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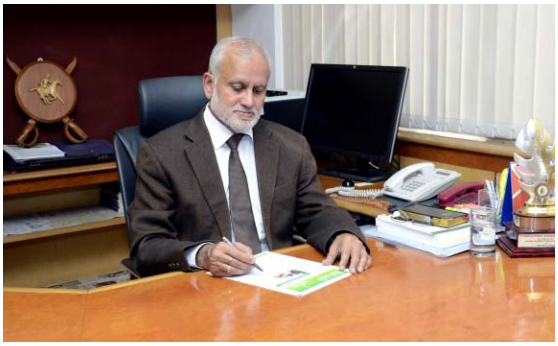
From the President's Desk

Blue Economy: Farming the Seas



Indian agriculture, deriving from both terrestrial and aquatic resources, has significantly diversified the food basket, and as mentioned in one of the previous articles, addressed the starch to protein paradigm. 'Look to the Seas' has become an attractive option and approach for diversifying food production systems, as well as appreciating the ecosystem services. Oceanic influence on human development goals is historically significant from the seafarers to the pursuit of global maritime trade, commerce and industry. Having recognized the fact that oceans are a resource for hydrocarbons, metals, minerals and bioresources, these shall be the next generation source for economic growth in the coming years.

The UN-Millennium Development Goals emphasized the use of oceanic resources, which gave birth to the concept of 'Blue Economy'. Dr. Gunter A. Pauli, in his book, 'The Blue Economy: 10 years-100 innovations-100 million jobs', brings out the potentials of ecosystem-oriented business, that would be sustainable and balanced. Spread from Australia to South Africa with several marginal seas, gulfs and straits, Indian Ocean is the warmest and third largest ocean on our globe. The Blue Economy has become an ideology for many Asian countries with ocean rims, since Indian Ocean has 20% of global oceanic waters. The Indian Ocean Rim Association, IORA, is an active group of 23 countries that sustains narratives on Blue Economy. The economic development of coastal region of our country is strongly influenced by the multi-dimensional utilization of marine resources.

With over 8,129 km long coastline and 2 million square km of Exclusive Economic Zone, along with the island territories of Lakshadweep and Andaman & Nicobar islands, India has a wide oceanic biodiversity as well as opportunity in utilizing the same for food, trade, tourism and livelihoods. Also, over 3,300 coastal villages attract attention in the context of threats of natural disasters. The coastal agri-ecosystem covers over 14% of the population and contributes nearly the same to the food basket. Fisheries and coastal aquaculture has been a sunrise sector, which contributes nearly 5% of the AgGDP, provides livelihood for 14 million people and gives over 10% of the agri-exports. However, the asset base of the coastal waters has been eroding,

because of overfishing, pollution from land-based sources, mangrove deforestation, climate change and ocean acidification. Hence, realizing the full production potential requires a paradigm shift to embrace a new, responsible and sustainable approach that is more environmentally, socially and economically effective.

Economic activities in the oceans include shipping, mining, oil, gas and energy, along with the bioresource utilisation, particularly fisheries, as being discussed. The aim of an overarching Blue Growth strategy is to assess the carbon footprints that these cause in the ecosystem and also devise ways and means to mitigate the cumulative impact of these economic activities on the living aquatic resources, biodiversity and ecosystem services. India has been pursuing a Blue revolution, through technologies and investments, though much more needs to be done apart from fishing, in terms of using the bioresources for bioactive compounds, feed and pharmaceuticals. As for example, the marine algae and seaweeds are highly sought after, for being used in nutraceuticals, medicines, cosmetics and so on.

The seas are beckoning to be explored in all their dimensions, potentials to be harnessed, and resources to be utilized. In several areas, particularly in the island systems, there is much to be invested and benefited. Resource management with due reference to availability and access, diversification, value addition, along with the international agreements, is the key requirement in the strategy. There are multiple agencies engaged in different activities in the marine ecosystem that need a holistic approach and synergy in these efforts. Deployment of new tools of ocean science, greater research intensity, higher investments and convergence of players, along with the community living with the seas for times immemorial, in a value chain approach, would pay dividends in the Blue economy of the country.

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For Kind Attention of the Fellowship

- The distinguished fellowship of the Academy may stay informed that the Annual General Body Meeting and Foundation Day Lecture are scheduled to be held on 4th and 5th June 2016, preceded by a Day-long Meet on 'Farmers' Welfare' on 3rd June, 2016. Please make it convenient to participate in the events.
- Commemorating the International Year of Pulses-2016, the NAAS is organizing a 'Strategy Workshop: Towards Self-sufficiency of Pulses in India' in collaboration with Indian Council of Agricultural Research, during 7-8 April, 2016.
- The XIII Agricultural Science Congress is scheduled to be held at University of Agricultural Sciences, Bengaluru, during 07–10 February, 2017. The theme of the Congress is CLIMATE SMART AGRICULTURE. The details of the Congress can be viewed at www.agricongress2017.in, which will be continuously updated with latest information.
- The Fellowship of the Academy is requested to enrich the NAAS News, with their innovative research thoughts and ideas, as well as Fellows' Views on researchable issues, in about one typed page.

95th Executive Council Meeting

The 95th meeting of the Executive Council of the National Academy of Agricultural Sciences was held on 16.03.2016 in the Academy Secretariat. A two-minute silence was observed in the memory of four deceased NAAS Fellows, *viz.*, Dr P. Joshi, Dr K.L. Sahrawat, Prof S.K. Sen and Dr M.V. Rao. The President, Dr S. Ayyappan, thereafter welcomed all the members and apprised the need to have an additional meeting of the council. It was decided to have four meetings in a year instead of three at present.

The Action Taken Report was discussed and approved as presented, with some suggestions. The recommendations of the Committee to review the election process of Office Bearers/EC Members were discussed and the revised rules would be submitted to the General Body for further consideration and approval. A committee was constituted to look into the earlier decision of the EC to re-introduce new section on 'Frontier Sciences' and submit its recommendations for consideration of the EC in its next meeting. Thereafter the approval of the General Body would be sought.

The EC members made suggestions about ranking of state agricultural universities for consideration of the committee. The suggestions will be sent to the Chairman of the Committee for consideration.

It was also decided that the Policy/Strategy Papers developed by the academy shall include an action plan. With regard to review all the policy papers so far published by the Academy, it was agreed to discuss the matter in the LOB meeting to screen all the policy papers and select a few of these on their merit and relevance in the present day scenario for further action. Further, the outputs of the Workshops/Brainstorming Sessions hereafter would be published under different categories, *viz*., Policy Paper, Strategy Paper, Status Paper, Introduction Paper.

The progress of the organization of XIII Agricultural Science Congress at Bengaluru was reviewed at length and it was decided to constitute a Committee to make further suggestions for improvement and strengthening the proposed programme. The EC members were also requested to send suggestions, if any, within a week's time including a list of prospective speakers for various Technical Sessions in their field of specialization.

The President appraised about the steps/action taken by the Academy so far towards GM crops advocacy. It was decided to : (i) prepare an updated scientific document on GMOs: Issues and Way Forward, and (ii) organize communication material for the public awareness including public representatives, through a Committee.

Programmes Held

New Year Get-together

New Year get-together of Delhi/NCR based Fellowship was held on January 01, 2016 at NAAS auditorium. Dr R. S. Paroda, Chairman TAAS and Former President NAAS, Professor R.B. Singh, Immediate Past-President NAAS, Dr S. Ayyappan, President NAAS, Secretary DARE and DG, ICAR, Professor Anupam Varma, Vice-President, Dr M.P. Yadav, Secretary NAAS and Dr K.V. Prabhu, Secretary NAAS were on the dais. The Fellowship of NAAS turned up in large numbers to participate in this annual event of the Academy. Dr Prabhu expressed gratitude to Dr R.S. Paroda for his gracious presence and thanked Professor R.B. Singh, Dr S. Ayyappan, Professor Anupam Varma for finding time to be part of this celebration. Dr M.P. Yadav, Secretary extended a warm welcome to all including the newly elected Delhi / NCR-based fellowship and associates. Dr Yadav informed the house the names of fellowship who have been elected for different vacant positions in the EC. He also introduced to the house the new fellowship elected under various disciplines and associates present. The elected fellowship outlined briefly their major scientific contributions.

Dr. S. Ayyappan, President, NAAS briefed the house about different activities / programmes executed by the academy during 2015 and sketched plans for 2016. He drew attention to the challenges in agriculture sector and

urged the fellowship to play an enabling role to achieve the set objectives. He informed the house about the resounding success of different events organized by the

Academy *viz*., 12th Agriculture Science Congress during Feb 3-6, 2015 at NDRI, Karnal followed by Silver jubilee events comprising Essay competition among the Post-graduate students of SAU's, Youth Convention, Panel discussion among NAAS-Associates, an inter-academy meeting of different science academies of the country, special lectures by eminent personalities, Prof M.S. Swaminathan, Founder Chairman, MSSRF; and Dr David Bergvinson, Director General, ICRISAT, during June 03-06, 2015. Dr Ayyappan also mentioned that the Academy had organised a number of brainstorming sessions on important thematic issues and further mentioned that the Brain-storming on 'Strategy for Future of GM Crops in India" was attended by Prof M.S. Swaminathan, Dr R.S. Paroda, Dr Manju Sharma and other important experts in the field of Biotechnology. He also shared that the celebration of Golden Jubilee of Green Revolution by the Academy on November 27, 2015 and honouring the yester-year stalwarts including the institutions that made it happen, was an important event. He stated that green revolution (GR) was a 'Harvest of Hope' and advocated that agricultural development during green revolution and post-GR was a matter of pride for the country. He further enlightened that during 2016 the Academy would hold expert consultation on pulses and legumes to mark the international year of pulses; organise identified theme based brainstorming sessions, initiate advance action to organise XIIIth Agriculture Science Congress at Bengaluru during 2017. He also shared some of the key points *viz,*. vision, practical action plan, implementation strategy, achieving goals and targets, tangible impact on common man of our technologies, relevant to agriculture, that emerged from the recent meeting of Secretaries of GoI with the Hon'ble P.M. Shri Narendra Modi Ji, held sometime in the last week of December, 2015. In this connection, Dr Ayyappan reiterated the need to improve the science communication with public and civil society. He thanked all EC members and the Secretariat for their whole hearted support and cooperation in smooth conduct of Academy business during the year 2015.

On this occasion several publications were released *viz*., State of Indian Agriculture-Soils; Status paper No.1; Policy papers 76, 77; NAAS-NEWS (December 2015 issue); Year Book 2016; NAAS-YEAR Planner 2016.

Dr R.S. Paroda, Chairman TAAS and Former President NAAS congratulated the President NAAS, EC members and the Secretariat for successfully conducting many important activities / programmes of the Academy during 2015 that have been well appreciated and in the process academy has gained esteem and importance. Dr Paroda also expressed concern that much still remains to be done and cited a large number of issues concerning agricultural development, which need to be addressed by NAAS / ICAR / GoI at various levels. He advised the fellowship to introspect on our "Agriculture Education System" and examine if it is delivering under emerging challenges? Dr Paroda highlighted the challenges of nutrition security; management of natural resources; identifying the role of women and youth in agriculture; emphasis on innovations and urged the fellowship to address these issues. The GM crop agenda needs to be settled once for all on well informed knowledge. He further stressed that NAAS fellowship should think globally but act locally, think of out of box solutions and project a unified voice on important policy issues. Dr Paroda was of the view that presently we are facing inadequacy of quality research management leadership and how to meet this challenge requires serious attention. He suggested that convergence and coordination could throw solutions.

Prof R.B. Singh, Immediate Past President, NAAS, in his remarks, while endorsing the concerns expressed by Dr Paroda, elaborated on different components of millennium development goals (MDG) and sustainable development goals (SDG). He highlighted how India has been working to achieve the specified targets under each and what remains to be done. He mentioned that we have to focus on holistic development within the ambit of AREEEE (Agriculture, Research, Education, Economy, Employment and Environment) that is hard to achieve, but we need to put in our efforts in this direction. It was emphasised by him that doing better agriculture will help in reducing the poverty; we need to promote and adopt climate smart agriculture technologies.

Several important suggestions provided by the esteemed fellowship were: (i) Academy should make available the Year Book to Kisan Channel of Doordarshan to enable programme developers to seek the services of appropriate experts in different fields of agriculture for improving the quality of programmes and they will also have consolidated information about expertise in the country; (ii) the Year Book may lay more emphasis on the area of work of each fellowship instead of his/her C.V.

Activities organized by the Regional Chapters

Karnal Chapter

A Brain Storming Session on "Targeting maximum achievable yield in wheat" was organized under the aegis of NAAS Regional Chapter, Karnal, on 19th December, 2015 at ICAR-IIWBR, Karnal under the chairmanship of Dr J.S. Sandhu, DDG (Crop Science), ICAR. The aim of the discussion was to initiate thinking about strategy for developing package and practices, identify suitable niches and to propose appropriate measures to attain and sustain high yield and production, similar to the one recently realized by some progressive farmers. There was also a discussion on whether or not

there will be a shift in the breeding strategy for developing better wheat varieties specifically targeting the high productive areas and conditions. Farmers

representing Madhya Pradesh, Uttar Pradesh, Haryana, Punjab and Bihar were invited to participate in the meeting. The initiative of Dr A.K. Srivartava, Director, NDRI, Karnal in the capacity of Convener and Dr A.K. Mohanty, Secretary, NAAS Regional Chapter, Karnal, enabled organizing such a fruitful interaction. Dr Ratan Tiwari, Principal Scientist, ICAR-IIWBR organized and coordinated the discussion. The following salient points emerged from the session:

1. Achieving yield of 6.0 t/ha is possible by properly following the seed replacement (new varieties), soil test based fertilizer (nutrient) application and other recommended agronomic practices for the area.
2. Target of 7.0t/ha can be met at individual farmer's level depending upon their crop management skills, application of organic manure, seed treatment and other input applications.
3. Getting 8.0t/ha is not an easy task and only few selected farmers having special skills, perfect timing and doses of input applications, use of growth regulators can achieve the target and that too if weather wise good crop year is there.

The actionable points that emerged are given in the sequel.

1. Weather forecasting, both medium and short term, can be very helpful in planning the crop activities so as to maximize the yield. Mobile App based information availability to the farmers shall enable them in using their inputs judiciously.
2. Soil test data, its interpretation and fertilizer application should be scheduled as per the requirement.
3. Issue of seed rate minimization and its optimum quantity for planting may vary from farmer to farmer based on their planting methods, growth habits (tillering capacity) of the variety selected and ways of intercultural operation.
4. Prophylactic measures to avoid crop losses due to possible diseases / weeds / abiotic stresses (heat, flooding / water scarcity) may be adopted. Growth regulator based sprays be tried to harness maximum possible yield.
5. Convergence of all agencies in providing timely and accurate information for the benefit of the farmers must be ensured.

Ludhiana Chapter

Dr (Ms) Madhuri Sharon, Director, Walchand Centre for Research in Nanotechnology and Bio-nanotechnology delivered a lecture on 19th January, 2016 at PAU under NAAS lecture series (Ludhiana Chapter) on the topic ***'Entry of Nanotechnology in Agricultural Arena'***.

Dr Sharon threw light on varied areas of agriculture where nanotechnology can play vital role such as in precision farming, crop improvement, nano fertilizers, nano pesticides and herbicides, soil and water management, post-harvest techniques and in food technology. She discussed the importance of carbon based nanomaterial sensors in precision farming and enhanced efficiency of nano fertilizers due to their high surface to volume ratio. The higher surface area of nanoparticle based fertilizers is expected to have enhanced probability to interact with the roots as wells as with desired microbes. She presented varied classes of carbon based nanomaterial (such as carbon nanofibres, graphenes, carbon nanotubes of required band gaps, functionalized carbon nanohybrids, etc.), which can be used for water management. Nanostructure based smart packing material, which can be edible, can repair small tears, should be lighter and stronger, have ability to respond to environmental conditions (such as temperature and moisture changes) and have food contamination alert.

Hyderabad Chapter

The Hyderabad Chapter of NAAS organized on 8th January 2016 at CRIDA, Hyderabad an invited lecture on "Crop Planning for Rainfed Agriculture" by Dr M. Velayutham, Former Director, NBSS & LUP, Nagpur. Dr K.P.R. Vittal, Former Director, NIASM, Baramati and NAAS Fellow, suggested that scientists should develop customized resource conservation technologies. Dr. Velayutham emphasized on: (1) Soil based crop and land use planning in semi-arid tropics, (2) Tailoring of crop varieties for different rainfall situations, (3) Differential nutrient recommendations based on soil test values in rainfed areas, (4) exploring the options for sustainable intensification in dryland areas.

National Science Day celebrations were organized at ICAR-CRIDA in association with National Academy of Agricultural Sciences, Hyderabad Chapter on 29th February 2016. On this occasion, a quiz competition was conducted in which Class IX students of 19 Kendriya Vidyalayas in Hyderabad participated. Each school was represented by a two-member team. The quiz programe was conducted in three rounds *viz.,* General Science, Agriculture and Rapid fire (General Knowledge). All the students participated with enthusiasm. The team from Kendriya Vidyalaya, AFC, Begumpet bagged first prize while second and third prizes were bagged by Kanchanbagh and KV - 1 AFA, Dundigul, respectively. One consolation prize was also awarded to KV - 2 AFA, Dundigul.

Dr. Ch Srinivasa Rao, Director, CRIDA gave away prizes and participation certificates. He congratulated all students for their participation and especially those who won prizes. He acknowledged the support extended by the Kendriya Vidyalaya Sanghatan administrative authorities at a short notice.

Brainstorming Session

A Brainstorming Session on Mentoring Scheme under the joint convenership of Dr S.N. Puri, Dr H.S. Gupta and Dr C. Devakumar was organized on March 7, 2016 in NAAS, New Delhi. The Session chaired by Dr S. Ayyappan, President, NAAS, was attended by Prof R.B. Singh, Prof P.L. Gautam, Prof Anupam Varma, Prof K.L. Chadha, Prof Anwar Alam, Prof M.P. Yadav, among other delegates. Dr S.N. Puri gave a brief background on the need for mentoring in NARS. He emphasized that mentoring should help to retain youth in agriculture, motivate them to take-up agricultural research, education and extension as career and felt that mentoring should also benefit the technical and administrative support in the system. Dr S. Ayyappan, in his remarks, underlined the vastness of the system *vis-à-vis* the stakeholders and the need to be more specific in targeting the mentees, both at individual and institutional levels, with in-built appropriate monitoring and evaluation mechanisms for enhanced performance.

Dr H.S. Gupta, Convener, in his presentation touched upon the definition and scope of Mentoring, its relevance to our system and if agreed, the ways and means of introducing and pursuing the scheme in the NARES. He mentioned that while mentoring has become an integral part of course curricula in western Universities in a structured way, it is yet to take roots in NARES. Considering the enormous challenges being faced in agriculture, Dr Gupta advocated that mentoring, if properly administered, would benefit our institutions to build bridges across the hierarchy levels, to empower in change management, enhance work ownership and sharing of responsibilities, retention of team members, expansion of learning ecosystem and good practices etc. This would pay dividends in terms of sustained, long-term organisational success, enhanced transfer of skills and knowledge, products and technologies, and services, cost-effective method of personality and professional development of mentees, enhanced performance and contribution, reduction of attrition and job-satisfaction of quality staff, expansion of collaboration and network. Dr Gupta highlighted the need to identify potential mentors and give them orientation training to enable them undertake mentoring in a more systematic way and properly evaluated. He

also informed about a system being practiced by the technical institutions in the country under the MHRD and advocated to use their Handbook of Mentoring and Performance Audit as a starting template for our system.

Dr S.N. Puri, Dr A.S. Dhawan and Dr V.D. Patil shared their experiences of introducing this concept in VNMKV, Parbhani.

Prof R.B. Singh focused attention on the paucity of minimum number of faculty members across the Universities and reiterated that for revamping them to meet the challenges emerging from within and abroad, the mentoring is a welcome idea. He outlined the need to expand the scope of STEM to STEAM by encompassing agriculture and after standardizing the scheme, scope exists to internalize it within our course curricula. Dr P. Bapaiah informed that this scheme is being sponsored by DST benefitting the students in IISER, Mohali and similar provisions exist under its INSPIRE programme. He mentioned that HRD Ministry is funding such initiatives under its GIAN programme. Therefore, Academy may also explore possibility of funding such programmes. Prof K.L. Chadha advocated the introduction of the schemes in selected institutions with long term objectives that can be tangibly measured. Prof Anwar Alam advocated for a simple scheme so that its execution and evaluation is easy to begin with. Dr P.K. Joshi elaborated on the use of success stories, case studies, book reviews, and biographies of Noble Laureates so that the mentees could be motivated. Many experts immensely contributed to the deliberations.

While concluding, Dr S. Ayyappan advocated the necessity of developing a strategy paper and a presentation during the Foundation Day events. He also suggested that by developing suitable questionnaire, NAARM may start compilation of database of mentors involving a reliable number of 100 case studies. Dr C. Devakumar proposed a formal vote of thanks to the Chair, all experts, and the NAAS Fellowship for participation in deliberations and valuable inputs during conduct of BSS.

Durable Insect Resistance in Crop Plants

J. S. Bentur[1]
Fellow NAAS

Rice – gall midge system

The maggots of the Asian rice gall midge, *Orseolia oryzae* (Wood-Mason), feed on the apical meristem staying within the plant, as a result of which the plant growth and development are severely affected. A tubular leaf sheath gall is formed suppressing panicle and grain formation. Average annual yield losses have been estimated to be worth about Rs. 2 crores. Since, the insect is an internal feeder, foliar application of insecticides is generally not effective in controlling the pest. Since the 1960s emphasis has been on breeding gall midge resistant rice varieties utilizing a handful of reported resistant genotypes. The first gall midge resistant rice variety Kakatiya was released for commercial cultivation in 1975. Since then over 100 rice varieties have been released and over 400 rice germplasm have been reported to be resistant to the pest (Bentur et al., 2012). Use of resistant varieties as the sole management strategy against this pest has stood out as a rare success story. This is because the resistance is simply inherited with a single major gene and resistance is of immunity level. Paradoxically, these very features have brought out the inherent limitations of the approach - durability of resistance. Even during the early phase of breeding for resistance, existence of geographically distinct gall midge populations (biotypes) was reported (Bentur et al., 2003). A set of resistant accessions of germplasm found resistant at Warangal in Andhra Pradesh was observed to be susceptible at Sambalpur in Orissa state. More concerning, however, have been the reports of emergence of new virulent biotypes in response to widespread cultivation of the resistant rice varieties (Bentur et al. 1987, Vijayalakshmi et al., 2006). With greater understanding of inheritance of gall midge resistance, genetic relationship between plant resistance genes and biotypes became evident.

Resistance genes and biotypes

Concerted efforts at Indira Gandhi Krishi Vishwavidyalay (IGKV), Raipur, unveiled the genetics of gall midge resistance leading to characterization of ten distinct major genes (Kumar et al., 2005). These genes have been designated as *Gm1* through *Gm10*. All except *Gm3* are dominant genes. Subsequently, another dominant gene *Gm11* was identified from the rice culture CR57-MR1523 (Himabindu et al., 2010). Even during the early stages of breeding for resistance, existence of gall midge biotypes was reported. Initially, the variations in reaction noted against sets of gall midge resistant rice lines was explained with characterization of three distinct gall midge biotypes (Kalode and Bentur, 1989). As the gall midge resistance genes were characterized

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and new virulent biotypes were reported, genetic basis of GMB became evident. So far seven distinct gall midge biotypes have been characterized on the basis of their reaction against rice differential lines carrying one of the 11 resistance genes (Table 1). More studies helped to group these lines into five distinct groups with some groups having more than one rice lines carrying different R genes. While this suggested common spectrum of resistance of these genes across the biotype spectrum, other studies brought out diversity in nature of resistance conferred by R genes (Bentur and Kalode, 1996). Resistance conferred by majority of the R genes is accompanied by expression of tissue necrosis, which is typical of hypersensitive reaction (HR) often reported in plant – pathogen interactions. Exceptionally, however, two of the genes viz., *Gm1* and *Gm8* displayed resistance without the expression of HR (Fig. 1). A close look at this grid of 11 plant resistance genes with diverse nature of resistance and response of the seven gall midge biotypes against these brings home the fact that none of the genes conferred resistance against all the reported biotypes of the pest and, conversely, none of the biotypes displayed virulence against all the reported plant resistance genes. It further could facilitate detection and characterization new R genes and

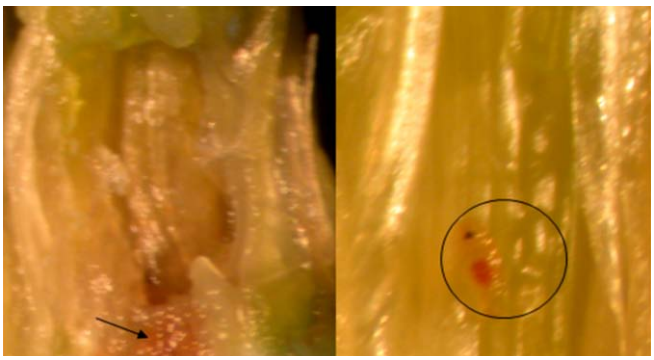

Figure 1: Expression of gall midge resistance in rice variety carrying HR+ type of R gene (left) with extensive tissue necrosis (arrow) and in rice variety carrying HR- type of R gene (right) without the expression of HR. Dead maggot seen in circle

biotypes. Further, studies on genetics of virulence reported so far (Bentur et al., 1992; Behura et al., 2000) suggest a single recessive gene, either sex linked or autosomal, responsible for virulence against the specific plant R gene. Thus a gene-for-gene relationship is evident between rice R genes and gall midge biotypes. Following the advances in molecular marker technology all most all of the gall midge resistance genes have now been tagged and mapped paving the way for pyramiding of R genes at discretion.

Table 1: Characteristic reaction patterns of the seven gall midge biotypes (GMB) against the set of 11 gene differential rice varieties showing diverse nature of resistance

Group	Designation	R gene	Nature of resistance	Reaction against gall midge biotype						
				GM B1	GM B2	GM B3	GM B4	GM B5	GM B6	GM B4M
I	W1263	*Gm1*	HR-	R	S	R	S	R	R	S
II	Phalguna	*Gm2*	HR+	R	R	S	S	R	S	S
	ARC5984	*Gm5*								
	Dukong6	*Gm6*								
	RP2333-156-8	*Gm7*								
	Madhuri L9	*Gm9*								
	BG380-2	*Gm10*								
III	CR57-MR1523	*Gm11*	HR+	R	R	R	R	S	S	S
IV	RP2068-18-3-5	*Gm3*	HR+	R	R	R	R	S	S	R
	Abhaya	*Gm4*	HR+							
	Aganni	*Gm8*	HR-							
V	TN1	None		S	S	S	S	S	S	S

Source: Bentur et al. (2011)

Mapping gall midge resistance genes

Collaborative research efforts initiated by International Center for Genetic Engineering and Biotechnology (ICGEB), New Delhi with Directorate of Rice Research (DRR), Hyderabad and IGKV, Raipur culminated in tagging and mapping of eight of the 11 R genes (Fig. 2). While chromosome 4 has a cluster of closely linked resistance genes like *Gm2, Gm3, Gm6* and *Gm7,* chromosome 8 carries *Gm4* and *Gm8* genes located distinctly apart. *Gm1* has been mapped on chromosome 9 and *Gm11* on chromosome 12 (Yasala et al., 2012). With reliable closely linked and flanking PCR based SSR markers available for these R genes, Marker Assisted

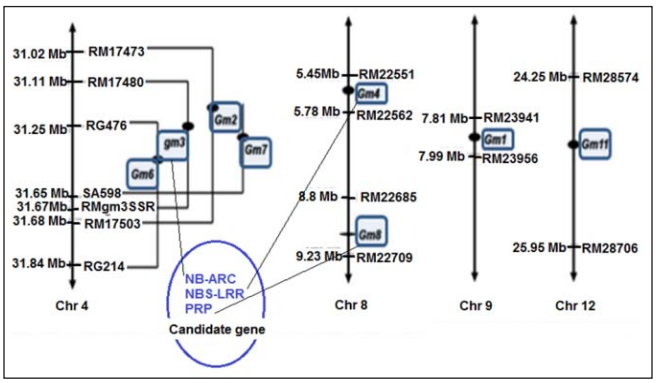

Figure 2: Eight of the rice gall midge resistance genes mapped and linked SSR or functional markers identified (modifies from Yasala et al., 2012)

Selection (MAS) and breeding was initiated to develop gene pyramids in the background of elite rice cultivars (Sama et al., 2014). It is postulated that pyramiding of two or more of the R genes in a single plant would not only confer wide spectrum of resistance across the gall midge biotypes but would also provide durable resistance (Cohen et al., 2004). While it is much easier to predict spectrum of resistance conferred by pyramiding two diverse genes pertaining to two different groups shown in Table 1, it is much difficult to predict durability of resistance.

Durable gall midge resistance

Adaptation against host-plant resistance is yet another instance of co-evolution between the insects and plants. The process is driven by initial frequency of allele of the gene conferring adaptation, nature of inheritance, fitness cost of the trait and intensity of selection pressure. Adopting the modified F^2 screen method in a study spanning eight years, it was demonstrated that though in a gall midge population at Warangal initial frequency of *avrGm2* allele (conferring virulence against Gm2 gene conferred plant resistance) was relatively low, its rate of selection was faster than the *avrGm1* allele (Bentur et al., 2008). Thus it is now feasible to determine the durability of R gene prior to it deployment in the field. Further studies on genetics virulence and fitness cost will refine our estimate. Models developed for testing strength of different strategies in prolonging the resistance in field (Cohen et al., 2004) have suggested pyramiding two or more genes that are undeployed and differ in their mechanism of resistance to be an effective solution. Our continued studies on molecular basis of gall midge resistance have established HR+ type of resistance (Rawat et al., 2013) to be distinctly different from HR- type resistance (Rawat et al., 2012). Thus we suggest pyramiding of *Gm3* with *Gm8* or *Gm4* with *Gm8* to be our best bet to confer durable gall midge resistance.

Conclusions

From our understanding of rice-gall midge system, it is imperative that durable insect resistance in crop plants is now within the domain of the proper planning and execution. Basic knowledge on genetics and nature of resistance coupled with population genetics studies to note virulence composition in target pest population are the prerequisites. Following marker assisted backcross breeding (MABB) approach popular mega varieties of the crop can be 'improved' with multiple and durable pest resistance.

References

Behura, S.K., Nair, S., Sahu, S.C. and Mohan, M. (2000). An AFLP marker that differentiates biotypes of the Asian rice gall midge (*Orseolia oryzae,* Wood-Mason) is sex-linked and also linked to avirulence. *Molecular Genomics and Genetics,* **263,** 328-334.

Bentur, J.S. and Kalode, M.B. (1996). Hypersensitive reaction and induced resistance in rice against Asian rice gall midge *Orseolia oryzae*. *Entomologia Experimentalis et Applicata,* **78,** 77-81.

Bentur, J.S., Srinivasan, T.E. and Kalode, M.B. (1987). Occurrence of a virulent rice gall midge (GM) *Orseilia oryzae* Wood-Mason biotype (?) in Andhra Pradesh, India. *International Rice Research Newsletter,* **12,** 33-34.

Bentur, J.S., Pasalu, I.C. and Kalode, M.B. (1992). Inheritance of virulence in rice gall midge, Orseolia oryzae. *Indian Journal of Agricultural Sciences,* **62,** 492-493.

Bentur, J.S., Pasalu, I.C., Sarma, N.P., Prasad Rao, U. and Mishra, B. (2003). Gall midge resistance in Rice. DRR technical Bulletin. Directorate of Rice Research, Hyderabad, pp.20.

Bentur, J.S., Cheralu, C. and Rao Ram Mohan, P. (2008). Monitoring virulence in Asian rice gall midge populations in India. *Entomologia Experimentalis et Applicata,* **129,** 96-106.

Bentur, J.S., Padmakumari, A.P., Jhansilakshmi, V., Padmavathi, Ch, Rao, Y.K., Amudhan, S. and Pasalu, I.C. (2011). Insect resistance in Rice. DRR Techncial Bulletin. Directorate of Rice Research, Hyderabad, pp. 86.

Cohen, M.B., Bentur, J.S. and Gould, F. (2004). Durable deployment of gall midge resistant varieties. pp.153-164 In : Bennett J, Bentur JS, Pasalu IC and Krishnaiah K (Edt.) New Approaches to Gall midge Resistance in Rice – Proceedings of the International Workshop, 22-24 November 1998, Hyderabad, India.

Himabindu, K., Suneetha, K., Sama, V.S.A.K. and Bentur, J.S. (2010). A new rice gall midge resistance gene in the breeding line CR57- MR1523, mapping with flanking markers and development of NILs. *Euphytica,* **174,** 179-187.

Kalode, M.B. and Bentur, J.S. (1989). Characterization of Indian biotypes of the rice gall midge *Orseolia oryzae* (Wood- Mason) (Diptera: Cecidomyiidae). *Insect Science and its Application,* **10,** 219-224.

Kumar, A., Jain, A., Sahu, R.K., Shrivastava, M.N., Nair, S.and Mohan, M. (2005). Genetic analysis of resistance genes for the rice gall midge in two rice genotypes. *Crop Science,* **45,** 1631–1635.

Rawat, N., Neeraja, C.N., Sundaram, R.M., Nair, S. and Bentur, J.S. (2012). A novel mechanism of gall midge resistance in the rice variety Kavya revealed by microarray analysis. *Functional and Integrative Genomics,* **12,** 249-264.

Rawat, N., Himabindu, K., Neeraja, C.N., Nair, S. and Bentur, J.S. (2013). Suppressive subtraction hybridization reveals that rice gall midge attack elicits plant-pathogen like responses in rice. *Plant Physiology and Biochemistry,* **63,** 122-130.

Sama, V.S.A.K., Rawat, N., Sundaram, R.M. Himabindu, K., Naik, B.S., Viraktamath, B.C. and Bentur, J.S. (2014). A putative candidate for the recessive gall midge resistance gene *gm3* in rice identified and validated. *Theoretical and Applied Genetics,* **127,** 113-124.

Vijaya Lakshmi, P., Amudhan, S., Hima Bindu, K., Cheralu, C. and Bentur, J.S. (2006). A new biotype of the Asian rice gall midge *Orseolia oryzae* (Diptera: Cecidomyiidae) characterized from the Warangal population in Andhra Pradesh, India. *International Journal of Tropical Insect Science,* **26,** 207-211.

Yasala, A.K., Rawat, N., Sama, V.S.A.K., Himabindu, K., Sundaram, R.M. and Bentur, J.S. (2012). *In silico* analysis for gene content in rice genomic regions mapped for the gall midge resistance genes. *Plant Omics Journal,* **5,** 405-413.

Forthcoming Programmes

1. Abiotic Stress Management with focus on Drought, Flood and Hailstorm
2. Food and Nutritionally Secure India by 2030
3. Biotic Stresses (Plant, Live-stock & Poultry, Fisheries, Weeds)
4. Agricultural Extension Research
5. Strategies for Enhancing Total Factor Productivity
6. Towards Self-sufficiency of Pulses in India

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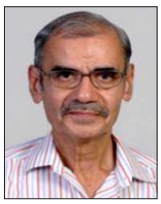
Obituaries



Dr Kanwar Lal Sahrawat

The scientific community of National Academy of Agricultural Sciences, New Delhi is saddened and shocked to know about the untimely demise of Dr Kanwar Lal Sahrawat on 3rd February, 2016. Dr Sahrawat was born on 7th November 1941. He initially served ICRISAT as a Soil Chemist from February 1978 to December 1991 in the Resource Management Programme. Later on, he moved to West Africa Rice Development Association (WARDA) to work as Principal Soil Scientist and worked from April 1991 to June 2001 in the Rainfed Program. Later, he joined at ICRISAT-India as a Consultant/Visiting Scientist and worked from May 2002 till February 2016. As a soil chemist, he played an important role in standardizing and comparing different methods of analysis by using conventional and state of the art technologies. As a scientist, his role was to conduct research in the areas of soil chemistry and fertility in the semi-arid tropic soils with emphasis on the role of sulphur and micronutrients on crop production under dryland agriculture. He also played a major role in preparing the soil fertility atlas to help showcase various types of soils and their deficiencies. He inspired and groomed several youngsters who worked with him for their post graduate, doctoral and post doctoral programmes at ICRISAT.

Dr Sahrawat received several awards and honorary positions. In 1974, he was awarded the Seth Lachhi Ram Chudiwala medal by the Indian Agricultural Research Institute, New Delhi. He had held the position of an Adviser for the International Foundation of Science, Stockholm, Sweden since the year 1998. Being a keen writer, Dr Sahrawat had contributed to 186 refereed journal articles and authored more than 100 publications, book chapters, research bulletins and workshop proceedings.

Dr Sahrawat was a warm, gentle, honest, and hard-working human being with highest degree of humility; who was considered a friend to many and a mentor to all who had the good fortune of knowing him. The NAAS family convey their sincere condolences to his family members who are in grief, loss and mourning.

Dr M.V. Rao

An internationally renowned agriculture scientist and one of the key proponents in spearheading the India's 'Green Revolution' in the country, Dr Mangina Venkateswara Rao, passed away in the night of Tuesday, March 10, 2016 in Hyderabad. He was 88 years old and is survived by his wife, a son and two daughters.

Working in the company of Nobel laureate Prof Norman Borlaug, Prof M S Swaminathan, Mr C Subramanian and many others who ushered in the Green Revolution during the early 1960s, Dr Rao was involved in testing and identifying the best varieties of wheat from Mexico, which were then grown in the country and changed the agriculture scenario forever.

The golden jubilee celebrations of the Green Revolution held in New Delhi on 27 November 2015, turned out to be Dr Rao's last public engagement. He was felicitated by the Hon'ble Union Agriculture Minister, Shri Radha Mohan Singh ji, and his 30-minute address to the galaxy of scientists and fellowship drew wide applause.

Born on June 21, 1928, at Perupalem in West Godavari district of Andhra Pradesh, Dr Rao joined the Indian Agriculture Research Institute (IARI) in 1956 as an Assistant wheat breeder, after completing his Master's degree from Purdue University. He became the Coordinator of the All-India Wheat Improvement Project in 1971. He rose to the position of Special Director General, ICAR during 1986-89. He also headed the Technology Mission on Oilseed. In 1990, he served as the Agriculture Expert with World Bank. He graced the office of Vice-chancellor of the Acharya NG Ranga Agricultural University during 1991-1997.

As former Vice-President of the National Academy of Agricultural Sciences (2000-2003), he played an important role on several committees, especially chairing the Committee on the New National Seed Policy. He served as a Member of the Board of Directors

of the International Rice Research Institute (IRRI) and Member of the Wheat Advisory Committee of the Food and Agricultural Organization (FAO).

He served as a Member of the Legislative Council of Andhra Pradesh during 2008-14. A recipient of the Norman Borlaug Award and the Linker's Award, Dr Rao was also honoured with the Padma Shri by the Government of India. Prof M.S. Swaminathan, on the event of his 90th birthday (7-8-2015) celebrations in Chennai, recalled the commendable role of Dr Rao in the gigantic task of breaking yield barriers of wheat, through technologies of public research. He in his condolence message, said "Rao's contributions to the food security of our country were truly monumental".

In the demise of Dr Rao, the country has lost a leading, highly reputed and a noble Agriculture Scientist whose monumental contributions will be remembered by entire national and international agriculture fraternity for years to come. The NAAS has lost an esteemed fellow and a visionary leader. The entire fellowship is saddened and mourns his demise and pays homage to the departed soul.

Prof Soumitra Kumar Sen

An internationally renowned plant geneticist and esteemed fellow of the academy Prof Soumitra Kumar Sen passed away on Feb 08, 2016 at his Kolkata residence. Prof Sen was born on 24.10.1936 in U.K. and did his Ph.D. in Genetics from Calcutta University in 1963 and D.Sc. in 1971. He started his professional career at Banaras Hindu University in 1963 and later moved to Bose institute in 1975 where he rose to the position of Director in 1990. From there he assumed the Directorship of Centre for Plant Molecular Biology, Calcutta up to 1997. This was followed by Directorship of IIT-BREF Biotek, at IIT, Kharagpur till 2007. At later stage, from 2007 onwards, he became Advisor, ALPGE, IIT Kharagpur, where he continued till the end. This enabled him to contribute significantly and lead the growth of plant biotechnology science in the country. During 1965 to 1982, Dr Sen was decorated with several overseas awards *viz.*, Alexander von Humbolt Fellowship of Germany, Max-Planck Society Scientist, Germany, Post-doc fellowship in two universities in USA and Germany. Prof Sen produced 85 Ph.D. students and has to his credit, 145 research papers published in internationally high-repute journals. Apart from being a Fellow of NAAS, he was Fellow of INSA, Indian Society of Genetics and Plant Breeding, and Alexander von Humbolt Stiftung Germany.

Prof Sen's work in Germany on elucidation of chromosome paring during meiosis and its relationship with genetic recombination is considered as one of the pioneering studies. He, with his team, generated for the first time, protoplast derived plants in Indian mustard. Prof Sen for the first time in the country, produced stable genetically engineered major crops like rice and cotton. The insect resistant GM crop generated by his team is considered as an exemplary case of GM work that has gone to farmers' fields.

In the demise of Prof S.K. Sen, the NAAS has lost an esteemed fellow and a leader in plant biotechnology in the country. The entire fellowship mourns his demise and pays homage to the departed soul.

Editors: Dr K.K. Vass and Prof V.K. Gupta

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