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Forum

Paddy Breeding Station, Tamil Nadu Agricultural University: Glorious and Eventful One Hundred Years

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The Paddy Breeding Station (PBS) established in 1912 is located in the most graceful sylvanic environment, all around surrounded by bountiful tanks. Come South West Monsoon, the tanks and farmers around them are so busy in doing the paddy cultivation in the celubrious and refreshing weather. Till the 19th century, farmers every where were doing the rice production with their experience. Scientific and technology based expertise was then not available. In the dawn of the 20th century, the Paddy Breeding Station was established to fulfil these objectives and to backstop the farmers with scientific rice culture.

In 1906, the Agricultural College was founded in Coimbatore to provide a scientific and technical mission for Agriculture Education and Research. Rice being our main food crop was to be addressed first. In 1912, the Paddy Breeding Station was established to initiate Rice Research in all its aspects. In the same year, Sugarcane Breeding Institute, another sibling of Paddy Breeding Station was simultaneously started. Both of them are now celebrating 100 years of lineage and eventful life, a rare co-existence of world famous Institutions. The Paddy Breeding Station is the first of its kind in India as well and also the first Research facility to be established in Agricultural College followed by the other crop breeding stations at Coimbatore and other locations in Tamil Nadu.

Studies with germplasm

Rice is a crop with its existence of more than 4500 years. The land races and varietal diversity in rice is rich and enormous. Abundant variation in useful traits is evident in the germplasm because of the existence of rice under cultivation for centuries and natural selection pressure in diversified vast environments. Managing the genetic variability is the primary function to enhance the genetic power of rice in terms of adaptability, performance and productivity. The Paddy Breeding Station, the pioneer institution, naturally was concerned first with this aspect of germplasm acquisition and management of genetic variation. In 1914, active germplasm assembling of 2000 or more was done. The Pioneering Stalwarts like F.R.Parnell and R.O. Illiffe designated as the Government Economic Botanists initiated studies on the selection of rice varieties that could help the rice farmers to harvest more yields. The Government Economic Botanists were succeeded by Crop Specialists, a focus more on specialized breeders for each crop. Dr. K. Ramiah was the first Paddy Specialist. In the first three decades, closer learning of Rice plant as a model crop system was in progress. Rice Biology and various traits of rice were studied so as to genetically manipulate the system for the benefit of mankind. Rice being a self pollinated crop was found suitable with multitudes of true bred lines. The rice biology, morphology, anatomy, breeding and adaptation that were investigated in a large assembly of useful germplasm provided the genetic selection basis. Systematic studies on genetics of inheritance of different characters were carried out in the first three decades in Paddy Breeding Station to improve the breeding skills F.R.Parnell, K.Ramiah and others investigated the inheritance of many of the traits – simple and complex. In 1908, Van der Stock first published the Mendelian segregation in rice. F.R. Parnell, K. Ramaiah and others in 1917 first published the rice genetics and reported first linkage group. The detection of genetic segregation in pollen for starchy and glutinous phenotypes in the anthers of F1 rice in 1921 is a land mark fascinating research.

The genes governing the inheritance pattern of traits such as plant types, plant parts, anthocyanin colour, spikelet features, grain types, blooming times, physiological behaviour and yield components in rice were designated in an orderly manner with gene symbols. In 1943 authentic standardized Gene Symbols was adopted. In 1927, Ramiah evolved the artificial hybridization technology in rice to get more cross pollinated seeds. The first Rice Genetics Monograph, a land mark publication by Dr. K. Ramiah was released in 1937. Origin of rice in 1951 is another important publication. The quest was for seeking how and why the variation in rice plant traits was very clear from many of the traits investigated.

Innovative research

Dr. Ramiah was first to isolate X ray induced dwarf mutations in rice GEB 24, almost in the next year of the discovery of X ray induced mutations in

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barley by Dr. L.J. Stadler. Such was the thrust, passion and purpose. In fact, the natural spontaneous mutant was first identified and released as the first improved rice variety GEB 24 from the Paddy Breeding Station in 1921. This variety is well known for its remarkable table top uniforming and appearance at flowering and maturity stage. GEB 24 is credited as the most influential rice variety in National and International breeding ventures. Ramiah in 1937 classified varieties according to grain type and grain number. In 1960-65 detailed assessment of *japonica* has made and it was adjudged as panicle type and *indica* as panicle weight type.

Varietal improvement

The knowledge on genetic basis of traits generated systematically and continuously has been promptly and regularly utilized in the on going rice breeding programmes in Paddy Breeding Station. As many as 13 pureline varieties differing in maturity, adaptation for different seasons, drought tolerance, resistance to blast, grain quality, fine grain types and translucent grains were developed and released as CO1 to CO 13 till 1940. The varieties CO 17 to CO 23 were also purelines and released from 1941 to 1945 for different seasons. A foundation for recombination breeding was already laid and was progressing well. The breeding efforts turned to be exploiting the existing variation and taking advantage of the recombinations also.The pursuit in this direction set forth in 1912 is continuing ever.

Recombination of useful traits and selecting best recombinants for useful and much needed agronomic features were accomplished. Varieties CO 14, CO 15 and CO 16 were the three first crossbred rice varieties released in 1940. CO 16 for the first time combined non lodging and blast resistance, the kind of combination that was never been there. Indeed the genes are from native germplasm resources. CO 14 is a classical search for non lodging “stiff straw” paddy through recombination breeding. CO 15 was a blast resistant variety.

Evolution is a continuous process. So also Human’s pursuit is continuous to understand and get benefited by the end products of evolution, he could come across. The rice varieties in South India have evolved with wide diversity for many morphological, physiological, genetic and adaptive functions. In respect of stiff straw, it offered only a limited scope that too in not a good agronomic base. The another sub species of *O.sativa*, namely *japonica* is with stiff straw combined with high fertilizer responsiveness and high photosynthetic efficiency and remained genetically isolated from *indica* rice.Systematic studies at Paddy Breeding Station narrowed down to the virtues of *japonicas* for high fertilizer responsiveness and panicle number types. Conceptualization on introducing or combining these characters into *indica* background was made in early 1940 by Dr.K. Ramiah Later when he moved over to CRRI, Cuttak as its first Director in 1946, *indica* – *japonica* project already introduced by him a decade back was in progress.The outcome was the impact making high yielding variety ADT 27 (Norin 8 / GEB 24) released in 1964 from Aduthurai, now the Tamil Nadu Rice Research Institute, India.

Meanwhile studies on hybrid vigour in rice was initiated in 1941 by Dr. K. Ramiah is yet another breeding approach to increase the yield levels of rice.

Cytogenetic research

Cytogenetics understanding was speedily improving from 1935 to 1950 in PBS and enabled the breeders to understand the species interrelation ship, chromosome homology and recombination potentials and ways to overcome barriers in gene transfers. Diploid wild species which have the same set of 2n: 24 chromosomes like that of cultivated *O. sativa* were considered as donors for some of those traits that were lacking in the cultivated rice. Mostly genes conferring resistance to diseases and pests and drought tolerance are available from wild species. Cytogenetical investigations revealed the intraspecific varieties provided large reservoir of genetic diversity and *O. sativa* var *indica, japonica and javanica* are subspecies, the latter two differentiated from *indica* by a set of characters and adoptive processes. *O. sativa* with 2n:24 was found to be a secondary polyploid in originating / evolving with x=5 and addition of chromosomes. Haploids and triploids were isolated abd studied.

Sixteen intra and inter varietal auto tetraploids were induced in GEB 24,CO 25,TKM 6 and SR 26B. Cyto genetical studies of the different auto tetraploids maintained for over five years indicated maximum of 10 quadrivalents frequently in all of them. Pollen and spikelet fertility were appreciable. Breeding selection for increased enhancement for these two traits was evident as expected while combining the increase in grain size and grain number was not possible. Selection for increase in grain size lead to decrease in grain number. The Paddy Breeding Station used to be the repository of *O.perennis*, *O.barthi, O.spontanea*, *O.nivara*, *O.rupifogon, O.fatua* and many awned land races transported by heavy flood waters that often disburse seeds, from long distance flood, disturbing swampy breeding grounds with active introgression. This also formed source of new variation.Dr. S.Sampath adduced evidences that *O.perennis* is the ancestor of *O.sativa*. Cytogenetical studies of F1s of differing interspecific combinations of diploid wild sp showed high degree of chromosome homology within AA genome to which the cultivated rice belongs but with varying degrees of sterility. Studies on *O.sativa* x *O.glaberrima* showed the African diploid cultivated species to be closely homologous and should have common origin with *O.sativa* and diverged later. *Indica* / *Japonica* hybrid of different combinations

showed gross chromosome homology. The sterility expressed in F_1s to varying degrees and segregating widely in subsequent generations in *indica* x *japanica* has been attributed to cryptic structural hybridity. In *O.sativa* x *O. glaberrima* no such evidences were found on structural differences although sterility exists to different degrees. Extensive observation were made on sterility expression in F_1 to F_4 generations in *O.sativa* x *O.glaberrima* and in *indica* x *japonica* (CO 37 / Oozura). Variety MDU 5 released from AC&RI,Madurai in 1998 is *O.glaberrima* x *O.sativa* (Pokkali) derivation and is interestingly semidwarf and suitable for semidry situations. Sterility responded for selection indicative of genic control, involving many genes. *O.glaberrima* and *O.stapfi* are genetically more distinct from *O.sativa* and *O.perennis*. In most cases, the duplicate gametic development factors present in the interspecific hybrids and cryptic structural differences were the underlying causes impeding with gene transference. These diploid species also had physiological specialization so as the genes which come into operation under different sets of environments in gaining sexual reproductive efficiency may be specific in their action. In 1957, a naturally occurring tetraploid species *O.malamphuzalensis (*2n:48) was identified. Later it was assigned BBCC genome.

Effect of music - In rice, beneficial impact and physiological excitation to increase the yield were tested in ASD 5 and TKM 6 for four years in field conditions for three seasons in controlled conditions. Nadaswaram music was played with Charugesi ragam for 30 minutes each day. No significant effect of music on yield or any other trait was recorded in the trials during 1961-65.

Green manure resources were given due importance.During 1985, *Sesbania rostrata* with stem nodulation in addition to root nodulation was introduces and released from PBS.This is in addition to the high nodulation, *Crotalaria juncea* released as CO 1 from the Forage Department. Highly proliferating Azolla types with high biomass accumulation in a shorter time were developed and disseminated to the rice growing farmers.

Tissue culture initiatives

Detailed protocol development was achieved for rice protoplast culture and to develop high volume Doubled Haploid (DH) in rice. Methodology to generate haploids and doubled haploids, establishment of DH plants in the fields, studying progeny performance in DH families and selection were practiced. DH plants developed involving CO 38, IR 50, Pokkali, ASD 8 and CO 40 hybrids reached upto Adaptive Research Trials in 1985. A wide array of DH progenies that varied from IR 50 like to *O.rupifogon* through different degrees of character combinations from both the parents were generated from anther culture of F_1 of *O.sativa x O.rupifogon*. They were true breeding, exhibited drought tolerance, grain variation and plant type. Among the many rice genotypes studied in different experiments over five years, IR 50, Ponni and Pokkali were found to respond well to anther culture.

Stress breeding

Recombination breeding was in the forefront from 1950 onwards and received a thrust. Since 1960, all varieties released from PBS were cross bred. Trait enhancing loci that exist in wild germplasm merit attention. In the Paddy Breeding Station around 1956, hybridization for gene transfer from *O.perennis* for drought resistance was commenced. Recombinants from the interspecific derivation of *O.perennis* x GEB 24 were screened over many location trials and drought induced situations. One culture was identified and released as CO 31 (Ottu Manavari) in 1963. Involving CO 31, in further breeding, TKM 11 and TKM 12 were released from Rice Research Station, Tirur, Tamil Nadu. By this time, all the released varieties had grain yield levels exceeding 5.5 t/ha which is almost 60% higher yield than pre 1960 releases.

Variety CO 34 (Kanchi) (TN1/CO 24) (115 days), CO 36 (Thiruchengodu ottu) (IR 8 / CO 32) (130 days) and CO 40 (Rajarajan) (IR 8/CO 25) 165 days yielded on an average of 7.5 t/ha over many environments. The leader variety Karuna CO 33 (IR8 x ADT 27) maturing in 105 days with yield of 6 t/ha was semi dwarf having short round grains is a notable addition in the list of released varieties from Coimbatore from 1970-80. CO 31 Amaravathi (culture 340 x Kannagi), a short duration farmer friendly variety. CO 37 (Vaigai) (TN 1 x CO 29) and CO 35 (Cauvery) (TN 1x CO 29) and Co 38 (Bagawathi) (IR 8 x CO 25) were high and stable yielders.

The redeemed focus was again on high yield combining with abiotic and biotic stresses. These objectives could be put into practices owing to the introduction and skillful adoption of various laboratory and field evaluation methods under controlled and field conditions by competent and dedicated team of breeders, agronomists, physiologists, entomologists and pathologists, owing to invigorated capacity building. Variety CO 42 is endowed with BPH resistance. Problem soils and water became no more constraints. Variety Co 43 (Dasal x IR 20) with fine grain and tolerance to alkaline and saline soils did well and spread fast. Multiple resistance to blast, RTV and BLB were incorporated in varieties on a durable resistant basis in CO 44, CO 45, CO 46 and CO 47 varieties. This period also looked into the complexities by different biotypes and races of pests and pathogens respectively.

Hybrid rice research

In the 1980 to 90, rice breeding strategy had a well planned swift towards utilizing cytoplasmic

genic male sterile lines following the success of hybrid rice in China. With acquiring CMS lines of V20A, V40A and Er Juan, the efforts started in 1982. The aim was to use the CMS as such and also to convert local improved germplasm into CMS and to introduce CMS lines from IRRI also. Concerted efforts were made to identify maintainers and restorers and hybrids synthesized with them for high yield. The expertise already available in TNAU in other crop systems has greatly helped in manipulation of the CMS system. In 1994, it was a notable achievement to identify and release the first hybrid in India, CORH 1 followed by CORH 2 in 1998 and CORH 3 in 2006. TNAU Rice hybrid CO 4 was released in 2011. The PBS/TNAU bred CMS lines and R lines were parents for these CORH 3 and TNAU Rice hybrid. The hybrids, CORH 3 and TNAU Rice hybrid CO 4 are able to yield 7 tonnes/ha and more combining good grain quality with multiple resistance. Both of them have been evaluated in AICRIP and had shown good performance across India. Varieties CO 48 (CO 43 / ASD 19) and CO 49 (C 20/RNR) were released in 2007 and 2008 respectively. The first decade of 21st century heralded with the synthesis of TNAU Rice variety CO CO 50 and TNAU Rice hybrid CO 4 and CO 50 the “new plant type super rice” (NPT) maturing in 135 days. TNAU Rice variety are the notable landmark products. This is why Paddy Breeding Station inventions stand ahead.

CMS based hybrids known as three line hybrid in Rice World is not the concluding point. In succession to 3 line hybrids, 2 line hybrids have been investigated with the introduced types, the basis being one of the parents as such will become sterile (TGMS) in relatively at higher temperature (32 c/24 c), while being fully fertile in cooler temperature (24 c /18 c)from pre flowering phase onwards. The functional male sterile line but female fertile regulated by temperature is the characteristics of the TGMS lines. With the introduction of TS 29, a TGMS line, stepped up efforts were made in the systematic conversion of Adapted local varieties that are amenable for high cross pollination during summer months. As expectedly, based on the proven track record performance, the Paddy Breeding Station has now integrated the 2 line hybrid breeding activity. As many as 16 TGMS lines have been developed and are being evaluated in two line hybrid combinations.

Biotechnological interventions

The desire for the introduction of modern biology – the molecular biology in the support of plant breeding and genetics was greatly fulfilled by the kind efforts of Rockefeller Foundation supported Rice Biotechnology program in 1988. Ably trained Breeders, Physiologists, Entomologists, Pathologists and Seed Technologists have now mastered the skills in Plant Molecular Biology and Biotechnology for the application to rice improvements. Each of the team dealing on various aspects in Rice improvement have now successfully come out with molecular biology aided interventions. Diagnostics, tracing and tracking the rice genes of interest, be it is sample or complex QTLs by molecular markers are frequently accomplished. Pyramiding of sets of resistance conferring genes and trait enhancing QTLs from within species and across the wild germplasm are of immediate breeding needs. Many upcoming activities of Rice Biotechnology are integrated and finding way into Rice Breeding in the PBS.

An unified vision of breeding was formulated in around 1960. The objectives were; non lodging, stiff straw, fertilizer responsiveness, medium to fine grain type, improved cooking qualities, non / shattering of grains, non dormant grains, increased grain to straw ratios, high yield and resistance to pests and fungal infections besides moisture stress tolerance. For accomplishing these objectives, selection of parents among the varieties and search for the presence of genes beyond the varieties namely in land races, semi wild progenitors and wild species was on for cross transference. Drought tolerance, a key factor that endures rice crop in rainfed, semidry and aerobic conditions in those fragile and less productive environments is gaining priority in rice breeding. Root traits such as deep roots, thick roots, profuse rooting besides fast and quick rooting were well recognized attributes and implicated in crop breeding. Many genetical, physiological, breeding, molecular genetics and biotechnological approaches have been visualized and practiced to achieve this goal. The holistic perception, insight and appreciation of resilience ability from the drought stress have not been critically considered along with root components.

PBS will continue to progress to widen the genetic base, and to provide genetics and breeding solutions to the very often repeated hardships to rice, take care of excessive weed competition, drought at different stages, designing rice crop with enhanced water and nutrient use efficiency, DMP with high apportionment to shoot and grains and suitability to mechanization thus reduction in drudgery and increasing the farming efficiency.

The research application of rice improvement originating and radiating from the 100 years lineage of the dynamic institution, the PBS, will safeguard the society with adequate food security despite the surging raise of population. It is well conceived by our society that Rice is Life, Rice is Culture and Rice is Food. Many more new inventions will continue to flow from the century old Paddy Breeding Station which has the strong desire and will to forward integrate all the new emerging technologies for the positive growth.

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