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INVITED ARTICLE

Rice Varietal Development In ANGRAU

- Status And Future Research Strategies

Rice is produced in a wide range of locations and under a variety of climatic conditions, from the wettest areas in the world to the driest deserts. **'**Rice is Life' for more than half of the Worlds' population and cultivation of rice has shaped the culture, diet and economic status of millions of people. Considering its importance the United Nations designated year 2004 as the 'International Year of rice'. Rice is grown in more than 100 countries across the globe in 158 million hectares, producing more than 470 million tonnes of milled rice. Major rice producing countries in the world are China, India, Indonesia, Bangladesh, Vietnam, Myanmar, Thailand, Burma and Philippines. Most of the rice produced is consumed by the producing countries and approximately 6 to 7 percent (~30 million tonnes of milled rice) is exported every year. The major rice exporters are India, Thailand and Vietnam; while major importers of rice are Philippines, Nigeria, Iran, Indonesia and the European Union (www.worldriceproduction.com and Rice Almanac, IRRI, Philippines, 2013).

In India, rice is grown in an area of 44 million hectares and is a staple food for more than fifty percent of its population. A total of 104 million tonnes of milled rice is produced in India with an average productivity of 3.38 t/ha. Major rice growing states of India are West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Tamil Nadu, Orissa, Bihar and Chhattisgarh accounting for more than 75 % of total rice production in the country (Rice Almanac, IRRI, Philippines, 2013).

Ninety per cent of rice produced in India is utilized for domestic consumption and the rest is being exported. Approximately 89 million tonnes of milled rice is required for domestic consumption. The per capita rice consumption has been decreased from 71.8 kilograms/year in 2000 to 68.2 kilograms/ year in 2009. By 2030, Indian rice production is expected to be 140 million tonnes of milled rice with 1.52 % of average annual growth rate of rice production. At the present rate of per capita rice consumption, total rice required for domestic consumption by in India by 2030 is estimated to be around 117 million tonnes of milled rice. Therefore 25 to 30 million tonnes of milled rice is estimated to be available for exports by 2030. India is the largest exporter of rice and exports rice to more than 125 countries. Total volume of Indian rice exports, including basmathi and non-basmathi rice, is approximately 48,000 crore rupees in 2015 (www.airea.net and Rice Almanac, IRRI, Philippines, 2013).

Andhra Pradesh is one of the most important rice growing states of India. The newly formed state of Andhra Pradesh comprises 13 districts with a population of 496 lakhs and is predicted to reach 591 lakhs with a decadal growth rate of 9.21

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Dr Paladugu Venkata Satyanarayana has 25 years of experience as Rice breeder in ANGRAU. He developed and released 13 varieties (6 main and 7 associated). i.e MTU1075 (Pushyami), MTU1121 (Sri Dhruthi), MTU1153 (Chandra), MTU1156 (Tarangini), APHR1, APHR2, MTU1031 (Tolakari), MTU1032 (Godavari), MTU1010 (Cottondora Sannalu), MTU1140 (Bheema), MTU1155 (Samvruddhi). He also developed several pre release varieties such as MTU1078, MTU1071, MTU1112, MTU1166 and minikits viz., MTU1187, MTU1184, MTU1194, MTU1210, MTU1217, MTU1224, MTU1226, MTU1229 and MTU1239. Dr. Paladugu developed several CMS lines for Hybrid rice. As Head of the RARS he bagged the National Awards Viz., Best AICRP Award for 2012-13 by IIRR and Best RARS Award by ANGRAU. Dr. Paladugu received several Awards like ANGRAU 'Meritorious research award for 2002' ARIC 'Crop Research award for 2004' 'Best Scientist Award by District Collector, West Godavari district for 2012' 'Dr. I V Subba Rao Memorial Best Scientist Award for 2012' 'Best AICRIP award for 2012 b y DRR-ICAR' 'Fellowship award by ASTA for 2014' 'Neelakantapuram Kaverappa Goldmedal for 2015' 'Golden Jubilee Best Centre award' 'Dhurmukhinama Samvatsara Ugadi Praskaram'. He visited China, Japan, Philippines on various Scientific assignments and he published more than 75 research papers in th National and International Journals. He also published 24 Booklets and 17 Research reviews and Book chapters.

% (2011 census). During 2016-17, rice was cultivated in over 21.06 lakh hectares with a production of 79.92 lakh tonnes and productivity of 3.794 t/ha of milled rice. Now, Andhra Pradesh stands 3rd after Punjab and Tamil Nadu in per hectare productivity of rice in India. The projected rice production for the state of Andhra Pradesh by 2030 will be 116 lakh tonnes of milled rice, assuming 2.0 % average annual growth rate of rice production (Statistical Abstracts of Andhra Pradesh, 2015).

Further, there is a projection of increase in area of irrigated rice, by approximately 1,00,000 hectares, after completion of Polavarm project on river Godavari and an additional yield of more than 4 lakh tonnes is expected from rice in Krishna and Guntur districts due to assured irrigation after completion of Pulichintala project over river Krishna (www.indianwaterportal.org). However, the rice area in low productive mandals of the state will be decreased due to crop diversification. By 2030, the rice area and yields are expected to be stabilized in the state of Andhra Pradesh with surplus quantities of milled rice to meet domestic consumption and rice exports.

Research establishments in ANGRAU

Rice is one of the most important mandate crops in Acharya N.G. Ranga Agricultural University. Research on rice is being carried out at eight research stations of the University.

1. Regional Agricultural Research Station, Maruteru, West Godavari District
2. Agricultural Research Station, Ragolu, Srikakulam District
3. Agricultural Research Station, Machilipatnam, Krishna District
4. Agricultural Research Station, Jangamaheswarapuram, Krishna District
5. Rice Research Unit, Bapatla, Guntur District
6. Agricultural Research Station, Nellore, Nellore District
7. Regional Agricultural Research Station, Nandyal, Kurnool District
8. Agricultural Research Station, Utukuru, Kadapa District

As on date 97 rice varieties / hybrids have been released by the University i.e., 52 from RARS, Maruteru; 25 from ARS, Nellore; 10 from ARS, Ragolu; seven from RRU, Bapatla; two from RARS, Nandyal and one from ARS, Pulla. Apart from releasing four mega rice varieties, a number of rice production technologies were developed and disseminated to rice farmers. Acharya N.G. Ranga Agricultural University has the credit of releasing first BPH tolerant rice varieties and rice hybrids in the country. We also developed dormancy breaking technique in rice, which is being implemented in the entire country. The rice varieties of ANGRAU are grown over 14 m.ha across the globe. Apart from India, ANGRAU varieties are grown in Bangladesh, Myanmar, Nepal, Srilanka and West African countries such as Nigeria.

Strengths of ANGRAU rice research stations in rice development

- ✓ Well established research facilities at Maruteru, Nellore, Bapatla and Ragolu
- ✓ Modern biotechnological and quality laboratories in Maruteru
- ✓ Strategic location of research stations to carry out research on biotic and abiotic stresses at Maruteru, Nellore and Ragolu.
- ✓ Maruteru is a major hot spot location for blast, BPH, BLB and sheath blight; Nellore for blast and Ragolu for gallmidge.

Major production constraints in Rice

- ✓ Major biotic stresses like BPH, Stem borer, BLB, Stem rot, sheath blight, red stripe and leaf & neck blast.
- ✓ Abiotic stresses like frequent floods during vegetative to flowering stage, increased salinity levels in the soil and stress due to heat and cold.
- ✓ Damage due to natural calamities like cyclones and heavy rains coinciding with harvest and prolonged cloudy weather during Kharif season.
- ✓ Marginal improvement in the yield during post green revolution period
- ✓ Wide spread cultivation of non climate resilient rice varieties
- ✓ Deterioration of soil fertility and productivity.
- ✓ Indiscriminate / imbalanced use of fertilizers and pesticides
- ✓ Improper drainage in low lying areas of rice cultivation.

- ✓ Lack of assured irrigation for timely sowing in certain areas.
- ✓ Lack of small scale farm machinery for various operations including post harvest handling suitable for small and marginal farmers.
- ✓ Lack of proper threshing, drying and storage facilities.
- ✓ Acute shortage of labour during peak operations leading to delay in timely operation and escalation of cost of production.
- ✓ Lack of efficient or proper spraying equipment.

Major research findings in rice RARS, Maruteru

- ✓ The research station has released 52 varieties including 23 pure line selections, 27 improved varieties through crossing and two rice hybrids.
- ✓ Three mega varieties released by this station *viz.,* MTU-7029 (Swarna), MTU-1001 (Vijetha) and MTU-1010 (Cottondora sannalu) which occupy approximately 18-20% area under rice **in the country and contribute about 24 m.t.** of rice to the national food pool.
- ✓ The varieties developed at RARS, Maruteru are being extensively cultivated over 9.0 m. ha in 13 states *viz.*, Telangana, Tamil Nadu, Karnataka, Kerala, Maharashtra, Orissa, Bihar, Chhattisgarh, Jharkhand, West Bengal, Madhya Pradesh, Uttaranchal and Uttar Pradesh contributing 24 m.t. of rice out of India's total annual rice production of 102 million tonnes and in 7 different countries in the world *viz.*, Sri Lanka, Nepal, Myanmar, Bangladesh, Uganda, Kenya and Ethiopia.
- ✓ Developed first BPH resistant variety in India - Vajram (MTU - 5249) and also first rice hybrids - APHR 1 and APHR 2 (1993).
- ✓ Developed MTU ITJ 206-7-4-1, a potential donor for brown plant hopper resistance in rice.
- ✓ The other popular varieties developed at Maruteru *viz.,* MTU 3626, MTU 1061, MTU 1075 and MTU 1064 etc. occupy around 8 lakh ha in A.P alone with a production of 2.0 million metric tonnes. The varieties MTU 1064 (Amara) and MTU 1061 (Indra) are having flood and salinity tolerance and are gaining popularity in coastal districts where occurrence of floods and salinity are common.
- ✓ The centre has distinction of releasing medium duration fine grain CMS lines viz., APMS 6A, APMS 8A, APMS 9A, APMS 10A, APMS 11A, APMS 12A and APMS 14A which are being currently used extensively to develop medium duration fine grain rice hybrids.
- ✓ RARS, Maruteru is considered to be one of the largest centres to produce high quality breeder seed. Out of 246 rice varieties which are under active breeder seed chain 10 varieties from Maruteru have got a national indent of 20% of the total breeder seed and the rice seed trading companies are realizing approximately Rs. 600-800 crores additional benefit every year by the sale of Maruteru varieties alone.
- ✓ Developed *sub1* introgressed lines of MTU 1064 and MTU 1075 through marker assisted breeding.
- ✓ Developed *saltol* introgressed lines of MTU 1010 through marker assisted breeding.
- ✓ Developed BPH tolerant breeding lines of MTU 7029, neck blast BPT 5204 through Marker Assisted selection.
- ✓ Identified *pi 1* gene conferring neck blast tolerance in WGL 167 through bulked segregant analysis.
- ✓ Swarna, MTU 1229, MTU 1064, MTU 1061, Swarna sub1, Samba sub1 varieties were found to be more nutrient efficient for both nitrogen and phosphorous.
- ✓ Identified presence of *Strong culm 2* (SCM2) in new donor II 110-9-1-1-1-1 and BPT 2270 conferring lodging resistance.
- ✓ Identified low shattering genes sh-7 in JGL 17004 and MTU 1081.
- ✓ Presence of leaf blast resistant genes were identified in MTU 1003 (pi 1, pi kh), NLR 34449 (pi 1, pi40 (t),pib,pi39) MTU 1002 and MTU 1003 (pi1,pi2, pi kh), MTU 1121

(pikh, pi5(t),pi40 (t), pi37, pi39), MTU 3626 (piKS), pi37,pi39), MTU 1010 (pi1, piz5,pi40(t)), MTU 1153 (piZ-5,pib), MTU 1156 (pi1,piz-5),MTU 1226 (pi1,piZ-5,pi5,pik^{S} , pi 40 (t)), MTU 1229 (pi1,piz5,pik^{s}), MTU 1210 (pi1, pi5(t), pi39), MTU 1184 (pikh,piz-5,pik^{s}, pi37,pi39) conferring field score of 3 in collaboration with plant pathology department.

- ✓ Presence of BLB resistance genes xa 21, 13, 5 was identified in RP 5586-95-4-2-1-1 in collaboration with plant pathology department.

Recently Released Rice Varieties

2015

- ✓ **MTU 1153 (Chandra) -** Released for the states of Punjab, Bihar, Chattisgarh, Odisha, Madhya Pradesh, Karnataka, Tamilnadu and Kerala. Short duration variety of 115-120 days with long bold grain and tolerant to blast.
- ✓ **MTU 1121 (Sri Dhruthi) -** Short duration variety of 125 days with medium slender grain and tolerant to blast and BPH. Recommended for Rabi season only.

2016

- ✓ **MTU 1156 (Tarangani) -** A high yielding rice variety with 115-120 days duration suitable for Rabi season, LS grain type, tolerant to blast and BPH, non lodging with strong culm, with 2 weeks seed dormancy and low grain shattering.
- ✓ **MTU 1140 (Bheema)** – A long duration variety of 145 days, MS grain type, possesses submergence tolerance up to 10 days in tillering stage and 2 weeks during germination.

2017

- ✓ **MTU 1155 (Samvrudhi)** – A medium duration rice variety, non lodging and resistant to leaf and neck blast, moderately resistant to BLB, sheath rot, brown spot and rice tungro disease.

ARS, Nellore

- ✓ Since inception of the research station 25 rice varieties were developed and released from this research station. Among these the most popular rice varieties are NLR 9674 (Kotha molagolukulu), NLR 28523 (Sriranga), NLR 33892 (Parthiva), NLR 145 (Swarnamukhi), NLR 34449 (Nellore Mahsuri), NLR 3041(Nellore Sona), NLR 30491 (Bharani), NLR 33358 (Somasila) and NLR40024 (Swetha).

ARS, Ragolu

- ✓ Released ten varieties viz., Gutti krishnakatukalu (RGL-1), Nagavalli (RGL-52), Vamshi (RGL-1746), Mahendra (RGL-1750), Pushkala(RGL-2624), Srikakulam sannalu (RGL-2537), Vasundhara (RGL-2538), Sreekurma (RGL-2332), Sreesatya (RGL- 1880 and Vamsadhara (RGL- 11414) and Srikulm sannalu is popular among the farmers with good quality and suitable for late planted conditions in North Coastal Region

RRU, Bapatla

- ✓ Released 5 long duration (BPT 5204, BPT 1768, BPT 4358, BPT 2270, BPT 2231), one medium duration (BPT 3291) and one short duration variety (BPT 1235).

RARS, Nandyal

- ✓ Released two rice varieties NDLR 7 (Nandyala Sona) and NDLR 8 (Nandyala Sannalu)

Focus on Direct Seeded Rice Research in Andhra Pradesh State

Rice is an important and staple food crop for more than half of the global population. Looming water crisis, water-intensive nature of rice cultivation and escalating labour costs drive the search for alternative management methods in rice cultivation. Direct-seeded rice (DSR) is a feasible alternative to conventional puddled transplanted rice with good potential to save water and to reduce labour requirement. Direct seeding offers advantages viz., faster and easier establishment,

reduced labour and less drudgery, more water use efficiency and less methane emission. It is fast replacing traditional transplanting in areas with good drainage and water control.

There are two types of direct seeding practices in India. First one is dry direct seeding (Dry DSR), where dry seeds are either broadcasted or dibbled on dry soils and second one is wet direct seeding (Wet DSR), where wet (soaked) seeds are either broadcasted or seeded with drum seeder in rows in puddled soils. In Andhra Pradesh the area under direct seeding has been increaseing gradually and in 2016-17, three lakh hectares of rice area was under DSR. In our state, dry DSR is practicing by several farmers in Krishna, Godavari and North Coastal zones where as Wet DSR is familiar to farmers of Godavari delta.

Hence a research project was initiated at RARS, Maruteru in 2013 to develop / breed varieties suitable for direct seeded conditions. The best entries identified in Multi location tests have been given for adaptive minikit testing in farmers fields in Andhra Pradesh during Kharif, Rabi 2016-17 and Kharif 2017. They are MTU 1224- a fine grain medium duration variety; MTU 1226- a late duration medium bold type, MTU 1229- A long duration medium slender grain identified as an alternative to Swarna and MTU 1210- A mid early variety suitable for both Kharif and Rabi. During the first year of minikit testing these varieties have shown good performance and hence given for second year testing in Kharif 2017.

Thrust areas of rice varietal development

- ✓ Sharing of germplasm – wild rice accessions, ANGRAU rice varieties, donors for major pests & diseases, abiotic stresses, advanced breeding lines for high silica content and culm strength, differentials for BLB, gall midge & Blast pathogens, pyramided lines for submergence, anaerobic germination, salinity, BLB and Blast.
- ✓ Exploitation of untapped genetic resources for yield enhancement and climate resilience.
- ✓ Focusing on development of nutrient, water, photo-radiation use efficiencies.
- ✓ Strengthening of research on bio fortification, value addition and export oriented rice.
- ✓ Pre breeding for identification of novel QTLs for prevalent biotic and abiotic stresses.
- ✓ Development of rice varieties suitable for different methods of cultivation with special focus on direct seeding.
- ✓ Addressing sheath blight and stem borer resistance through Transgenics/ RNA i technology
- ✓ Development of high yielding hybrids with multiple resistance and good cooking quality traits.
- ✓ Enhancement of yield potential of rice by pyramiding of genes governing yield related traits into mega varieties to feed the ever growing population of the country and state.
- ✓ Climate smart rice varieties -Developing climate smart/ climate resilient rice varieties using advanced genomic tools that can withstand the ill effects of drought, salinity, heat, submergence, lodging and cold etc. coupled with high yield.
- ✓ Breeding for water and nutrient use efficient rice (nitrogen and phosphorus) varieties for low input cost and environmental safety.
- ✓ Exploitation of untapped genetic resources for yield enhancement and climate resilience for dual flood tolerance mechanism (quiescence and escape strategies) using *Oryza grandiglumis* and *Oryza coarctata / Porteresia* for salinity tolerance (cultivating rice using salt water)
- ✓ Genome wide association studies for identification of resistant genes for major biotic and abiotic stresses.
- ✓ Development of low GI rice varieties with desirable quality traits
- ✓ Development of biofortified rice varieties with iron and zinc
- ✓ Development of rice suitable for export purpose.

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