on "Etiology of Fusarium wilt of Banana and race status" chaired by Dr C.D. Mayee, Dr S.K. Singh (RAU, Samastipur) and Dr Chanda Kushwaha (BAU, Sabour) presented disease scenario in Bihar, particularly in Katihar and Purnea districts and studies conducted on its management. The Chairperson in his concluding remarks suggested the need for detailed survey of the banana growing areas with uniform methodology to understand the race pictures. He even suggested that FOC isolates to be sent to NRC Banana as well as IARI for proper race identification and maintenance. During the session on "Management Strategies" chaired by Dr P.K. Chakraborty, Dr S. Uma, Director, (NRCB, Trichy) presented the initiatives taken by the institute for mitigating the threat of TR 4 in the country. She also informed about the tolerant sources available against the disease, transcriptome database prepared for the host-pathogen studies and gene identification. Dr S.C. Dubey (NBPGR, New Delhi) stressed the need for quarantine measures to contain the virulent race of FOC. Dr T. Damodaran (CSSRI, Regional Station, Lucknow) presented a brief account on the demonstration of FUSICONT technology for the management of Fusarium wilt in 150 acres in Uttar Pradesh and Bihar. Dr Shailendra Rajan (CISH, Lucknow) presented a brief report on geospatial mapping of FOC TR4 in the Northern India. Dr S.K. Shukla, DGM, BCIL, New Delhi presented the banana tissue culture industry's role in mitigating banana wilt. During the concluding session chaired by Prof Anupam Varma, the participants also deliberated on etiology of Fusarium wilt of Banana, race status and management strategies in detail and formulated recommendations for immediate and long-term action.

Recommendations

Urgent/Immediate

1. A network project need to be formulated on Fusarium wilt of banana to assess distribution profile of the disease, to develop methodology for race identification and to devise suitable management options including GM technology. Further funding from National Agricultural Science Fund or DAC, Govt. of India may be explored. (Action: NRCB / IARI)
2. Contain infection of virulent race in disease affected areas in states wherever its occurrence has been reported. In disease prone areas, only one banana crop should be taken.
3. Field sanitation must be strictly implemented. Destroy the harvested plants. Diseased plant debris should be burnt.
4. Use only certified planting material.
5. Soil amendments should be tested at multi-locations.

Long term

1. Continuous disease monitoring in banana growing areas involving tissue culture companies and Krishi Vigyan Kendras. Remote sensing using drones could also be deployed.
2. Race identification and distribution in banana growing areas to identify the disease free areas.
3. Validation of ICAR-FUSICONT technology to establish its robustness.
4. Develop suitable management options including GM technologies.
5. Epidemiological studies on pathogen survival in the soil and role of irrigation on the disease spread should be conducted in scientific manner.

Activities of Regional Chapters

Mumbai Chapter

Under the auspices of the Western Chapter, Dr A.K. Srivastava, Vice President, NAAS, New Delhi, delivered a lecture on "**India's Journey from Food Security to Nutritional Security**" at the Central Institute of Fisheries Education (Deemed University), Mumbai, on 10th July 2019 on the occasion of Fish Farmers Day. Dr Gopal Krishna, Director/ Vice-Chancellor of the Institute, welcomed the Speaker, Guests, Faculty and students highlighting the importance of the occasion being celebrated all over the country by the Fisheries Departments, Colleges and Institutes. Dr Srivastava introducing the subject, dwelt on the remarkable performance by the farmers who transformed the 'Food Deficient' and 'Food Import' country in 1947 to 'Food Self-sufficient' and 'Food Export' country by 1980 by adopting the 'Technology-driven practices' that have brought about Green, White, Blue and Yellow revolutions within the last four decades. The food grain, pulses, horticulture, milk and fish production, having increased to 281.37 million tons (mt), 24.51 mt, 314.67 mt, 176.35 mt and 12.60 mt respectively, besides meat 7.7 mt and eggs 95.2 billion by 2017-18 has brought about a tremendous change in its per capita availability. While the National Food Security Act of India (2013) ensures food availability to both rural and urban population, the need now is to go ahead and target the nutritional security for all Indians.

Further, it is essential to note that climate change may lead to a reduction in agricultural productivity by 25%, decrease in per capita availability of arable land (0.09 ha by 2050), depleting water table and nutritional status of soil, increasing incidence of pests and lack of hygiene in production, storage, processing and marketing of foods would be a perennial threat involving an outbreak of food borne zoonotic diseases. There would thus be a need to produce more from less for more.

Hunger and Malnutrition: A Blot on Humanity

Despite significant increase in agricultural production and productivity, very high levels of under nutrition and malnutrition continue to persist in India in various forms such as stunting, wasting, anaemia, vitamin deficiency, obesity, etc. According to a recent estimate by UN-FAO, around 854 million people worldwide are undernourished of which about 200 million, constituting around 18-19% of the total population, are in India (Fig. 1).

According to UNICEF-WHO-WBG Joint Report (2017), the number of stunted children decreased from 198.4 million to 154.8 million during last the two decades across the world while the number of those suffering from wasting diseases increased from 30.4 million to 52 million. Children with low weight-for-height (wasting) have an increased risk of mortality.

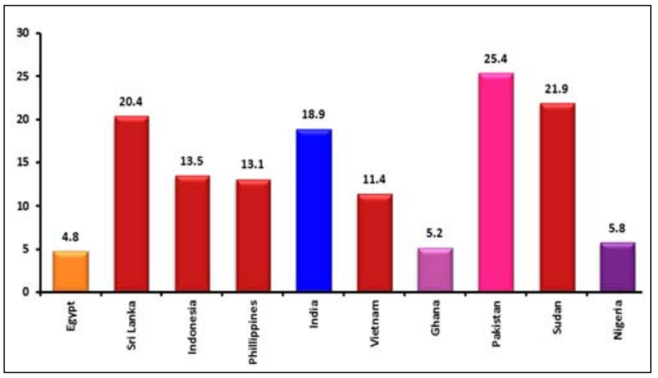

Fig. 1: Undernourishment in Total Population India vs Neighbouring Countries

Addressing the burden of wasting will require a multipronged approach including prevention, early identification and treatment. Malnutrition is the leading cause of death worldwide in children under the age of five and accounts for deaths of 2.6 million children every year and leaves millions more with life-long impairments (Fig. 2).

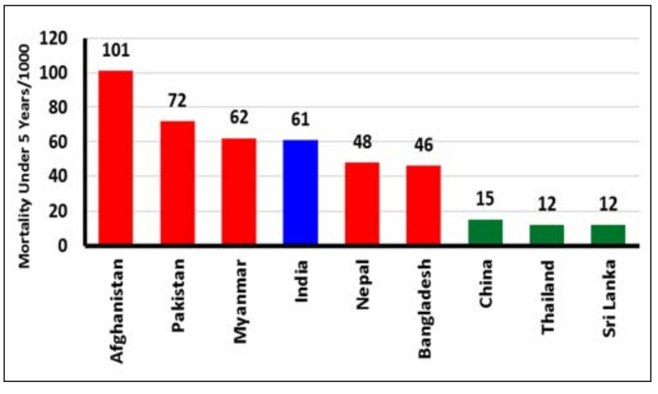

Fig. 2: Death Rates for Children Under 5 India Vs Neighbouring Countries

Hunger and Malnutrition Addressed

One of the world's largest early childhood care programme – the Pan India "Integrated Child Development Services (ICDS)" – with the main objective of supplementary nutrition to children (6 months to 5 years), pregnant women and lactating mothers was initiated in India in 1975. However, this programme became more visible when India launched the "National Nutrition Policy" in 1993 and "Mid-day Meal Scheme" in 1995. Since then the focus on nutrition is on the rise with several new schemes like National Nutrition Plan of Action (1995), National Nutrition Mission (2001), Policy on Infant and Young Child Feeding (2004), Policy on Control of Anaemia (2004), Guidelines for Administration of Zinc Supplements (Diarrhoea Management; 2007), and many others.

In 2013, India announced the National Food Security Act (NFSA) which focuses not only on food but nutritional security as well. Recently, India has also started moving in the direction of food fortification and has released a draft on Food Safety and Standards (Fortification of Foods) Regulations, 2016 followed by several consultations on fortifying various foods. In 2018, a long-awaited development was seen with the launching of the National Nutrition Mission, popularly known as ***Poshan Abhiyaan*.**

Summing up, Dr Srivastava concluded that while science-led growth and development in food and agriculture will continue to feed future India, a "Mission Mode" action is required to address malnutrition. In this regard, dairy, fishery and horticulture may play a major role as the focus now needs to shift from calorie centric to balanced nutritional diet. Lastly, he urged that we should work together towards the common National goal to provide food and nutritional security to every Indian citizen.

Dr S.D. Tripathi, Convener of the Western Chapter thanked the learned speaker and esteemed participants.

Lucknow Chapter

NAAS Lucknow Chapter in collaboration with ICAR-CISH, Lucknow organized a brainstorming meet on August 20, 2019 at ICAR-CISH, Lucknow to commemorate the success of ICAR-FUSICONT technology developed for the management of Fusarial wilt of banana and further strengthen the technology for registration, licensing and large scale adoption. under the Chairmanship of Dr P.K. Chakrabarty, Member, ASRB, New Delhi. More than 70 participants including senior NAAS Fellows, former VCs, Directors of the ICAR institutes, scientists from ICAR-IISR, ICAR-CISH, Lucknow, ICAR-CSSRI Regional Station, Lucknow, progressive banana farmers from Uttar Pradesh and Bihar, President Uttar Pradesh Kela Utpadak Sangh, Nodal officer, RKVY, Officials of State Department of Agriculture, U.P., District Horticultural Officers of state department from 20 districts of Uttar Pradesh, President, MATI Foundation, Sant Kabir Nagar, U.P. and students participated in the session.

Dr S.K. Pandey, Convener, NAAS Lucknow Chapter while welcoming the participants briefly highlighted the importance of NAAS Lucknow Chapter. Dr S. Rajan, Director (CISH, Lucknow) briefly presented the journey of ICAR-FUSICONT technology developed by the combined efforts of CISH, Lucknow and CSSRI Regional Station, Lucknow.

Some of the recommendations emerged after a thorough discussion on the issues addressing the disease survey and management in the region included:

- Creation of State Level Disease Management Committee (SLDMC) to create alert, awareness and restrict disease spread in the state of Uttar Pradesh and Bihar.
- Financial support to ICAR-CISH and ICAR-CSSRI institutes by National Horticulture Board through MIDH schemes for large scale technology transfer and implementation of ICAR-FUSICONT technology, awareness and community enabled disease management in the affected districts.
- Advise nurseries to use bio-hardening technology developed by ICAR-CSSRI and ICAR-CISH using ICAR-FUSICONT through MoU.
- Raising of disease free tissue culture plantlets in soil less media (using coir pith), disinfestations of vehicle carrying the planting material, field sanitation must be strictly implicated through official order of the State Horticulture Departments of respective States for all the nursery men and tissue culture laboratories.
- The bio-formulation ICAR-FUSICONT may be considered by the Ministry of Agriculture and Farmers Welfare for providing provisional license at the earliest based on preliminary data to enable the protection of IPR of the technology and also facilitate commercialization.

Coimbatore Chapter

A meeting of NAAS Fellows in Coimbatore was held on 24.08.2019 at ICAR-SBI, Coimbatore. Dr S. R. Sree Rangaswamy, Dr C. Ramasamy, Dr Bakshi Ram, Dr R. Visvanathan and Dr R. Viswanathan attended the meeting. The issues pertaining to the region were discussed during the meeting. The following major issues were identified:

1. Depletion of ground water and increasing salinity of soil and water,
2. Climate change issues especially on unpredictable North East monsoon,
3. Developments in food processing and value addition,
4. Agri Start-ups

Metabolic Engineering and Bio-processing for Value Addition to Agriculture

Sudesh Kumar Yadav

Center of Innovative and Applied Bioprocessing (CIAB), Sector-81, Mohali

With exceeding human population and depleting natural resources, there is need to come up with novel alternative strategies/resources which could reduce the emerging gap between demand and supply of various essential products. Metabolic engineering and value addition of agricultural produce are such dependable options.

Metabolic engineering

Redirection of one or more enzymatic reactions to improve production of existing compounds, to produce new compounds in plants or to mediate the degradation of compounds is defined as metabolic engineering. Various problems such as abiotic and biotic stress management in crops, low productivity and undesired product formation are now being addressed with metabolite engineering. However, to utilize the immense potential of this field, uninterrupted attention to understand the mechanism behind metabolic pathways and identification of key players involved in regulation is mandatory. Few efforts made in understanding the mechanisms of metabolic pathways and their significance are summarized.

Stress tolerant plants

Environmental stress (abiotic and biotic stress) is one of the major factors that limit crop productivity worldwide. Understanding of the basic mechanisms employed by plant defense system against these stresses could prove beneficial in engineering stress tolerant plants, which in turn could increase crop productivity. Various pathways are reported to play crucial role in imparting tolerance against abiotic and biotic stress. Glyoxalase and flavonoid pathways are two such pathways. The glyoxalase pathway has been explored and its role as well as underlying mechanism for providing stress tolerance has been unravelled.

During glycolysis, a highly reactive carbonyl product, methylglyoxal is produced which is highly toxic to living cells. To counter this toxic product, cells employ glyoxalase pathway. When we started working on glyoxalase pathway, limited information was available to explain how stress tolerance was imparted and what were the key players involved in this pathway. Only the role of glyoxalase I (Gly I) enzyme in various abiotic stresses was documented. The role of Gly II has been established in imparting high tolerance to methylglyoxal (MG) and salt concentration. This effect was more profound when Gly I and Gly II were pyramided. Having established that Gly I and Gly II played significant role in salt tolerance, a relationship between MG concentration and abiotic stress was documented. Upon exposure to environmental stress, accumulation of MG was enhanced in plants. Mutated or non-functional Gly I gene (having under expression of this gene) also increased the accumulation of MG under salt stress. Over-expression of glyoxalase enzymes during salt stress has been found to resist the increased levels of MG. This was further demonstrated by expressing Gly II gene in *Oryza sativa* cv PB1, a crop plant. Transformed plants resisted exceptionally high concentration of salt (upto 400 mM of NaCl) and grew well compared to control plants.

Flavonoids are one of the largest groups of plant secondary metabolites and are responsible for a variety of biological functions such as abiotic and biotic resistance, male fertility, generation of antioxidants against reactive oxygen species, production of colorful anthocyanins to attract insect pollinator. By altering the expression of enzymes involved in this pathway, end product could be controlled/ manipulated. Seedless fruit, one of the desirable traits for crop plants could be produced by silencing of flavonol synthase (*FLS*) gene without effecting flavonoid production. Interestingly, flavan-3-ols (such as catechin, epi-catechin and epi-gallocatechin) content was elevated along with increased activity of anti-oxidant enzymes while flavonol (quercetin) and anthocyanins content was decreased in *FLS* silenced plants. It has been reported that flavan-3-ols (catechins) were directly interacting with anti-oxidants enzymes (APx, GR and CAT) and provided resistance against salt tolerance and *Alternaria solani* infection. Genes encoding enzymes for flavonoid biosynthetic pathway and antioxidant pathway were under epigenetic regulation particularly DNA methylation was demonstrated by us for the first time.

A relationship has been established between anthocyanidin reductase (ANR) and anthocyanin content. ANR is an important branching point enzyme in flavonoid pathway which channelizes the intermediate flavonoid biosynthetic pathway toward flavan-3-ols biosynthesis. Individual over expression of dihydroflavonol 4-reductase (DFR) and anthocyanidin reductase (ANR) gene lead to reduced anthocyanin content and increase in flavan-3-ols proving that the pathway was being diverted towards flavan-3-ols production rather than anthocyanins. However, the combined effect of these two genes did not significantly differed from the transgenic lines expressing either *CsDFR* or *CsANR* but a better seed germination rate with unique flower color was observed. In an effort to unravel the drought resistance mechanisms in non-model plant, our group reported the comprehensive transcriptome of horse gram (*Macrotyloma uniflorum*), one of the highly drought tolerant legumes. To have better understanding of gene and protein regulatory networks for drought stress, one of a kind global protein-protein interactome (PPI) map for legumes was developed.

Commercially important plants with medicinal/ health benefits

Apart from stress resistance related studies, significant efforts have been put towards understanding of commercially important plants having medicinal/health benefits. Work has been done towards understanding caffeine biosynthesis and degradation in tea. A rapid, efficient and economical Agro bacterium-mediated root transformation system for tea was developed. A small RNA (sRNA) library was constructed to understand the regulatory mechanisms involved in tea specifically those revolving around small RNAs. A comparative transcriptome analysis of three tea cultivars varying in yield, quality and environmental sensitivities was performed to provide better candidate genes for key metabolic pathways. Caffeine content has been reduced in tea by 40-60 % through silencing caffeine synthase (CS) gene, thus providing a healthy solution to caffeine sensitive people. Similarly, understanding of steviol glycoside pathway has also been developed. Gene responsible for hydroxylation of *ent*-kaurenoicacid, a substrate for steviol glycoside synthesis was not known. A putative gene *SrKA13H* encoding for an enzymatic protein responsible for C-13 hydroxylation from *Stevia rebaudiana* has been identified and was found to be responsible for the synthesis of steviol. Further efforts have been made to understand the genetic regulation of steviol glycoside biosynthesis. For this, a gene encoding ent-kaurenoic acid-13 hydrolase (*SrKA13H*) was silenced along with three UDP glycosyltransferases (*SrUGT85C2*, *SrUGT74G1* and *SrUGT76G1*) involved in stevol glycoside biosynthesis. Silencing of *SrKA13H* and *SrUGT85C2* shifted the metabolite flux towards gibberellins biosynthesis and limited the flux towards steviol glycoside pathway.

Value addition to agriculture through bio-processing

Recently, bio-processing has gained a lot of interest because of its obvious green advantages. It focuses on utilization of biomass rather than fossil energy for the production of industrial products. Various pharmaceutical, food, flavour and chemicals are widely produced using bio-processing. Biocatalysts such as enzymes, micro-organisms, plant cell or animal cells are utilized to produce the desired products. Few process technologies developed on utilization of various agri-biomass are briefly explained.

Value addition through waste valorisation

An economical and efficient process to convert xylose from corn cob to xylitol has been reported. The developed process involves activated carbon and membrane separation technology for detoxification of acid hydrolysate. Xylitol productivity was significantly improved with a high recovery and purity. An eco friendly bio-process for producing acetic acid from apple pomace, entirely based on microbial processing without involving any commercial enzymes has been developed. Later utilizes a novel *Acetobacter pasteurianus* SKYAA25 for acetic acid production from apple pomace. Environment friendly process utilizing xylanase produced by *Acinetobacter pittii* MASK25 for the production of xylo-oligosaccharides from physically treated rice straw and corn cob was demonstrated. Furthermore, upon incorporation of enzyme into magnetic CLEA the efficiency of catalyst was increased. Another significant contribution of bio-processing is the production of bacterial cellulose. Bacterial cellulose is structurally similar to plant cellulose (PC) and is secreted in pure form free from lignin, pectin, hemicelluloses and phytate. The developed process employs a novel *Acetobacter pasteurianus* RSV-4 and utilizes various agro-forestry industries residues. A significant yield of bacterial cellulose was reported using whey, tomato juice, cane molasses and orange pulp. The produced bacterial cellulose was found to be of high purity.

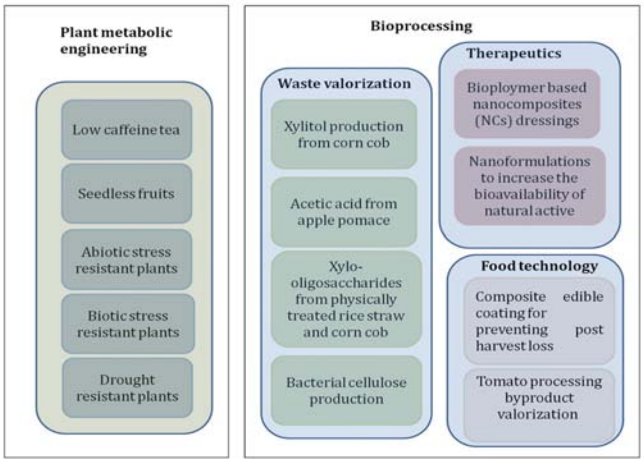

Figure 1. Selective metabolic processes and bio-processing technologies for value addition to agriculture

Bio-processing in health/medical sector

A bio-polymer based nano composites (NCs) as dressings for acute and diabetic wound repair has been developed. For this, bamboo and *Syzygium cumini* cellulose nanocrystals (CNCs) were developed to hasten the process of healing events in acute and diabetic wound conditions. The resultant NCs possessed water absorption capacity and string antibacterial activity which showed synergistic effect on *in vivo* skin wound healing and resulted in faster and significant wound closure in treated mice. Plant based extracts have various pharmaceutical properties such as hepatoprotective, anticancer, antioxidant and immune-modulating activity, but poor aqueous solubility and lesser bio-availability makes these natural extracts less efficient. Nano formulations to increase the bio-availability of such natural active plant extracts have also been developed. Technologies were developed to increase the bio-availability of some important extracts. Few worth mentioning are: Picroliv, a mixture of picroside I and kutkoside (Picroliv) from rhizome of *Picrorrhiza kurroa*; Betulin (BT), a highly effective anticancer agent; podophyllotoxin (PODO); quercetin having anticancer and antiviral properties; tea polyphenols catechin (CAT) and epicatechin (ECAT) for treating various diseases. Above studies documented the improvement in efficacy of these molecules upon encapsulation in nano particles and their use in therapeutics.

Techniques to prevent post harvest losses

Techniques are being developed to minimize post-harvest loss of agri-produce which is a major concern to achieve food security worldwide. Interventions targeting to prevent such losses and value addition practices are effective solutions. Recently, a composite edible coating has been developed to minimize post harvest decay and to reduce ripening of tomato, a climacteric fruit. Edible coatings based on commercial pectin, corn flour and beetroot powder has been reported to significantly increase the shelf life and retain quality of tomato. Concerning value addition, tomato pomace, a waste of food processing industries, is rich in fibre along with bioactive compounds and pigments and thus could be a good food ingredient for bakery products such as bread and muffin. The addition of tomato pomace in bread and muffin were found with increased nutritive value and higher consumer acceptability.

Taken together, the significant contribution towards dissemination of information could be further utilized to develop biotic and abiotic stress tolerant crops, production of secondary metabolites and pharmaceuticals. Techniques for shelf-life enhancement of postharvest crops and utilization of food processing wastes in value added products development could find potential commercial applications.

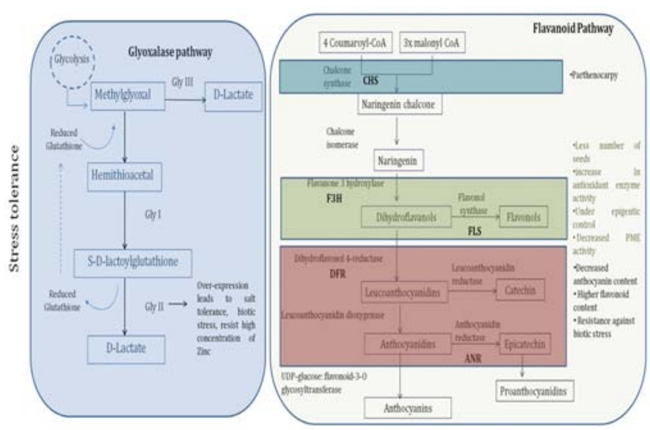

Figure 2. Importance of metabolic engineering in agriculture

Awards and Honours

Dr Brahma Singh, a Fellow of the Academy was awarded **Dr A P J Abdul Kalam Memorial NABS- Life Time Achievement Award 2018** by National Academy of Biological Sciences, Chennai during Inaugural function of 11th NABS-National Conference held at Pondicherry University, Pondicherry, India on 25th September, 2019.

Forthcoming Programmes

Topic	Convener(s)	Proposed Date
Brain Storming Session on Payment for Ecosytem Services	Dr P.S. Birthal	31.10.2019
Strategy Workshop on Food Borne Zoonotic Diseases	Dr A.K. Srivastava	21.11.2019
Brain Storming Session on Big Data Analytics	Dr Rajender Parsad	04.12.2019
Strategy Workshop on Potential of Non-Bovine Milk	Dr M.S. Chauhan	05.12.2019
Brain Storming Session on Improving Livestock Through Artificial Insemination	Dr A.K. Srivastava	06.12.2019
Strategy Workshop on Bio-fortification	Dr U.S. Singh	07.12.2019

Change of Addresses

- Dr P.K. Chakrabarty, Member, Agricultural Scientists Recruitment Board, R.No. 202, Krishi Anusandan Bhavan-I, New Delhi 110012, Tel.: Off. (011) 25840017; Cell: 9540029275, Email: pranjibc@gmail.com; member.ps@asrb.org.in
- Prof S.R. Niranjana, Former Vice-Chancellor and Chairman, Department of Studies in Biotechnology, University of Mysore, Manasagangotri, Mysore 570006, Karnataka, Tel.: Off. (0821) 2419881; Res. (0821) 2411118; Cell: 8197077637, Email: niranjanasr@rediffmail.com
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Fellows Views

Agriculture today is in direct competition with non-agricultural technocrats particularly in the area of IT and Artificial Intelligence. While people from non agricultural background like IITians, MCAs, Mathematicians, Engineers etc. have come up with superior technological interventions like microbe based coating of seeds to counter entry of pathogens, use of drone to monitor pest and disease problems and other AI based technologies not to mention about the kind of Apps to forewarn the farmers about impending weather forecast, exact date of sowing for higher yields etc., what is our preparation in the NAAS system to prepare our agri-human resources well versed and skilled with these already proven and applied technologies in selected parts of the country. These are ongoing, what we need is these PLUS. How do we prepare our faculties to resort to such teaching? Further, following the implementation of doubling farmers' income (DFI), the issue of doubling our economy from 2.86 trillion to 5 trillion has been flagged. What should be the preparation of NAAS to double agriculture sector economy within 5 years to keep this important sector of economy in driver's seat? Lastly, how do we move to facilitate achieving zero hunger by 2030 as has been focused in SDG? Do we keep on following the course curriculum most of which have become outdated or embrace a change with major orientation to commerce and technology?

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Regenerative Agriculture

In view of the global climate change, currently there is renewed interest in restorative agricultural practices that essentially increase the sequestration of carbon dioxide in the air into soil, using solar energy through photosynthesis. Using legumes as ground cover, and crop rotations it enhances nitrogen fixation and thus, helps in building the quality and quantity of soil organic matter contributing to increased moisture availability and bio-diversity. Agriculture influences all aspects of life in the world and, in turn, is influenced by them, including climate, and water availability, it currently aims to work holistically with the system for progressive improvement. Carbon sequestration is considered most important to achieve climate restoration and stability. As agriculture influences all aspects of carbon sequestration, restorative agriculture is considered most important to achieve climate restoration and stability.

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Biodegradation of Chlorinated Pollutants in Groundwater by Organohalide Respiring *Dehalococ-coides*

Groundwater is the greatest source of drinking water, besides its usage for agriculture and industrial purposes throughout the world. However, groundwater quality deterioration and supply of safe drinking water is a major concern. In India, river Ganges, Brahmaputra and Indus Basins are some of the world's largest fluvial systems, however, its distribution of usable groundwater in the region varies considerably and the presence of contaminants has constrained the continued availability of safe water. Chlorinated ethenes such as Tetrachloroethene (PCE), trichloroethene (TCE), dichloroethene isomers (cis1,2-DCE, trans-1,2-DCE, and 1,1-DCE), and vinyl chloride (VC) are ideal solvents for numerous applications, and their extensive use in industries and agriculture makes them prominent groundwater pollutants in most industrialized countries including India. According to 2010 statistics, about 38% of groundwater was found to be with chlorinated solvents. These compounds are of special concern because they are suspected carcinogens, leading to the setting of maximal admissible concentrations in drinking-water. Chlorinated solvents tend to sink to the bottom of aquifers as they are usually heavier than water, which makes solvent contaminated aquifers much more difficult to clean up than those polluted by petroleum hydrocarbons.

Reductive dehalogenationis, the main known mechanism for the anaerobic degradation of PCE and TCE, with the formation of metabolites such as DCE isomers, VC, ethene, and ethane being the major intermediates and end products. Activity of reductive dehalogenases (RDases), an enzyme present in organohalide respiring bacteria, utilizes chlorinated hydrocarbons as terminal electron acceptors. *Dehalococcoides*, which obtain energy via the oxidation of hydrogen and subsequent reductive dichlorination of chlorinated organic compounds in a mode of anaerobic respiration called organohalide respiration are, thus far, the only known bacteria capable of absolutely dechlorinating PCE and TCE to the benign product ethene, which has potential applications in the bioremediation of contaminated ground water sites. Bio-stimulation is a type of natural remediation that can improve pollutant degradation by optimizing conditions such as addition of nutrients and electron acceptors or electron donors, pH and temperature control to increase the number or stimulate the activity of indigenous micro-organisms capable of biodegradation. The primary advantage of bio-stimulation is that bio-remediation is undertaken by already present native microorganisms that are well-suited to the subsurface environment, and are well distributed spatially within the subsurface. In situations, where indigenous bacteria cannot rapidly degrade recalcitrant chemicals, bio-augmentation may be the only means for successful bio-remediation. Bio-augmentation involves the addition of laboratory grown microorganisms capable of biodegrading the target contaminant or serving as donors of catabolic genes.

Despite significant efforts to isolate *Dehalococcoides* with culture-based approaches, these attempts were not that much successful in identifying the bacterial populations responsible for the observed dechlorination. Cultivation independent based meta-genomic approaches have been used to shed light on the identity and examining diversity of the dechlorinating populations. Hence, the future research should be focused on the integration of the monitoring and identification of *Dehalococcoides* species by the presence of RDase genes as genetic markers, and bio-augmentation of PCE and TCE contaminated groundwater with the priority on exploitation of the reductive dechlorination process and finding organisms that efficiently reduce VC to ethene for environmental clean-up. This will have potential applications in improving efficiency, predictability and reliability of bio-remediation and for cleaning contaminated subsurface environments and restoring drinking-water reservoirs.

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Time to Redefine Farmer

Agriculture and agriculture communities have consistently faced challenges. These challenges have magnified in the recent past with climate change induced disasters. All the governments and scientific community have pooled the resources to address the food security. Given the type of technologies in place, the scientific community will certainly provide solutions to the issue of food security. What may come, we will bring food to the plate. Shall we be able to empower the farmers, all kind of agriculture communities, for the prosperous India? What are we solving, agriculture, means to produce food, or the status of farmer. Let's redefine Farmer!!

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Integrated Input Management (IIM) for Higher Crop and Input Productivity

The modules of integrated pest management (IPM), integrated water management (IWM) and integrated nutrient management (INM) have been developed for higher individual input management by the concerned scientists. Since, these modules are developed in isolation of each other; we need to remember that there is direct relation between nutrients and water, pests and water, pests and nutrients. These modules cannot be studied and strategized individually. There is thus, strong need to study these modules in an integrated manner under the banner of integrated input management (IIM) in a single field study. Moreover, such IIM modules need to be developed separately for different cropping systems for higher input use efficiency.

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Soil Inorganic Carbon (SIC as $CaCO_3$) Sequestration: a Hidden Treasure in Soil Eco-system Services.

Calcification is the primary pedogenic process in the Indian arid and semi-arid tropical (SAT) soils by capturing atmospheric CO_2 but immobilizes C in unavailable form in soils, which retards the emission of CO_2 from both cultivated and non-cultivated SAT soils. This fact supports the world views on no positive role of anthropogenic CO_2-increase in the global warming phenomenon. A recent review indicates that SIC is not a useless C reserve as it makes calcareous and sodic soils, resilient by supplying C a ions during the cultural practices of agricultural crops (with or without chemical ameliorants), under forest and natural grassland cover. This unique ecosystem services of SIC assume a great importance in the carbon cycle alongside coupled carbonate weathering representing an atmospheric CO_2 sink.

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Obituary

Dr Khem Singh Gill, (Sept 1, 1930 – Sept 17, 2019)

(1930 - 2019)

Born on September 1, 1930, at Kaleke village in Moga. Dr Gill graduated in Agricultural Science from Khalsa College, Amritsar in 1949 and secured his Master's degree (M.Sc.) from Punjab University in 1951. He started his career as a Research Assistant at the Department of Agriculture, Government of Punjab and later moved to Punjab Agricultural University (PAU) as Assistant Oilseed Breeder before taking a break from work to pursue his Doctoral Studies in Genetics at the University of California in 1963-66. He returned to India and joined Punjab Agricultural University as a Professor of Genetics (1966-1968). Dr Gill later became Head of the Department of Plant Breeding (1968–79), Dean of the College of Agriculture (1979–83), Director of Research (1983–87), and Director of Extension Education (1987–89). He eventually became the Vice Chancellor of PAU during 1990-1993.

Dr Gill contributed in the development of improved cultivars of linseed, sesame, and wheat and in the genetic improvement of pearl millet, barley and triticale. His researches were documented by way of over 475 scientific papers, articles, and many books. He also guided several Doctoral and Master's students. A dedicated plant breeder, Dr Gill developed more than 30 varieties of different field crops which included 17 improved varieties of wheat, five high-yielding hybrids and composites of pearl millet, three varieties of linseed, two of sesame, one of barley and two of cluster bean.

As the team leader of the Wheat Improvement Programme, Dr Khem Singh Gill did stupendous work on the development and identification of improved cultivars of wheat, which revolutionised wheat production.

Dr Gill was a Fellow of Third World Academy of Sciences, Italy; Indian Society of Agricultural Sciences; Indian National Science Academy; President, Indian Society of Genetics and Plant Breeding (1982); Senior Vice-President of International Triticale Association, Australia and Brazil; The Genetic Association of India; founder member, National Academy of Agricultural Sciences, India and International Federation for Women in Agriculture; and Founder President, Crop Improvement Society of India.

Dr Gill was decorated with several awards, including Padma Bhushan, by the Government of India in 1993, Rafi Ahmad Kidwai Memorial Prize in 1976, National Professor of Eminence (ICAR), Team Research Award by ICAR, Appreciation Award by the United States Department of Agriculture, Washington, FICCI Award, Fellow, Academy of Sciences for the Developing World (TWAS), Medal for Wheat Research and as trustee of the board by the Mexican Government, CIMMYT, Mexico.

Dr Khem Singh Gill breathed his last and left for heavenly abode on September, 17 2019. In the demise of Dr Gill, the NAAS has lost an esteemed Fellow and an acclaimed agricultural scientist and administrator. The entire Fellowship mourns his sad demise and pays homage to the departed soul.

Editors: Dr V.K. Bhatia and Dr Kusumakar Sharma

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