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2018-19

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Preface

I am privileged to place before you the annual report of ICAR-Indian Institute of Rice Research for the period 2018-19. The Institute is justifiably considered as one of the leading research Institutions of ICAR conducting basic and strategic research on rice and also co-ordinating the largest network program in the country, perhaps in the world. Timely arrival of south-west monsoon and its reasonable well distribution across the country notwithstanding few cyclones and low pressure depressions in the eastern belt resulted in an estimated record rice production of 115.60 million tonnes. The progress of research during the period of report is quite encouraging with 4 hybrids and 30 varieties being released for cultivation. The breeder seed production was also satisfactory with 720 tonnes seed of 262 varieties being produced and distributed. Several proven rice production technologies were demonstrated through 870 FLDs covering 15 states.

On the research front, significant breakthroughs were achieved in identifying resistant genetic stocks against BPH and WBPH, heat tolerant variety, promising lines under low phosphorous, high Zinc lines and several promising cultures resistant to biotic stress.

The year is also significant in that the scientists of the institute were conferred with individual awards at national level in recognition of their commendable services, received patents and copyright for AICRIP Intranet. Eight scientists have been deputed abroad for advanced training and as consultants. Four externally funded projects with a total outlay of 200 lakhs were sanctioned to the institute with other ongoing projects.

A summary of these activities is presented in this Annual Report.

(S R Voleti)
Director (A)

Hyderabad
30th July 2019

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Executive Summary

All India Coordinated Rice Improvement Project (AICRIP)

A total of 34 varieties including 4 hybrids and 30 varieties were released for different ecologies during 2018-19. Four hybrids and 10 varieties were released by Central Varietal Release Committee whereas twenty varieties were released by State Varietal Release Committee. State-wise, 11 varieties for Tripura, 5 for Odisha, 2 for Karnataka and one each for UP and Tamil Nadu were released by SVRC.

Crop Improvement

- ✓ AICRIP Plant Breeding conducted 45 varietal trials and 5 hybrid rice trials in 939 experiments (792 varietal and 147 hybrid rice) at 122 locations (45 funded and 77 voluntary centres) in 27 states and 2 union Territories across seven zones of the country during 2018.
- ✓ A total of nine hundred and two varieties are tested in forty five varietal trials of which two hundred and nineteen varieties were found promising across the zones and states in diverse ecologies.
- ✓ A set of 77 hybrids were evaluated in four hybrid rice trials viz., IHRT-E, IHRT-ME, IHRT-M and IHRT-MS. Twelve hybrids were found to be promising.
- ✓ The Variety Identification Committee identified 11 varieties and 9 hybrids for release in different states.
- ✓ Breeder seed production of 262 rice varieties and parental lines of six hybrids as per DAC indent was conducted at 42 centers across the country. Overall 7204 quintals breeder seed was produced against the allocated target of 4323 quintals. Breeder seed production of 21 varieties was taken up at ICAR-IIRR centre with a total production of 163 quintals against the target of 173 quintals.

Crop Production

Agronomy

- ✓ In Agronomy Program, a total of 210 experiments were conducted at 44 locations on various aspects of rice agronomy to generate technologies which can reduce the cost of cultivation and enhance the productivity.
- ✓ Under nutrient management trials in different ecologies 15 entries performed well and were identified as promising.
- ✓ Mechanical transplanting method resulted in the highest grain yield (5.63 t/ha) followed by manual transplanting (5.21 t/ha) and SRI (5.06 t/ha). 150% RDF in *kharif* season followed by 100% RDF in *rabi* season was found to be the optimum.
- ✓ Cost of cultivation under flooding was higher across all the locations from Rs. 33,443 to Rs. 45,850/- and there was a saving of Rs. 3,800/- per ha at Mandya under alternate wetting and drying over flooding. Similarly, water input was reduced.
- ✓ An increase of 11% grain yield due to iron coating of seeds in direct seeded rice situation was reported across the test locations over uncoated seed.
- ✓ Under late planting condition, application of higher dose of fertilizer (125% of RDF) and closer spacing gave significantly higher grain yield of rice.
- ✓ The systemic post emergence herbicide Thiobencarb @ 5 l/ha and Rinskor (31.25-37.5 g/ha) at 4-7 leaf stage were found promising with higher weed control efficiency.
- ✓ Pre *kharif* pulse crop increased grain yield by 9.5% over rice-rice system across the locations.

Soil Science

- ✓ AICRIP on soil science conducted 7 trails during *rabi* 2017-18 and *kharif* 2018 in 17 locations representing typical soil and crop systems and important soil rice growing regions.
- ✓ In the 30th year of study on long term soil fertility management in RBCS, RDF+FYM recorded maximum yield at all three locations and FYM alone treatment was on par to RDF in *kharif* at MND and TTB.
- ✓ In the trail on soil quality and productivity assessment in farmer's fields at six locations, soil quality index varied across the farmers' fields in all locations and did not match with crop productivity in most sites. Yield gap was maximum (51%) at Chinsurah and minimum at Maruteru (16%). Based on the nutrient requirement of a particular site, fertiliser prescriptions were recommended and they will be validated in the following *kharif* season.
- ✓ Gypsum application in sodic soils and liming in acid soils in conjunction with NPK improved rice yields. IIRR varieties; DRR Dhan 42, 43, 45 and 46 in sodic soils and US 312, Bina Dhan 8, Bina Dhan 75 and Maheswari in acid soils were found promising.
- ✓ Nutrient expert recorded highest grain yields in about 70% of the farmers' sites tested with a higher dose of N and K and lower dose of P there by saving the costly P fertilisers.

Plant Physiology

- ✓ Silicon application had resulted in 9% increase in mean grain yield. The Maximum increase was observed in US-313 and KRH-4. Application silicon to water stressed crop reduced the negative impact of water stress.
- ✓ Out of 30 rice genotypes tested only Govind, IET27514 IET27522 and IET27515 show relative tolerance based on drought index values.
- ✓ High temperature reduced the mean grain yield by 25%. Based on% reduction in yield under elevated temperature condition IET 27680 and IET 25713 show relative tolerance to high temperature. Based on yield stability index and ASV IET 26468 followed by IET 27477 and IER 24911 can be identified as relatively heat tolerant.
- ✓ Out of 21 entries screened for multiple abiotic stress tolerance none of the entries show tolerance to all the stresses. However, IET 26487, IET 26493 and BPT 2782 show tolerance to at least two abiotic stresses.
- ✓ The trial was conducted with three nitrogen treatments. Based on yield and stability values Varadhan x BPT5204/10 and Sampada x Jaya/3 and Sampada x Jaya/3, Sampada X Jaya/2 and Varadhan x BPT5204/10 can be identified as stable genotypes under 0 Kg N and 50 kg N ha^{-1}
- ✓ Out of 15 AVT entries tested at 7 locations only IET 27559 showed relative tolerance to low-light stress. All other entries suffered yield loss by >45%.

Crop Protection

Entomology

- ✓ Seven major trials encompassing various studies with 393 experiments (87.3%) were conducted at 41 locations (32 funded + 9 voluntary) in 22 states and one Union territory.
- ✓ A set of 1661 entries including 1425 pre-breeding lines, 94 hybrids, one cultivar and 28 germplasm accessions and 113 check varieties were evaluated against 12 insect pests in 213 tests (46 greenhouse reactions+167 field reactions). 104 entries (6.62%) were promising against various insect pests of which 15 entries were under retesting.
- ✓ 16 breeding lines *viz.*, BPT 2601, CB 15569, CB 15144, MTU 1303, MTU 1305, MTU 1306, MTU 1307, MTU 1308, MTU 1309, WGL 1250. WGL 1319, WGL 1320, RNR 19416,

RP 5995 Bphk17-5, IR 73382-80-9-3-13-2-2-1-3-B (HWR-16) and RP 5690-20-6-3-2-1, four germplasm accessions viz., IC 216735, IC 76013, IC 75975 and IC 76057 and two checks PTB 33, RP 2068-18-3-5 and MO1 were promising against brown planthopper.

- ✓ SKL 07-11-117-50-65-60-267, WGL 1164, Aganni and W1263 were promising against gall midge. HWR 24, MSM 139, NEG 186, HPR 2613 and HWR 3 were promising against leaf folder. Sixteen entries viz., JGL 32467, JGL 32485, BK 39-179, JGL 33080, JGL 33124, JGL 34508, RP 5587-B-B-B-209, RP 5587-B-B-B-253-2, BK 35-155, JGL 34505, KAUPTB 0627-2-11, KAUPTB 0627-2-14, RP 5587-B-B-B-258-1, RP 5587-B-B-B-262, RP 5588-B-B-B-B-232 and JGL 28547 were promising against stem borer. BPT 2231, BPT 2611, IET 27275, IET 27284, IET 27480, IET 27379 and IET 27392 were promising against 2-3 insect pests.
- ✓ PTB 33 with bph2+Bph3+unknown factors and RP 2068-18-3-5 with Bph33(t) gene were promising at all 10 locations while Rathu Heenati with Bph3+Bph17 genes and T 12 with bph7 gene performed better in 5 locations. Aganni (*Gm8*), INRC 3021(*Gm8*) and W1263 (*Gm1*) were promising against gall midge in 5-8 tests.
- ✓ There was no adverse impact on the performance of the two newer insecticides (spinetoram + methoxyfenozide) when applied alone or in combination with fungicides (hexaconazole and tricyclazole) confirming the compatibility of the chemicals when used as tank mix in the field.
- ✓ The essential oils like eucalyptus oil was found effective against stem borer; cedar wood oil was effective against gall midge, all the essential oils were moderately effective against planthoppers, effective against leaf folder and safer to natural enemies.
- ✓ Late planting of rice resulted in high incidence of stem borer, gall midge, leaf folder, caseworm, brown planthopper and white backed planthopper except whorl maggot as compared to early and normal planting.
- ✓ Non-pesticidal methods such as increasing floral diversity, water management, organic manures, alleyways as part of ecological engineering resulted in reduced planthopper populations and increased natural enemy populations.
- ✓ In the bio intensive pest management plots, pest incidence was reduced and natural enemies were higher as compared to farmer's practice.
- ✓ A significant negative relationship was observed between i) leaf folder damaged leaves and grain yield and ii) hispa damaged leaves and grain yield.
- ✓ Integrated pest management practices resulted in lower insect pest incidence, disease incidence, weeds, higher grain yields and high benefit cost ratio compared to farmer's practice.
- ✓ Population monitoring of insect pest populations through light trap collections revealed yellow stem borer and brown planthopper to be the major insect pests along with leaf folder and GLH in low numbers.

Plant Pathology

- ✓ AICRIP programme on Plant Pathology during *kharif* 2018 involving 14 trials including host plant resistance, virulence of plant pathogens, disease observation and disease management trials were conducted at different AICRIP locations.
- ✓ In various screening nurseries, 1418 entries were evaluated and the following promising cultures showed resistant reaction for more than two diseases: IET # 28014, 28015, 26027, 27077, 27094, 27280, 28020, 25618, 27579, 27668, 27781, 27747, 27806, 25826, 26576,

26594, 27461, 27466, 27467, 27378, 27333, 27377, 27389, CB14161, NWGR-11048 and RNR-11450.

- ✓ Virulence pattern of *Pyricularia grisea* and *Xanthomonas oryzae* pv. *oryzae*: Reaction pattern of 24 isolates of *Pyricularia grisea* on 25 differentials were grouped into 8 clusters. The reaction pattern revealed a shift in pathogen profile structure at many locations. Two Bacterial blight resistance genes *xa13* and *Xa21* showed susceptibility at 11 hot spot locations. The isolate from Maruteru showed exceptional virulence and all the differentials showed susceptible reaction to this isolate.
- ✓ Across the locations, delayed sowing/ planting increased the disease development of leaf blast, brown spot and sheath rot. Normal sown crop recorded high disease severity of bacterial leaf blight and disease progress of sheath blight, was high in the early and normal sown crop. Neck blast was severe in the normal sown crop.
- ✓ The combination product is trifloxystrobin 25% + tebuconazole 50% WG (0.4g/l) found effective against leaf blast, neck blast and sheath rot. Azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC (1.0 ml/l) found effective against sheath blight and sheath rot. Mancozeb 50% + carbendazim 25% WS (30.5%) and Flusilazole 12.5% + carbendazim 25% SC found effective in managing brown spot of rice.
- ✓ Incorporation of FYM, seed treatment, application of DAP, MOP in the nursery area followed by the application of FYM + *Trichoderma* during land preparation, cultural practices, application of 75% RDF + micronutrient solution, one blanket application of cartap hydrochloride at 15 DAT and propiconazole at booting stage in main field found to be most effective and consistent in reducing the incidence of leaf blast, neck blast, sheath blight, brown spot and sheath rot and also increasing the grain yield.
- ✓ Among the seven different essential oils tested two sprays of Clove oil @ 2 ml/l found better against leaf blast, whereas Neem oil @ 2 ml/l and Cedar wood oil @ 2 ml/l effective for reducing leaf and neck blast disease severity.
- ✓ Production Oriented Survey was conducted in 15 States of 17 AICRIP centres. During 2018 three cyclones *viz*., *'Daye'*in south Odisha, adjoining Andhra Pradesh; *'Titli'* in near Palasa, Andhra Pradesh and *'Gaja'* in Tamil Nadu made severe impact.
- ✓ Many farmers from different states also expressed the need for timely availability of seeds of different hybrids, different inputs, farm mechanization (on hire basis/custom hiring), market facility and farm loan.
- ✓ Severe outbreak of bacterial bight reported from Nizamabad and Suryapet districts of Telangana. Similarly false smut (in parts of Uttarakhand, Mandi in Himachal Pradesh and Siddharthnagar in UP), sheath blight (in Haryana, Punjab, Karnataka and Chhattisgarh), Neck blast (in Himachal Pradesh, Karnataka and Chhattisgarh) caused severe damage.
- ✓ BPH/WBPH was very widespread in moderate to severe form in most of the districts of Haryana and many parts of Vidharbha region of Maharashtra and Telangana. There was severe attack of rice hispa in Nizamabad district of Telangana

Transfer of Technology

- ✓ During the year 2018-19, 870 FLDs were conducted through which a cafeteria of rice technologies were demonstrated covering 18 states and five major rice ecosystems of the country.

Lead Research

Crop Improvement

Plant Breeding

- ✓ DRR Dhan 52 (IET 23354: RP5125-12-5-3-B-IR84898-B-B): It was identified for release in the states of Haryana, Gujarat and Odisha in 2018. It is a reproductive stage heat tolerant culture under elevated temperature up to 5-8◦C. It showed higher yield and higher fertility than all the heat tolerant donors and varieties of rice at elevated temperature. It showed resistance to blast, moderate resistance to neck blast, brown spot, sheath rot and RTD. It is also fund promising for cultivation in boro areas.
- ✓ The 21 inter-specific BC1F3 populations consisting of 2500 lines derived from *O. sativa* (IR64) and *O. glaberrima* (20 accessions) was developed to constitute NAM (nested association mapping) population. A total of 3000 BC1F3 populations derived from crossing Samba Mahsuri with 25 accessions of *O. rufipogon* evaluated for yield related traits and nearly 25 promising lines were selected for further testing. 1200 introgression lines were screened for blast resistance and 150 resistance lines were identified. One accession of *O. glaberrima* and several wild introgressed lines of *O. rufipogon* found to be tolerant to reproductive stage salinity. 1200 *O. rufipogon* derived lines were screened for BPH resistance at BPH resistance and five lines showed the resistance
- ✓ High yielding advanced breeding lines (34) from three way/backcrosses of elite cultivars/TJP/introgression lines with resistance gene(s) were selected with trait combination of high grain number, strong culm and high biomass (NPT traits). 5 entries (JBC166-10, JBC163-2, JBC173-19, JBC179-21 and JBC159-8) recorded a high yield potential of 7-8 t/ha during *kharif* 2018. IET 27785 (Swarna/ IRGC63248//Swarna Sub 1) is promoted for testing in central zone in AVT1-IME and recorded 13% yield advantage over the best check in central zone and 4.93% in eastern zone.
- ✓ Mapping population (174) in BC2F6 generation from Swarna/*O. nivara* (CR100008) was evaluated for shattering and dormancy related traits. Two putative markers RM488 on chr1 and RM247 on chr12 were found to co-segregate with dormancy and shattering traits in Swarna/*O. nivara* (CR100008) BC2F6 mapping population. One breeding line JBB 661-1 derived from the cross of RP Bio 226/ IRGC 39050//MTU 1081 has been identified as non-shattering type.
- ✓ RP 5690-20-6-3-2-1 derived from the cross Sona mahsuri/SR 26-B was found promising in 9/16 tests evaluated in PHS trial during *kharif*, 2018. It was screened at 13 locations in 16 tests (9 green house and 7 field tests) against BPH, WBPH and mixed populations of planthoppers under both field and greenhouse conditions.
- ✓ Registered a genetic stock (IC 0619226) designated as RP 5316-RIL-243 possessing resistance to combined population of BPH and WBPH during seedling as well as reproductive stages with Plant Germplasm Registration Committee of ICAR in 2019
- ✓ Swarna possessing the yield enhancing genes, *Gn1a* + *SCM2* + OsSPL14 were crossed with NILs of Improved Samba Mahsuri' (Blast resistance genes *Pi2*+*Pi54*) to incorporate disease resistance in addition to yield enhancing genes. Three BC2F1 plants processing grain type similar to recurrent parent were selected and backcrossed with 'Swarna' to develop backcross derived lines (BC3F1s).
- ✓ The donor Habataki (*Gn1a* + *SCM2*) for yield enhancing genes was crossed to recurrent parent NDR 359 to developed F1s.

Two BC2F1 plants processing grain type similar to recurrent parent were selected and backcrossed with 'NDR 359' to develop backcross derived lines (BC3F1s).

- ✓ Fresh crosses were attempted during 2018-19 utilizing high yielding varieties having high zinc (DRR Dhan 45, DRR Dhan 48, DRR Dhan 49, CSR 27, BPT 5204, Swarna, Telangana Sona and Chhattisgarh Zinc Rice-1)/ germplasm (IR 99674-9-2-2, IR 95097:3-B-16-11-4-GSB, IR 99282-41-4-2, IR15M1003 and IR 95040:12-B-3-10-2-GBS) lines and farmers' varieties (Dhusuri Baratee, Kajol ghorya, Bitti, Sati and Dhan Sirhatti). Two mapping populations (IR14M110/JAMIR and IR14M141/ KALIBORO) were evaluated during *kharif* 2018. Two promising cultures [(IR14M124 (GID: 4152780) and IR14M102 GID: 4230360)] with high Zinc content were nominated for AICRIP trial during *kharif* 2018 of which one entry performed better than check and contained Zinc 24 ppm.
- ✓ Wazuhophek x Improved Samba Mahsuri mapping population was phenotyped for low soil P tolerance. Total 13 QTLs were detected after analysis in both the IciMapping version 4.0 and QTL cartographer software. The region between markers RM22554 and RM8005 on chromosome 8 found as hotspot for QTL as 10 QTLs out of 13 for different traits are present in this region. Twenty phenotypic extreme lines of Rasi x Improved Samba Mahsuri were phenotyped for low Phosphorus tolerance and genotyped with 106 SSR polymorphic markers. QTL mapping resulted in the identification of 15 QTLs for various traits.
- ✓ Four land races WB-12, WB-22, WB-24 and WB-27 were identified as novel source for low soil P condition and completely devoid of pup1 region. qRT-PCR results for gene expression analysis revealed that genotypes carrying the P tolerance gene viz., ISM NIL and MTU1010 NIL showed higher expression of OsPHO1;2, OsPhT1;6 and OsSPX1 genes under P- condition.
- ✓ Evaluated 679 germplasm lines and have identified several entries with high grain protein content (≥ 10.0%): JAK 218 (10.1%), JAK 223 (10.3%), JAK 228 (10.2%), JAK 685 (10.6%), JAK 719 (10.6%). JAK 312 had a long panicle, high grain number (~350) and strong culm with ~9.1% protein.
- ✓ A total of 50 crosses were attempted between aromatic and aromatic short grain type and also between aromatic and non-aromatic types which include Shobini, Gontra bidhan -3, Narendra, Lalmati, Muhulakuchi, Neelabati, Kalikati, Kalanamak, Dubraj Bandi, Joha Bora, Joha, Loung choosi B, Champaran Basmati 4, Ganjeikalli, Thakurabhog, Muhulakuchi, Champaran Basmati 1, WGL 14 and Sugandha samba.
- ✓ 33 Candidate varieties for DUS tests in rice were conducted for first season/year during *kharif* 2018 against 52 reference varieties at IIRR, Hyderabad. In addition 49 new varieties against 68 reference varieties under second year of testing, 2 VCKs against 4 reference varieties and DUS Characterization of 387 Farmers' varieties were included in the DUS testing as per DUS Test Guidelines.

Hybrid Rice

- ✓ Twenty promising genotypes were identified from the available breeding materials and 46 crosses were attempted between the promising lines. Around 600 test crosses, 250 paired crosses and 94 varietal crosses were made for further evaluation. Of the 220 test crosses evaluated, 20 promising test crosses and 35 promising restorers were identified for further evaluation. One hundred eighty five single plant selections were made from the breeding materials in various segregating generations.
- ✓ Four promising aerobic restorers (PSV24, PSV 250, PSV372 and PSV 375) were evaluated

for its performance (station trial), among them, three hybrids viz., APMS6A/PSV375, APMS6A/PSV250, IR 79156A/PSV372 were identified as best combination and nominated for aerobic and salinity trial.

- ✓ Hybrid rice seed production was taken up during *Rabi* & *Kharif 2018* for the newly identified three rice hybrids viz., CRMS 32A X PRP 192, APMS 6A X PRP 119, IR79156A X PRP 192.
- ✓ The improved lines of IR 79156B and IR 58025B for stigma exsertion trait was under conversion process to CMS line, which are in BC_1 generation.

Biotechnology

- ✓ Genome based sequencing (GBS) of 96 RILs identified three QTL on chromosome 8, 9 and 11 were found to be associated with polished Zn in a mapping population of MTU1010/ Chittimuthyalu. Three significant markers (8_7761710, 9_17940114 and 11_6204290) with 19.8, 18.6 and 20.4% PV for zinc content in polished rice from the QTL are being characterized.
- ✓ Expression of potassium channel SKOR gene (LOC_Os06g14030) has shown positive correlation (0.62) with single plant yield in a set of 18 rice genotypes under low N.
- ✓ A hypothetical protein OsI_17904 with two alternative forms was up-regulated among the transcripts in the efficient genotypes as identified from the two transcriptome data sets of two efficient and two poor genotypes grown under low and recommended nitrogen at booting stage.
- ✓ Fingerprinting of a set of 48 parental lines revealed that a moderate genetic distance is ideal for obtaining higher level of heterosis.
- ✓ Analysis of the whole transcriptome profiles of immature florets of the popular WA-CMS line, IR58025A and its isonuclear maintainer line, IR58025B, collected at pre-anthesis stage revealed down-regulation of both nuclear and organellar genes involved in key metabolic processes of cell respiration, photosynthesis and other energy yielding metabolites in IR58025A, relative to IR58025B, indicating a general shift towards conservation of energy and other key resources in the florets of WA-CMS line.
- ✓ Screening of 220 germplasm lines resulted in identification of a new set of 92 restorer lines (i.e. possessing the restorer alleles with respect to *Rf3* and *Rf4*) and 21 potential maintainer lines (i.e. devoid of the restorer alleles with respect to *Rf3* and *Rf4*).
- ✓ Well characterized yield enhancing genes, viz., Gn1a, SCM2, OsSPL14 and Gw5 were transferred into the genetic background of elite cultivar, Improved Samba Mahsuri through marker-assisted backcross breeding.
- ✓ Identified, molecular mapped and characterized a novel BPH resistance gene/ QTL, named Bph33 on Chr. 1 from the breeding line RP2068-18-3-5.
- ✓ Developed breeding lines of Improved Samba Mahsuri with genes conferring resistance against blast, BPH, gall midge and tolerance to low soil phosphorus.
- ✓ Introgressed Pup1 gene/QTL into the genetic background of Improved MTU1010 and IR64.
- ✓ The stable mutants of BPT 5204 were characterized for complete panicle emergence (CPE) using MutMap, QTL mapping and RNA-seq approaches. Unique SNP peak, responsible for causative mutation was found in chr-11 at the region of 20.14 to 20.19 Mb consisting of 36 SNPs in both the mutants which were absent in the wild type BPT 5204.
- ✓ The BPT 5204 mutant for sheath blight tolerance was characterized using MutMap. A unique peak at chr-1 (40.1 – 41 MB) region in the sheath blight (Shb-6) tolerant bulk and valley in the susceptible bulk was found indicating the region's contribution in conferring sheath blight tolerance.

- ✓ Identified a candidate gene Os03g0281466 (Malectin-serine threonine kinase) named as Pi68 (t) conferring leaf and neck blast resistance by combining QTL mapping and expression profiling. Validated the effect of qBL3 by introgression into susceptible variety i.e. BPT 5204 and identified progeny having field resistance for both leaf and neck blast.
- ✓ Characterized the gene encoding polygalacturonase, AG1IA_04727 as key pathogenicity and virulence factor, and a potential target to achieve sheath blight resistance through RNAi using whole genome transcriptomics of a highly virulent *R. solani* strain (Wgl-2), and RNA-seq of infected rice tissues of six rice genotypes.
- ✓ The sequence analysis of Os8N3 gene suggested that it possessed the effector binding element (EBE) of Xoo effector PthXo1.
- ✓ The adverse effects of RTBV and RTSV infection in photosystem II (PSII) activity of rice was demonstrated by analyzing the Fv/Fm ratio, expression of psbA and cab1R genes, and direct interaction of RTBV ORF I protein with the D1 protein of rice.
- ✓ Relative expression (qRT-PCR) of Sucrose Phosphate Synthase (SPS), Galacturonosyl Transferase (GalAT) and Phosphoglucomutase (cPGM) genes were assessed during mid to late vegetative stages and at the onset of flowering. There was an increase in SPS transcript levels and a decrease inGalAT and cPGM transcript levels during mid to late vegetative stages to flowering in Jarva and Gondra Bidhan.
- ✓ Comparative sequence and structural analysis of Pectin methyl esterases (PME) with their homologues identified putative amino acids crucial in catalysis and protein-protein interaction. Loop length variation and sequence conservation in substrate binding cleft of 53 PME genes (8 subtypes identified through phylogenetic relationship) from rice were analysed and this act as a base for gene manipulation in PMEs.
- ✓ RNA-seq of shoot and root tissues in BPT 5204 and CR Dhan 202 under aerobic and anaerobic conditions at panicle initiation stage showed up regulation of higher number of transcripts encoding transporters, transcription factors, hormones under aerobic condition. The transcription factors viz. MADS4, MADS5, MADS6, MADS7, MADS15 and transporters involved in sugar (SWEET3A) and nutrient uptake (PHT1; 6, MDR-like ABC and vacuolar iron transporter homolog 2) were highly and uniquely expressed in the aerobic adapted cultivar (AAC) CR Dhan 202 under aerobic condition indicating their role in adaptation.
- ✓ Identified promising rice lines (ATR-473, ATR-486, ATR-385, ATR-472, PUP-2, PUP-1, NH-1, ATR-275) suitable for aerobic system of cultivation based on comparatively desired root characters and high seedling vigor among the panel. Under aerobic conditions the BPT 5204 mutants viz., TI-24, TI-87, TI-124, TI-25, TI-35, TI-16, TI-7, TI-35, TI-16, TI-3 TI-37, TI-4, TI-59, TI-166 were identified with robust root system and are being characterized further.
- ✓ Developed activation tagged lines of BPT5204 through *Ac-Ds* system by using pSQ5 construct and 31 homozygous lines of *Ac-Ds*, 3 lines of Ac and 1 line of Ds system were identified. The water use efficiency of Ds-1 stable line was better in both un-stressed and stressed conditions as compared to BPT 5204. The mutant line En-62 (En-Bar construct) on evaluation under water stress conditions showed increased water use efficiency. The loss of function mutant with LOC_Os06g24540 gene was responsible for increased water use efficiency.

ICAR-National Professor Project

- ✓ Developed marker defined chromosome segment substitution lines (CSSLs) as a genomic resource in the background of popular varieties using two wild rice accessions *O. rufipogon* and *O. nivara.* Of which 80 CSSLs of *O. rufipogon* and 137 CSSLs of *O. nivara* were promising.

- ✓ Four years' yield evaluation data of five introgression lines from KMR3 x *O. rufipogon* WR120 BC4F8 BILs (NSR lines) in normal conditions, recorded mean yield 23 to 25g, 65% higher yield potential than KMR3 (17g). Two ILs were identified as high yielding low P tolerant lines when screened low P field for two years.

Crop Production

Agronomy

- ✓ Mechanized SRI recorded statistically comparable growth parameters, root growth characteristics, yield parameters and grain yield compared to normal transplanting. MSRI incurred significantly lower cost of cultivation and generated higher gross returns, net returns and benefit: cost ratio over normal transplanting.
- ✓ Nutrient Expert based recommendation of nitrogen with NCU (75%) + VC (25%) enhanced growth and yield of rice significantly with higher economic returns.
- ✓ Among water management practices, AWD resulted significantly higher grain yield (5.75 and 5.80 t/ha) over saturation method (5.38 & 5.49 t/ha) with water saving to the tune of 30-40%.
- ✓ Growth parameters, yield attributes and Grain yield were significantly high in RDF+ ZnSo4 and FeSo4 foliar spray 3 times; RDF+ ZnSo4 basal application. Post-harvest quality analysis showed no significant influence of soil or foliar application on head rice recovery, milling%, hulling%, length/breadth ratio, gel content etc.
- ✓ Green Neem leaf mulching @5 t/ha recorded lower weed population and weed biomass at 48 DAS; higher growth parameters, yield attributes and yield and comparable with weed free treatment followed by pre and post emergence herbicide application in aerobic rice system.
- ✓ Conservation agricultural practices in rice-maize system revealed that *kharif* rice transplanted at 1st July followed by *rabi* conventional tilled maize resulted in the highest weed control efficiency, system productivity (13.2 t/ha) and net returns of Rs. 96,967/- per hectare.
- ✓ Integrated nutrient management with organics and inorganics resulted in higher crop growth and yield attributes which led to increased grain yield and straw yield. Nutrient supply through integrated nutrient management and residue incorporation tended to increase the nutrient content in both grain and straw.
- ✓ Fabricated soil puddling machine using 0.5hp electrical motor and stand. A specially designed tool for puddling in pots has been fabricated and testing is in progress.

Soil Science

- ✓ The varieties Rasi, Varadhan, TL 93, MTP 5, MTP 3, PUP 221, B/V 243-1695 were identified as promising for both native soil and applied N utilization and their responsiveness. Among the N sources, neem coated urea (NCU) either alone or along with nitrification inhibitor (NI) was superior to combined application of NCU + Vermi compost (VC)+NI, rice straw compost (RSC) and VC at all N levels.
- ✓ The rice crop establishment methods significantly impacted both the greenhouse gas i.e., methane and nitrous oxide emissions throughout the crop growth period. The highest seasonal integrated flux (SIF) for methane was observed in conventional transplanted (TPR) method followed by SRI while AWD methods resulted in lower flux with irrigation at 5 cm and 10 cm depletion of ponded water, respectively. Methane

emissions decreased by 40 per cent in SRI and by 49 and 58 per cent in AWD at 5 and 10 cm, respectively as compared to TPR. The GWP was lowered by SRI and AWD methods as compared to the conventional TPR mainly due to lower methane emissions. SRI lowered the GWP by 23 per cent while AWD methods by 27 – 28% over TPR

- ✓ Ground truth survey during *kharif* and *rabi* of 2018-19 at peak vegetation time in West Godavari district was done. Measured NDVI from rice vegetation and collected leaf and soil solution samples for analysis. NDVI at the end of September (2018) indicated a significant correlation of 0.192* (n=136) with rice yield. The low 'r' value was because of ironing out of differences between fields due to averaging of crop cutting experiments at mandal level.
- ✓ The nitrite reducing activity of *Bacillus amyloliquifaciens, B. brevis, B. brevis-M, B. brevis-P, B. cereus, B. sonorensis, B subtilis* resulting in the release of ammonium was in the following order of culture filtrates of *B. cereus* (114.36 µM NO_2 reduced min^{-1}) and *B. brevis* (112.01 µM NO_2 reduced min^{-1}) followed by *B. sonorensis* (110.76 µM NO_2 reduced min^{-1}). The highest accumulation of ammoniacal nitrogen in the culture supernatant was however observed in *B. brevis* (1.28 µg NH_4-N produced h^{-1}) and *B. subtilis* (0.91 µg NH_4-N produced h^{-1}) indicating the efficiency of these isolates in converting nitrite to bio available ammoniacal nitrogen.
- ✓ The field experiment was conducted at the IIRR research farm during *kharif* and *rabi* of 2018 and isolated the nitrogen fixing microbes were isolated using N free media. A total of 355 nitrogen fixing bacteria were purified and the purified cultures were screened for ARA (Acetylene Reducing Assay) through GC analysis, among these seven cultures which are showing high ARA activity were identified as potential N fixers.
- ✓ Characterized ZnO nanoparticles were tested on plant foliage in the controlled environment (Pot culture study) and the foliar application of nano ZnO at two different intervals (30 and 45 DAT) enhanced the chlorophyll a and b content by 10 and 5% over control but which was lower than $ZnSO_4$ treated plants. In the similar way plant height and straw Zn content was enhanced by the application of nano ZnO at 150 mg L^{-1} at two intervals.
- ✓ Nutrient holding capacity of hydrogel was characterized with various nutrients. Hydrogel was able to absorb applied micro elements such as iron (Fe) and Zinc (Zn) in both red and black soils of Rajendranagar. Pot culture experiment conducted with different doses of hydrogel indicated that increased doses of hydrogel increased the water absorption capacity. Hydrogel application @ 0.5g/Kg soil was found better for water and nutrient use efficiency than the other tested treatments

Plant Physiology and Biochemistry

- ✓ Leaf gas exchange traits were measured in flag leaves using *LI6400XT* two sets of genotypes. Both the sets showed significant ($p<0.01$) variation in intrinsic water use efficiency (iWUE) which is the ratio of photosynthetic efficiency and stomatal conductance (PN/gs) and Carboxylation Efficiency (PN/Ci). Ci/Ca showed strong negative association with P_N and along with C*i* it played a significant role in determining the photosynthetic efficiency in rice.
- ✓ A field experiment with 20 breeding lines for identification of good physiological donors indicated that 13 lines showed with good yield potential and ideotype characteristics.
- ✓ To understand the variation in similar amylose containing varieties, out of 20 varieties, the expression pattern of starch synthesizing genes was similar in Improved Samba Mashuri and Tellahamsa at different stages of grain filling period.

Crop Protection

Entomology

- ✓ 3000 entries were evaluated for BPH resistance and only 14 entries viz., IC 76013, RP 5690-20-6-3-2-1, IET 26565, IR 64, IET 27274, PY74, HWR 30, HWR 19, AYT 31, OYT 5, OYT 15, OYT 23, AGBD 2018- 173 and AGBD 2018-401 were highly resistant to brown planthopper with a damage score of < 1.0.
- ✓ Eight lines derived from *O. glaberrima* were found resistant to gall midge biotype 1. Field screening of material at vegetative and reproductive crop growth stages through multi-location testing, identified BK39-179 and BK35-155 as promising for yellow stem borer. There was a negative correlation between grain yield and dead heart incidence (r=-0.3857, p=0.0388).
- ✓ QTL analysis of 92 BILs (BC_2F_8) derived from Swarna X *O. nivara* cross identified 21 QTLs including one for damaged area on chromosome 4, three for leaf length on chromosome 5 and 7 and rest for leaf width. Two major QTLs for qDA4.1 and qDP4.1 were found between RM273-RM248 which is the candidate region for further investigation.
- ✓ Six rice entries viz., SM 363, SM 669, MAS 946-1, NPS 5, NPS 14, DB 9 showed resistant reaction to rice root-knot nematode *Meloidogyne graminicola.*
- ✓ There was no adverse impact on the efficacy of either of the insecticides spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC and triflumezopyrim when applied with fungicides hexaconazole and tricyclazole or vice versa confirming the compatibility of the chemicals when used as tank mix in field.
- ✓ Four essential oils viz., cedar wood oil, lemon grass oil, Camphor oil and Eucalyptus oil at 2% and 4% were effective in reducing yellow stem borer and leaf folder damage in the field.
- ✓ Two Biointensive pest management modules varying in the seed treatment with *Triochoderma asperellum* IIRRCK1 and *Pseudomonas fluorescens* increased stem borer egg parasitization (18.9%-22.3%) and number of spiders 5.7 to 7.5/10 hills and *reduced stem borer damage* (7.4-9.8% dead hearts).
- ✓ Insecticides viz., acephate, chlorpyriphos, rynaxypyr, cartap Hydrochloride, fipronil, flubendiamide and triazophos at recommended doses were effective against swarming caterpillar *Spodoptera mauritia* causing 100% mortality within 72 hours.
- ✓ Three entomopathogenic nematode species *viz., Heterorhabditis indica, Steinernema glaseeri* and *Metarhabditis amsactae* were pathogenic to rice army worm *Spodoptera mauritia* and *H. indica* caused 100% mortality.

Plant Pathology

- ✓ Developed IET 25484 a Near isogenic line (NIL) of Swarna having *Pi-2* (a blast resistant gene) and it was released as DRR Dhan 51 through CVRC.
- ✓ Blasts NILs developed through MAS nominated to AICRIP and two NILs were promoted to AVT2 NIL trial. Six rice blast NILs developed through MAS were nominated in AICRIP under AVT1 NIL.
- ✓ Out of 4957 rice lines evaluated against rice blast disease under artificial inoculation in Uniform blast nursery pattern, 670 recorded resistant reaction.
- ✓ Developed bacterial blight (BB) resistant lines with BB resistance gene, *Xa38* in the background of ISM and IET 27294 has been promoted to AVT2. Developed advanced backcrossed lines in the background of APMS 6B by pyramiding two BB resistance genes, *Xa21* and *Xa38*.
- ✓ Sixty isolates of *Xanthomonas oryzae* pv. *oryzae* collected from different rice growing districts of Chhattishgarh were characterized on the

rice differentials, and were grouped into 9 pathotypes.

- ✓ A total of 273 MAGIC populations were phenotyped against RTD and 3 lines (201/318, 343/366 and 164/397) were found to be resistant by expressing disease score 3.
- ✓ Tungro disease infection leads to reduced net photosynthetic rate and transpiration rate and increased *intercellular* CO_2 concentration. The mean Fv/Fm ratio, representing the efficiency of the PSII, was significantly reduced (17%) in the infected plants.
- ✓ The consortia mixture of native antagonistic fungi *Viz., Penicillium oxalicum, Trichoderma asperellum* IIRRCK1 and *T. viride* IIRR1 were effective against sheath blight and blast pathogens of rice. *T. asperellum* IIRRCK1 was found to have growth promoting activities on rice and found to induce tolerance towards drought and cold.
- ✓ Artificial screening technique for false smut under glass house and field conditions to identify the resistant sources against false smut disease of rice was standardized. Out of 162 genotypes that were artificially inoculated with false smut pathogen under field condition, 92 genotypes showed varied level of susceptibility (with number of smut balls/panicle ranging from 1-31).
- ✓ About 120 isolates of sheath blight pathogen characterized by using different methods and 70 isolates were preserved in long term (-20 °C) storage. The pathogen *R. solani* induced defense enzymes viz., PAL, SOD, POX, PPO only in tolerant cultivars (Whazhuophek, Ngonolosa and Tetep) compared to susceptible cultivars (TN-1 and IR-50).
- ✓ Among the 43 HWR entries (from IRRI) artificially screened at field during the years 2015 to 2019, five entries identified as tolerant *viz.*, HWR-15, HWR-22, HWR-23, HWR-35 and HWR-35. About 380 lines of magic lines were screened and identified 96 lines with 5 score.
- ✓ Out of 1418 entries and F8 population (330) of improved Sambha Mahsuri X Wazuhopehk evaluated under artificial disease pressure at field conditions around 45 entries and 25 lines of F8 population were recorded moderately resistant/tolerant and resistant reaction respectively.
- ✓ The combination product is trifloxystrobin 25% + tebuconazole 50% WG (0.4g/l) found effective in minimizing the leaf blast. Azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC (1.0 ml/l) and new molecule mefentrifluconazole (0.35 ml/ 0.4 ml) found effective against sheath blight.
- ✓ During *kharif* 2018, it was observed that brown spot disease incidence and severity was very low to low in areas of Jagtial, Kamareddy, Masipet and Nalgonda districts of Telangana.
- ✓ Out of the different light sources and light regimes used to trigger the sporulation in *Bipolaris oryzae*, exposure of fungal culture to 12 hours of near UV (NUV) followed by 12 h of incubation under dark condition at 26 °C was found to trigger the excellent sporulation in fungus.
- ✓ Among the different nutrient sources used for the growth and sporulation of *Bipolaris oryzae*, it was found that rabbit food agar could induce good vegetative growth and sporulation in fungus after exposure of fungus to 12h of NUV and 12 h dark condition. Chopped sorghum and maize grains could also induce very good sporulation among the natural media tested for the sporulation of the fungus.
- ✓ Total 17 isolates of Sheath rot fungus were collected and morphological characters were studied for their colony growth, colony color, type of growth and sporulation. The isolate Karjat showed the maximum radial growth

(8.07 cm) and the isolate Varanasi showed the minimum radial growth (6.10 cm). *Sarocladium oryzae* taking more than 35 days to fill the entire petri plate.

- ✓ Five different media were tested for *S. oryzae* growth and sporulation. Oat meal agar media supported the best growth and sporulation compared to the all media tested and cornmeal agar media supported less growth and sporulation.
- ✓ Six isolates of Stem rot fungus were collected from Telangana state and they differ significantly one from the other. They differ in sclerotia formation, place of sclerotia formation in the plate and days to form the sclerotia.

Training and Transfer of Technology

- ✓ IIRR organized three training programs on various aspects of Rice Production technologies, through which 67 participants were trained. Eight one day training programmes for the farmers on various need based topics like importance of quality seed, Quality Seed Production, Integrated weed management, preparation and use of Bio-fertilisers, Rice based cropping system were organized and totally 388 farmers were trained.
- ✓ Under the Tribal sub-plan, a total of 200 farm households were supported with improved rice production technologies to enhance their livelihood covering two districts, Mahabubnagar and Ranga Reddy of Telangana State.
- ✓ IIRR organized Seed and Farmers day on 3rd Nov, 2018. About 500 farmers across Andhra Pradesh, Telangana and Karnataka states participated in the event. Technologies developed by IIRR including 52 high yielding rice varieties, rice germplasm, mechanised transplanting, INM and IPM technologies, various crop establishment methods along with water saving techniques were displayed and explained to the farmers.
- ✓ IIRR Geoportal was developed using open source technologies GeoServer and GeoExt. Geo-referenced maps can be easily published in this portal. Since there are many GIS based applications developed in IIRR, the entire work was effectively visualized through this portal.
- ✓ Developed a mobile App on Rice IPM in Telugu language, demonstrated and installed successfully for 75 farmers. This is currently available in google play store https://play.google.com/store/apps/details?id=org.iirr.varipirusasyarakshana&hl=en

Introduction

Genesis

Mandate

Organization

Infrastructure

Linkages

Staff & Budget

Significant Achievements

Introduction

Genesis

The All India Coordinated Rice Improvement Project (AICRIP) was established in 1965 at Hyderabad, with the responsibility to organize multi-disciplinary, multi-location testing and develop suitable varietal and production technologies. AICRIP capitalized upon the available research infrastructure in different states of India and successfully introduced a national perspective in technology development and testing. AICRIP was later elevated to the status of Directorate of Rice Research (DRR) from April 1983 with the added mandate of pursuing research on irrigated rice.

In 1965, AICRIP was started with 22 centers (19 main and 3 testing centers) with 7 zonal centers and 12 regional centers. During fifth five year plan (1974-79) the main and sub centers were classified single cropped (24) and double cropped (21) centers. Excepting Pondicherry and Varanasi which were fully funded by the ICAR, the rest of the centers were financed on a 75:25 with State Agricultural Universities (SAUs-25%) or 50:50 per cent basis with State Departments of Agriculture (SDAs-50%). During VI plan period (1980-85), 8 more sub centers were sanctioned raising the total to 53. There were a total of 61 centers including 8 subject related special centers. In the VII plan period (1985-89) the number of centers was reduced to 50 (18 main and 32 sub centers. During the eighth plan (1992-97) there were 51 approved centers of which six centres were withdrawn and Karnal centre was merged with Kaul in the IX plan period (1997-2002). The total number of centers during X plan (2002-2007) increased to 46 with the approval of Kanpur and Nagina centers and to 47 during XI plan (2007-2012) with addition of Navsari in southern Gujarat in western India. The Directorate has evolved into an efficient and successful program of partnership in rice research bringing together more than 300 rice researchers from 47 funded and over 100 voluntary research centers. In the 12th plan, Indian Council of Agricultural Research (ICAR) has upgraded the DRR to Indian Institute of Rice Research (IIRR).

The Mandate

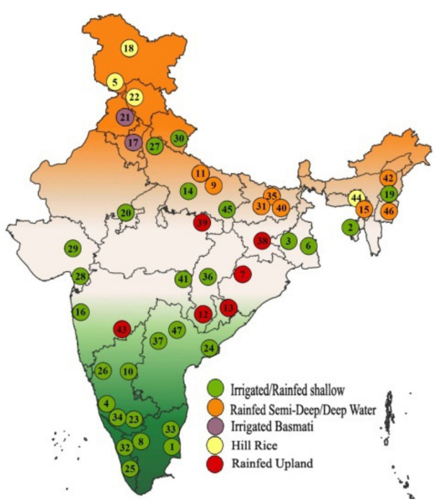
Basic and strategic research for enhancing rice productivity under irrigated ecosystem.

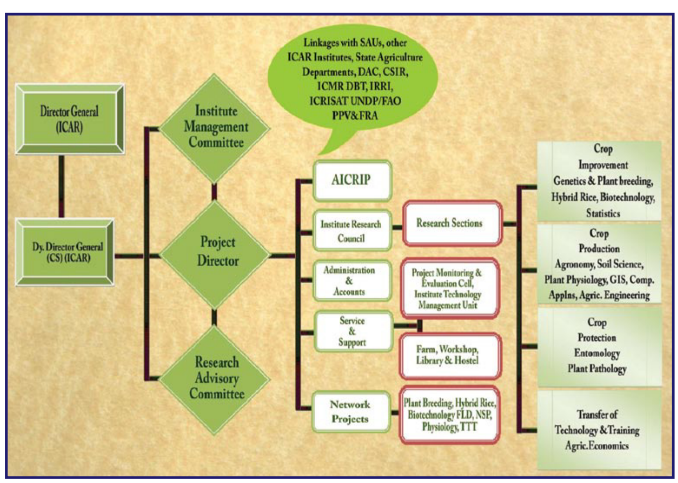
Coordination of multi-location testing to develop location specific varieties and technologies for various ecosystems.

Dissemination of technologies, capacity building and establishing linkages.

The Organisation

IIRR is an important constituent institute of ICAR under direct supervision of the Deputy Director General for Crop Sciences. The detailed





organizational setup of the Institute is provided in its organogram. For fulfilling its mandate effectively, IIRR is organized into four sections and ten units along with centralized service wings and administration. AICRIP activities are integrated into the mandate with senior most scientists of each discipline acting as the PIs of the programme. There are 45 funded and more than 100 voluntary centers involved in rice research activities. Research and institutional activities are planned and guided by Research Advisory Committee and Institute Management Committee while the progress is critically evaluated once in five years by the Quinquennial Review Committee (QRT).

S. No.	Center	S. No.	Center	S. No.	Center	S. No.	Center
1	Aduthurai	13	Jeypore	25	Mugad	37	Ranchi
2	Agarthala	14	Kanpur	26	Nagina	38	Rewa
3	Bankura	15	Karjat	27	Navasari	39	Sakoli
4	Brahmavar	16	Kaul	28	Nawagam	40	Titabar
5	Chatha	17	Khudwani	29	Pantnagar	41	Tuljapur
6	Chinsurah	18	Kohima	30	Patna	42	Upper shillong
7	Chiplima	19	Kota	31	Pattambi	43	Varanasi
8	Coimbatore	20	Ludhiana	32	Pondicherry	44	Wangbal
9	Faizabad	21	Malan	33	Ponnampet	45	Warangal
10	Gangavati	22	Mandya	34	Pusa		
11	Ghaghraghat	23	Maruteru	35	Raipur		
12	Jagdalpur	24	Moncompu	36	Rajendranagar		

Infrastructure

The Institute is equipped with state of the art facilities with fully equipped laboratories for all the sections, centrally air cooled greenhouses for screening germplasm for resistance against pests and diseases, net-houses, growth chambers, screening nursery beds, containment transgenic poly-houses and heat tunnels. Field facilities include a well laid out experimental farms at Rajendranagar (20 ha) and Ramachandrapuram (40 ha) with a wild rice garden and pollination chambers along with adequate farm machinery, godowns and limited cold storage facilities. A centrally air conditioned auditorium with 350 seating capacity, seminar halls, guest house, hostel facilities and a canteen for imparting training and to disseminate information using latest multi-media and ICT tools. The Central library of the institute is a fully digitized with over 4,654 books, 6,500 bound volumes and subscribes to 55 Indian and 13 foreign journals. The significant achievements of the Institute are exhibited in the form of posters, graphs and other visuals for the benefit of visitors through a state of the art museum.

Linkages & Collaborations

ICAR-IIRR has a strong and wide network of linkages and collaborations with research organizations both in India and abroad. Under AICRIP, it has 45 funded centres affiliated to State Agricultural Universities and Departments of Agriculture of 27 states and 2 Union territories besides five ICAR institutes. 90-100 voluntary centres are providing support in the evaluation and testing work.

Research Linkages: ICAR-IIRR has a strong collaboration with CGIAR institutes such as International Rice Research Institute (IRRI), Philippines and International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Hyderabad and many National institutes like CRIDA, NBPGR, New Delhi (ICAR); PPV&FRA, New Delhi, IICT (CSIR) and NIN (ICMR), Hyderabad and IICPT, Delhi University, Centre for Cellular and Molecular Biology (CCMB), Hyderabad and Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad.

Academic linkages: ICAR-IIRR has accreditation from several universities such as ANGRAU, PJTSAU, Osmania University, University of Hyderabad, Jawaharlal Nehru Technological University, Yogi Vemana University, Kakatiya University, University of Agricultural Sciences, Bangalore, Acharya Nagarjuna University etc.,

ICAR-IIRR also has a strong **Public Private Partnership** (PPP) mode of operational linkage with the private sector, especially relating to hybrid rice technology and its commercialization. This partnership started two decades back has turned out to be one of the best examples of PPP in the country.

The Staff

S. No.	Category	Sanctioned	Filled	Vacant
1	Scientists (excluding Director)	71	67	04
2	Administration	32	24	08
3	Technical	44	**35**	08
4	Supporting Grade	15	08	07
	Total	**161**	**134**	**27**

The Budget (2018-19)

(Rupees in lakhs)

Item	2018-19	
	Outlay	Expenditure
IIRR, Hyderabad	3851.22	3836.10
AICRP Rice, Hyderabad	3507.50	3507.50

Research Achievements

Coordinated Research

Crop Improvement

New Varieties and Hybrids released

Crop Production

Agronomy

Soil **Science**

Plant Physiology

Crop Protection

Entomology

Pathology

Transfer of Technology

All India Coordinated Rice Improvement Project (AICRIP)

Crop Improvement

New Varieties and Hybrids released

A total of 34 varieties including 4 hybrids and 30 varieties were released for different ecologies during 2018-19 (Table). Four hybrids and 10 varieties were released by Central Varietal Release Committee whereas twenty varieties were released by State Varietal Release Committee. State-wise, 11 varieties for Tripura, 5 for Odisha, 2 for Karnataka and one each for UP and Tamil Nadu were released by SVRC.

Table List of Varieties and hybrids released by Central and State Varietal Release Committee during 2018-19

Sl. No	Variety / Hybrid	IET No	Cross Combination	FD	Eco-system	GT	Reaction to Pests and diseases	Notified States
	Central Releases							
1	MRP 5408 (Hybrid)	24143	PMS 255 / PR540	101-103	IRM	LS	MR-BL, RTV & BS	AP, KA, PY, OD, BI, MN, CH, JK
2	VNR 2111 Plus (Hybrid)	24075	VNRF 121 / VNRRB 1968	90	IRE	LB	MR-GM	PB, UT, HA, OD, BI, WB, MP
3	VNR 2228 (Hybrid)	24951	VNRF 102 / VNRRDN 10221	100-105	IM	MS	MR-BL, BLB & RTV	UT, HA, RA, OD, BI, UP, CH, MH
4	VNR Laxmi Plus (Hybrid)	25287	VNRF 48 / VNRRB 412	115	IRL	SB	MR-BL, BLB	CH, MH, GU
5	Bina Dhan 17 GSR	24460	C418/(Zhongg413)2//SH109/Zhong413)2	86	IRE	LS	R-BLB & ShBl, MR-BPH	WB, AS, TR
6	BRRI Dhan 69	24461	WuShan YouZhan / PI312777	120	BORO	MB	R-BL, BLB, Shbl & SB	WB, AS, TR
7	BRRI Dhan 75	24459	Yuefenzhan / E-Zhong 5	87	IRE	MS	R-BL, BLB & Shbl MR-GLH, SB & BPH	WB, AS, TR
8	Pusa Samba 1850	25480	BPT5204/DHMASQ164-2B//BPT5204*3	110	IRM	MS	R-BL	CH, OD
9	ADT 52	25521	CR 1009/ ADT 49	118	IRL	MS	R-GM, MR-BL, SB, LF	CH, MH
10	CSR 56	24537	CSR 21/ CSR 10	100	IRSA	LB	MR-BL, BLB, SB, LF	UP, HA
11	CSR 60	25378	IR 4630-22-2-5-1-3 / IR 05N204	100	IRSA	LS	MR-BL, RTV, BPH, WBPH	UP, PO
12	Gujarat Anand Rice 14 (GAR 14)	24619	GR 7 / (Mahi Suganda/2-1)	110	ASG	MS	MR-BL, BLB, SB & GM	MH, GU
13	Swarna shreya	24003	IR 78877-208-B-1-1/ IRRI 132	85-90	ARB	LB	MR- BL, RTV, BS, SB, GM, LF	CH, MP, BI

Sl. No	Variety / Hybrid	IET No	Cross Combination	FD	Eco-system	GT	Reaction to Pests and diseases	Notified States
14	YNP 9761	24338	NPR 9/ NPR4	105-110	IRME	SB	MR-BL, ShBl & BS	CH, WB, OD, BI
	State Releases							
15	CSR 46	18710	IR 72 / CSR 23	98	IRSA	LS	R-B, WBPH & LF MR-BL, ShBl & BS	UP
16	Gobinda	21009	OR 1206-26-2 / IR 57313	105	IRM	MS	MR: BLB, ShBl & GM	OD
17	Hasanta	21477	OR 1206-26-2 / OR 1534-129	120	RSL	SB		OD
18	Ashutosh	21341	OR 1301-32 / IR 52561	120	RSL	SB		OD
19	ADT 51	23617	BPT 5204 / Improved White Ponni	124	IRL	MS	R-BL, MR-BLB, ShBl, SB, BPH & LF	TN
20	Gomati Dhan (TRC 2005-1)	21512	Pyzum / BPT 5204	107	IRM	MS	MR-BL, BLB, BS	TR
21	Khowai (TRC 2005-3)	21564	Jagannath / Jaya	102	IRME	MS	MR-BL, BLB, BS	TR
22	KHP 13	21479	Indravathi / IR 62181-B-49	135	IRL	MS	MR-BL, T-SB, LF	KA
23	KKP 5	24250	BPT 5204 / IET 21075	100	IRM	MS	T-BL, BLB & BPH	KA
24	Pradeep	20923	OR 1206-26-2/ IR 62140	105	IRM	LS	MR-BL, ShBl	OD
25	Pratibha (OR 2172-7)	21582	IR 64/// IR 72// Jagannath / NCJ 10	95	IRME	LS	R-BL & BS	OD
26	Tripura Aush	24732	IR 78877-208-B-1-2 x IR 74371-54-1-1	71	IRE	LS		TR
27	Tripura Chikan Dhan	22112	C 53 X IR 28224-3-2-3-2	98-100	IRME	MS		TR
28	Tripura Hakuchuk 1	24659	IR 78877-208-B-1-2/IR 74371-54-1-1	68-70	ARB	MS		TR
29	Tripura Hakuchuk 2	–	IRRI 132 x IR 74371-54-1-1	68-71	RUP	LS	MR-BL, BLB & BS	TR
30	Tripura Jala 1	22167	TRC 229-F-41 x Jaya	120	SDW	LS		TR
31	Tripura Khara 1	22837	Aday Sel/*3 IR 64	90-94	Drought	LS		TR
32	Tripura Khara 2	22835	Aday Sel/*3 IR 64	90-94	Drought	LS		TR
33	Tripura Nirog	22850	IR 24594-204-1-2-3-2-6-2 X IR 28222-9-2-2-2-2	92-95	BORO	SB		TR
34	Tripura Sarat	22113	IR 728-120-1-2-2 X IR 72870-19-2-2-3	98-100	BORO	MS		TR

Coordinated varietal testing

During 2018, the 54th year of AICRIP testing, a total of 49 trials (45 varietal trials and five hybrid rice trials) were conducted in 939 experiments (792 varietal and 147 hybrid rice) at 122 locations (45 funded and 77 voluntary centres) in 27 states and 2 union Territories across seven zones of the country. The 49 trials were constituted with 1328 entries (1251 varietal and 77 hybrid rice) including 177 checks. The overall receipt of data was 78.96% of which 89.18% and 65.83% data was received from funded and voluntary centres respectively. Twenty six promising lines were identified in varietal trials (Appendix 1).

Hybrid Rice

The total area planned to hybrid rice has reached three million ha during the year 2018 and more than 80% of the total hybrid rice area is in the states of Uttar Pradesh, Jharkhand, Bihar, Chhattisgarh, Madhya Pradesh, Odisha and Haryana. So far, 105 hybrids have been released in the country for commercial cultivation. During the period under report, five hybrids (central releases-3; state releases-2) were released (Table) and notified by CSCCSN & RV for commercial cultivation in different states of the country.

Initial Hybrid Rice Trials

Four Initial Hybrid Rice Trials (IHRT) viz., Early, Mid Early, Medium and Medium Slender grain type were conducted with 18, 30, 18 and 11 hybrids respectively at 35 to 38 locations of the country. Promising hybrids identified based on overall mean yield advantage over the checks are given in appendix 2.

Monitoring of AICRIP trials:

A multi-disciplinary team of 67 scientists from ICAR- IIRR, ICAR- NRRI and scientists from co-operating centres have monitored 73 AICRIP centres in different states. Monitoring of AICRIP trials was taken up between September to December 2018.

National seed project and Breeder seed production:

Breeder seed production of 262 rice varieties and parental lines of six hybrids was organized at 42 centers across the country as per DAC indent. A total production of 7204 quintals of breeder seed was achieved against the allocated target of 4323 quintals (**Appendix 3**). At ICAR-IIRR, 173 quintals of breeder seed of 21 varieties was produced.

Crop Production

Agronomy

A total of 210 experiments were conducted at 44 locations on various aspects of rice agronomy to generate technologies which can reduce the cost of cultivation and enhance the productivity.

Nutrient Management Trial (NMT)

Nutrient management trials (NMTs) were conducted during *kharif* 2018 to find out the production potential of promising cultivars and their response to varying levels of nutrients and to identify the optimum dose and the effect on late planted rice situations. Evaluation of promising cultivars (36 cultures) belonging to 12 groups *viz.,* early hill (irrigated), medium hill (irrigated), early (DS), medium, late, medium slender, rainfed shallow low land, alkaline, inland saline, coastal saline, aerobic and biofortified trials in transplanted situation, for their response to integrated nutrient management at 50, 100 and 150% recommended dose of fertilizer (RDF) was undertaken at AICRIP locations. Popular varieties and new entries which performed better under various agro-ecologies were Vivek Dhan-86, Shalimar rice 1, IET-25121, IET-26356, Sahbhagidhan, Govind, IET 25746, IET 26027, IET 25997, IET 25785, IET 25269, IET 26263, IET 25795, IET 25793, IET 25856, IET 22836, IET 25059, IET 26168, IET 26383, IET 26375 26375 and recorded higher mean grain.

Cultural Management Trials

Cultural management trials conducted across the locations revealed that mechanical transplanting resulted in the highest grain yield (5.63 t/ha) followed by manual transplanting (5.21 t/ha) and SRI (5.06 t/ha), which can be promoted among the farmers. Similarly, 150% RDF in *kharif* season followed by 100% RDF in *rabi* season was found to be the best combination irrespective of crop establishment methods. Cost of cultivation incurred under flooding was higher across all the locations and varied from Rs. 33,443/- (Varanasi) to Rs. 45,850/- (Mandya). There was a saving of Rs. 3,800/- per hectare at Mandya under alternate wetting and drying over flooding. Similarly, input water also saved to the tune of 70 cm/ha.

In another trial, Iron coated seed with seed rate of 25 kg/ha and broadcasted in 1-2 mm water level condition (direct sowing) recorded higher grain yield (4.18 t/ha) than 3.44 t/ha under uncoated seeds. There was an increase of 11% grain yield due to iron coating of seeds. Phosphorus management in rice revealed that there was an increase of 19.2% and 6.9% in grain yield due to application of 40 kg P_2O_5/ha over without and 20 kg P_2O_5/ha application of phosphorus, respectively. Under late planting condition, higher dose of fertilizer (125% of RDF) and closer spacing gave significantly higher grain yield of rice.

Weed Management Trials

Integrated Pest Management in rice was practiced in rice during *Kharif* 2018 at 11 locations and the results showed that across the locations, weeds, insect pests, and disease incidence was low in IPM plots. Weed population and weed biomass recorded at all the locations were considerably reduced by two to five times in IPM implemented plots compared to farmers practice and resulted in significantly higher grain yields. Thiobencarb at different doses was evaluated in wet direct sown rice in comparison to the promising pre and post emergence herbicides at different locations during *kharif* 2018. Systemic post emergence herbicide thiobencarb @ 5 l/ha applied at 20 days after sowing was found superior, resulting in higher weed control efficiency; higher grain yields and the performance was comparable to hand weeding twice, standard post emergence herbicide bispyribac sodium @ 300 ml/ha.

Rice Based Cropping Systems

With an objective to identify the effect of conservation agriculture management practices on rice and rice based cropping systems, a new trial was initiated. Main plot treatments comprised of three crop establishment methods (M1 – Transplanting, M2 – Wet seeding (line sowing under puddle condition) and M3: Aerobic rice – Dry rice cultivation). The sub plot treatment consisted of 3 different residue/ straw management (S1 – No residue, S2 – 15 cm height of rice straw retention and S3 – 30 cm height of rice straw retention). Among the crop establishment methods, transplanting method gave better yields at most of the locations due to reduced weed competition. Higher average higher system productivity (9.05 t/ha) was recorded under rice-cowpea system at Mandya. Weed population was low under transplanting method but the average cost of cultivation was higher. Wet seeding was promising at Ragolu and Chinsurah. Pre-*kharif* pulse crop increases grain yield significantly over rice-rice system at most of the locations.

Soil Science

In the 30th year old study on long term soil fertility management in RBCS, the results indicated the significantly superior performance of RDF+FYM and RDF over other treatments at MTU in both seasons and in *kharif* at TTB. Whereas, RDF+FYM was superior to all other treatments at MND during *kharif* and at TTB during *rabi*. FYM alone treatment was on par to RDF in *kharif* at MND and TTB. Omission of major nutrients resulted in maximum yield reduction compared to micronutrients at all three locations. Responses to N application were more MND and MTU and to K at TTB compared to other nutrients. In general, INM and organics alone treatments resulted in improvement of soil fertility parameters which had reflected positively in rice productivity t all locations.

Yield gap analysis was assessed to ascertain the gaps of technology and compared the yield variations among low yielders and high yielder *vis* a *vis* uptake, soil quality index gaps. Very high yield was noticed at Chinsurah almost to the tune of 51% followed by 26 and 29% at Ghagraghat and Karaikal, respectively. Yield gap variations were comparatively low at Maruteru (16%) and Pantnagar (18%) due to narrow gap of grain harvest existed. At Faizabad, yield gap was to the tune of almost 20%.

Gypsum coupled with NPK application improved rice yields at Kanpur and Mandya by 65-127% and 7-15%, respectively. The genotypes DRR Dhan 46, CSR 23, DRR Dhan 42, DRR Dhan 42, DRR Dhan 45, DRR Dhan 43 produced the highest yields when supplemented with 100% GR (4.46-4.61 t ha^{-1}) at Kanpur, whereas the highest yield with same genotypes was observed in unamended native sodic soils of Faizabad. At Mandya, CSR-23, IR30864, DRR Dhan 40 and DRR Dhan 43 recorded highest yields with 100% GR application (5.69-6.09 t ha^{-1}) and exhibited better tolerance to sodicity at Mandya compared to other genotypes as demonstrated without gypsum treatment. In Faizabad, the genotypes NDRK 500051, IRSSTN 30, IRSSTN 30, IRSSTN 110 and NDRK 50063 recorded highest yields (3.74-4.89 t ha-1) without gypsum amendment.

Liming increased grain yields by 9-19%, 15% and 17% at Raipur, Ranchi and Titabar, respectively. Genotypes tolerant to native soil acidity were Mahesw3ari, Binadhan, PA 6444, Mahamaya at Raipur and MTP 7, 3447, MSM, TI-93, US 312 and PUP-1 at Titabar. Whereas genotypes BInadhan75, KRH 4, Bina Dhan 17 and US 312 exhibiting highest response to liming were also observed to be tolerant to acidity at Ranchi.

Recommended dose of fertilisers (RF) and Nutrient expert based fertiliser recommendation were experimented in multi-location sites to identify the better performing treatment. The superiority of Nutrient expert based fertiliser recommendation in grain and straw production was observed in all centres except Chinsurah and Khudwani where RDF was performed better. Site variations were evident with regards to total uptake of NPK even with in centres and among different treatments which depended on the soil supply potentials and plant requirements.

From the fourth year study on “ Bio-intensive pest management”, it can be summarized that among four locations (CHN, IIRR, PDU and TTB), BIPM was significantly superior to farmers practice (FP) at CHN and TTB locations during *kharif* and both treatments were on par at IIRR and PDU, in terms of grain yield. This could be attributed to the significant increase in yield components at CHN. The pest incidence was either reduced in BIPM plots or on par compared to Farmers practice. The natural enemies were higher in BIPM plots in all locations. No significant difference was noticed in nutrient content, uptake and grain quality parameters between BIPM and FP and improvement in soil properties with BIPM was observed at CHN and TTB.

In the first year study on “Residue management in organic rice based cropping systems” stated that rice productivity was highest under RDF while control maintained the lowest grain yield values. However, crop residues at 100 and 150% N were on par and significantly superior to RDF at Ghagraghat while combined application of residues (75% N) with GM/GLM (25% N) was on par with RDF at Ghagraghat, Karaikal and Pusa. Nutrient uptake was highest under RDF. The crop residue treatments were at par and did not vary much in terms of nutrient uptake and maintained higher nutrient use efficiencies over RDF. Moreover, this being the first year of the trail, no significant change in post-harvest soil nutrient status was observed with residue treatments.

Plant Physiology

Physiological studies under All India Co-ordinated Rice Improvement Program were conducted at eight funded centres, (Coimbatore, Maruteru, Pantnagar, Pattambi, Rewa, Raipur, Karjat and Titabar), two ICAR institutions (IIRR Hyderabad and NRRI Cuttack) and six voluntary centres (RARS Chinsurah, NDUAT Faizabad, PJNAR Karaikal, RARS Karjat, IGKV RAIPUR and BAU Ranchi) in 2018-19. The salient findings of the experimental research are presented below:

Influence of silicon solubilisers on induced stress tolerance in rice genotypes

In view of the importance of silica in rice nutrition, a trial was conducted at different AICRIP locations spread across the country. The experimental lay-out was split-plot with three replications. The treatments include T1= Control (water spray), T2=0.8% silixol, T3 = Silixol + water stress, T4=Water stress. Water stress was imposed after PI stage by withholding irrigation. T2 resulted in >9% increase in mean grain yield (mean of all varieties & locations). T4 resulted in >20% reduction in mean grain yield.

Maximum yield improvement was observed in US-312, KRH-4 (>14%) and PA-6444 (12%) over T1. Imposition of water stress had resulted in substantial yield loss in all the varieties. The mean grain yield was reduced by >20% over control by water stress. Maximum yield loss was observed in Sahabhagidhan followed by HRI-174. Minimum yield loss was observed in KRH-4 and PA-6444. T3 had resulted in partial mitigation of negative impact of water stress and significant genotypic differences were observed. The reduction in yield loss due to silicon application was higher (> 9% over T4) in PA-6129, Sahabhagidhan and HRI-174 and marginal mitigation in PA-6444 and US-413.

Screening of elite rice cultures for drought tolerance:

A trial to study the drought tolerance traits of rice cultures with respect to yield and other attributes under dry spells was conducted with 22 AVT entries and 8 released varieties at 5 AICRIP centres. The treatments consisted of two irrigation regimes **a.** Irrigated as per the recommended schedule and one totally rain fed condition without any supplementary irrigation. The reduction in grain yield was highest in IET 27524, Tulasi, IET27510 and IET 27509. In fact, very few entries IET 27515, Sahabhagidhan and IET 27525 showed yield reduction <50% over irrigated control. All other entries suffered substantial yield losses under rain fed condition. Govind produced highest yield followed by IET Nos. 27514, 27522, 27520, 27525, 27519 and Sammaleswari under rainfed condition and may be considered as relatively suitable for rainfed condition. They also showed high Mean Rank with low SE and may be considered as relatively drought tolerant.

Evaluation of rice genotypes for terminal heat stress tolerance suitable for future climate

Field grown crop was covered with polythene at panicle initiation (PI) stage upto maturity to induce heat stress. The mean grain yield (all varieties and locations) was reduced by >25% under elevated temperature regime and varied from 315 gm^{-2} (IET 26790) to 472 gm^{-2} (IET 25713). The mean grain yield *(all genotypes)* varied between locations. The per cent reduction in grain yield over control under elevated temperature was minimum (>5%) at HAT and highest at REWA (>66%) followed by PTB (>60%). IET 26780 and IET 25713 showed <15% yield reduction over control. Whereas IET 26790 and IET 26465 followed by Sahabhagidhan showed >35% yield reduction over control. Yield indices computed from yield recorded under control and elevated temperature conditions, IET Nos. 26804, 26799, 26756 and MTU 1153 showed high rank value and low SE. CO-51 followed by IET 26804 and IET 26807 are with low ASV value can be considered as stable genotypes under elevated temperature. However, the yield average of CO-51 across the locations was less than the mean grand yield. Whereas both IET 26804 and IET 26807 noted slightly higher yield than the grand mean yield. In this trial IET 26468 ranked 1st in stability followed by IET 26468, IET 26477 and IET 24911.

Physiological characterization of selected rice genotypes for multiple abiotic stress Tolerance

Multiple abiotic stress (MAS) tolerance of traditional cultivars possess poor agronomical traits like photosensitivity, poor grain quality and lower yield. Hence, 21 entries were screened for MAS. IET 26487, IET 26493, BPT 2782, Karjat7 and Lalat were identified as promising for MAS. However, the study reveals that entries with MAS tolerance are very few and different entries performed differently under stress induced conditions.

Evaluation of Radiation and Nitrogen use efficient promising rice genotypes

Nitrogen (N) nutrition affects all levels of plant function from metabolism to resource allocation to growth. Nitrogen use efficiency (NUE) in plants is a complex phenomenon that depends on a number of internal and external factors, which include soil N availability, its uptake and assimilation of carbon and nitrogen. The highest average grain yield (across the locations) was produced by Varadhan x BPT 5204/10 (413 g m^{-2}) followed by Sampada x Jaya/3 (408 g m^{-2}) under 0 kg N ha^{-1}. Under 50 kg N ha^{-1}, highest mean grain yield was produced by Sampada x Jaya 3 (543 413 g m^{-2}) followed by Sampada x Jaya/2 (523 g/m^{-2}) and Varadhan x BPT 5204/10 (509 g m^{-2}). Entries producing higher grain yield under low N can be considered as NUE genotypes.

The AMMI biplot analysis conducted for both 0 and 50% RDBN revealed that MTU, KJT, PNR, CBT locations were similar and do not exert significant environmental effect. Sampada x Jaya/3, Varadhan x MTU1010/2 and Rasi x Jaya/2 were less affected by environments. The ASV was least in Sampada, Sampada x Jaya/3 followed by MTU 1010 0 kg N ha^{-1}. Under 50 kg N ha^{-1} treatment, the ASV was least in Varadhan x BPT 5204/10 followed by MTU and Sampada. Genotypes having low ASV value can be considered as stable genotypes under low N levels. Based on yield stability index (YSI) values, Varadhan x BPT 5204/10 and Sampada x Jaya/3 under 0 kg N ha^{-1} and Sampada x Jaya/3, Sampada x Jaya/2 followed by Varadhan x BPT 5294/10 under 50 kg N ha^{-1} can be considered as stable genotypes across the environments.

Screening of rice varieties for tolerance to low light stress

Light intensity is one of the most important environmental factors that determine the basic characteristics of rice development. In view of the importance of low light tolerance in rice crop, a new trial was formulated during the 51st Annual Rice workers Group Meeting of AICRIP held at IGKVV, Raipur. 15 AVT entries were tested at 7 locations. Under low light, the mean grain yield was reduced by 45% over control. Maximum reduction in grain yield over control was observed at NRRI followed by RPR and PNR (>50%). The reduction in grain yield was highest in IET 27543 followed by IET 27563 and IET 27550, minimum in IET 27559 (>27% reduction) and <35% over control in the remaining genotypes. Thus, none of the tested genotypes are tolerant to low light stress. Amongst the 15 entries tested only IET 27559 showed relative tolerance to low light stress.

Crop Protection

Entomology

All India Coordinated Entomology Programme was organized and conducted during *kharif* 2018 with seven major trials encompassing various studies such as Host plant resistance, Insect biotype studies, Integrated Pest Management studies, Chemical control studies, Ecological studies, Biocontrol and Biodiversity studies. In total, 393 experiments (87.3%) were conducted at 41 locations (32 funded + 9 voluntary) in 22 states and one Union territory.

A set of 1661 entries including 1425 pre-breeding lines, 94 hybrids, one cultivar and 28 germplasm accessions and 113 check varieties were evaluated against 12 insect pests in 213 tests (46 greenhouse reactions+167 field reactions). 104 entries (6.62%) were promising against various insect pests of which 15 entries were under retesting.

16 breeding lines *viz*., BPT 2601, CB 15569, CB 15144, MTU 1303, MTU 1305, MTU 1306, MTU 1307, MTU 1308, MTU 1309, WGL 1250. WGL 1319, WGL 1320, RNR 19416, RP 5995 Bphk17-5, IR 73382-80-9-3-13-2-2-1-3-B (HWR-16) and RP 5690-20-6-3-2-1, four germplasm accessions viz., IC 216735, IC 76013, IC 75975 and IC 76057 and two checks PTB 33, RP 2068-18-3-5 and MO1 were promising against brown planthopper.

SKL 07-11-117-50-65-60-267, WGL 1164, Aganni and W1263 were promising against gall midge. HWR 24, MSM 139, NEG 186, HPR 2613 and HWR 3 were promising against leaf folder. Sixteen entries viz., JGL 32467, JGL 32485, BK 39-179, JGL 33080, JGL 33124, JGL 34508, RP 5587-B-B-B-209, RP 5587-B-B-B-253-2, BK 35-155, JGL 34505, KAUPTB 0627-2-11, KAUPTB 0627-2-14, RP 5587-B-B-B-258-1, RP 5587-B-B-B-262, RP 5588-B-B-B-B-232 and JGL 28547 were promising against stem borer. BPT 2231, BPT 2611, IET 27275, IET 27284, IET 27480, IET 27379 and IET 27392 were promising against 2-3 insect pests.

PTB 33 with bph2+Bph3+unknown factors and RP 2068-18-3-5 with Bph33(t) gene were promising at all 10 locations while Rathu Heenati with Bph3+Bph17 genes and T 12 with bph7 gene performed better in 5 locations. Aganni (*Gm8*), INRC 3021(*Gm8*) and W1263 (*Gm1*) were promising against gall midge in 5-8 tests.

There was no adverse impact on the performance of the two newer insecticides (spinetoram + methoxyfenozide) when applied alone or in combination with fungicides (hexaconazole and tricyclazole) confirming the compatibility of the chemicals when used as tank mix in the field.

The essential oils like eucalyptus oil was found effective against stem borer; cedar wood oil was effective against gall midge, all the essential oils were moderately effective against planthoppers, effective against leaf folder and safer to natural enemies.

Late planting of rice resulted in high incidence of stem borer, gall midge, leaf folder, caseworm, brown planthopper and white backed planthopper except whorl maggot as compared to early and normal planting.

Non-pesticidal methods such as increasing floral diversity, water management, organic manures, alleyways as part of ecological engineering resulted in reduced planthopper populations and increased natural enemy populations.

In the bio intensive pest management plots, pest incidence was reduced and natural enemies were higher as compared to farmer's practice.

A significant negative relationship was observed between i) leaf folder damaged leaves and grain yield and ii) hispa damaged leaves and grain yield.

Integrated pest management practices resulted in lower insect pest incidence, disease incidence, weeds, higher grain yields and high benefit cost ratio compared to farmer's practice.

Population monitoring of insect pest populations through light trap collections revealed yellow stem borer and brown planthopper to be the major insect pests along with leaf folder and GLH in low numbers.

Plant Pathology

AICRIP programme on Plant Pathology during *kharif* 2018 involving 14 trials including host plant resistance, virulence of plant pathogens, disease observation and disease management trials were conducted at different AICRIP locations.

In various screening nurseries, 1418 entries were evaluated and the promising cultures showed resistant reaction more than two diseases were IET # 28014, 28015, 26027, 27077, 27094, 27280, 28020, 25618, 27579, 27668, 27781, 27747, 27806, 25826 26576, 26594, 27461, 27466, 27467, 27378,27333, 27377, 27389, CB14161, NWGR-11048 and RNR-11450.

Virulence pattern of *Pyricularia grisea* and *Xanthomonas oryzae* pv. *oryzae*: Reaction pattern of 24 isolates of *Pyricularia grisea* on 25 differentials were grouped in to 8 clusters. The reaction pattern revealed a shift in pathogen profile structure at many locations. Two Bacterial blight resistance genes *xa13* and *Xa21* showed susceptibility at 11 hot spot locations. The isolate from Maruteru showed exceptional virulence and all the differentials showed susceptible reaction to this isolate.

Across the locations, delayed sowing/planting increased the disease development of leaf blast, brown spot and sheath rot. Normal sown crop recorded high disease severity of bacterial leaf blight and disease progress of sheath blight, was high in the early and normal sown crop. Neck blast was severe in the normal sown crop.

The combination product is trifloxystrobin 25% + tebuconazole 50% WG (0.4g/l) found effective against leaf blast, neck blast and sheath rot. Azoxystrobin 18.2% w/w + difenoconazole

11.4% w/w SC (1.0 ml/l) found effective against sheath blight and sheath rot. Mancozeb 50% + carbendazim 25% WS (30.5%) and Flusilazole 12.5% + carbendazim 25% SC found effective in managing brown spot of rice.

Incorporation of FYM, seed treatment, application of DAP, MOP in the nursery area followed by the application of FYM + *Trichoderma* during land preparation, cultural practices, application of 75% RDF + micronutrient solution, one blanket application of cartap hydrochloride at 15 DAT and propiconazole at booting stage in main field found to be most effective and consistent in reducing the incidence of leaf blast, neck blast, sheath blight, brown spot and sheath rot and also increasing the grain yield.

Among the seven different essential oils tested two sprays of Clove oil @ 2 ml/l found better against leaf blast, whereas Neem oil @ 2 ml/l and Cedar wood oil @ 2 ml/l effective for reducing leaf and neck blast disease severity.

Production Oriented Survey was conducted in 15 States of 17 AICRIP centres. During 2018 three cyclones *viz*., *'Daye'*in south Odisha, adjoining Andhra Pradesh; *'Titli'* in near Palasa, Andhra Pradesh and *'Gaja'* in Tamil Nadu made severe impact.

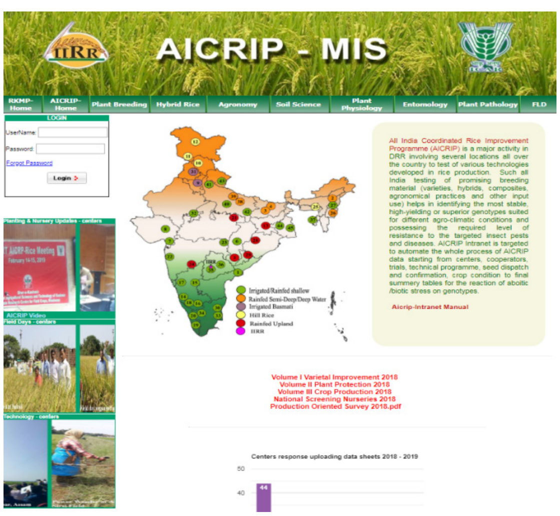
Many farmers from different states also expressed the need for timely availability of seeds of different hybrids, different inputs, farm mechanization (on hire basis/custom hiring), market facility and farm loan.

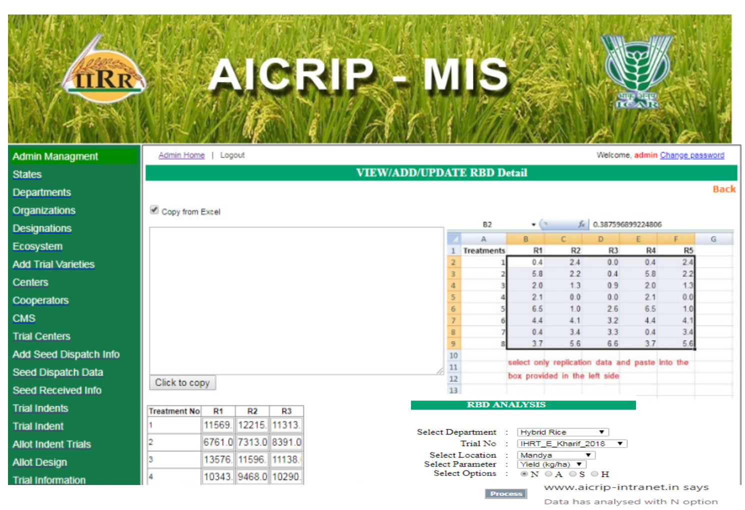
Severe outbreak of bacterial bight reported from Nizamabad and Suryapet districts of Telangana. Similarly false smut (in parts of Uttarakhand, Mandi in Himachal Pradesh and Siddharthnagar in UP), sheath blight (in Haryana, Punjab, Karnataka and Chhattisgarh), Neck blast (in Himachal Pradesh, Karnataka and Chhattisgarh) caused severe damage.

BPH/WBPH was very widespread in moderate to severe form in most of the districts of Haryana and many parts of Vidharbha region of Maharashtra and Telangana. There was severe attack of rice hispa in Nizamabad district of Telangana

AICRIP Intranet

AICRIP-Intranet was updated with image gallery of sowing and crop condition of rice crop in different centers and visit of monitoring teams to AICRIP centers during 2017-18. During the year, >50% of the centers uploaded data through AICRIP Intranet. This experimental database has been maintained on IIRR server. Data entry interfaces of Random Block Design (RBD), screening pest and disease modules were refined and analysis modules were added to AICRIP-Intranet portal.





Research Achievements

Lead Research

GEQ-Genetic enhancement of quality for domestic and export purpose

GEY-Genetic enhancement of yield and stress tolerance

ABR-Application of biotechnology tools for rice improvement

RUE–Enhancing resource and input use efficiency

SSP–Sustaining rice system productivity

CCR–Assessing and managing crop response to climate change

IPM–Integrated pest management

HRI–Host-plant resistance against insect pests and its management

HRP-Host-plant resistance against pathogens and its management

TTI–Training, transfer of technology and impact analysis

GEQ - Genetic enhancement of quality for domestic and export purpose

GEQ/CI/BR/8: Enhancing nutritional quality of rice through biofortification

Fresh crosses were attempted during 2018-19 utilizing high yielding varieties having high zinc (DRR Dhan 45, DRR Dhan 48, DRR Dhan 49, CSR 27, BPT 5204, Swarna, Telangana Sona and Chhattisgarh Zinc Rice-1)/ germplasm (IR 99674-9-2-2, IR 95097:3-B-16-11-4-GSB, IR 99282-41-4-2, IR15M1003 and IR 95040:12-B-3-10-2-GBS) lines and farmers' varieties (Dhusuri Baratee, Kajol ghorya, Bitti, Sati and Dhan Sirhatti).

A total of 46 high Zinc rice genotypes received from IRRI along with checks were evaluated. Zinc content varied from 15.27 ppm to 24.06 ppm. Two mapping populations (IR14M110/JAMIR and IR14M141/KALIBORO) were evaluated during *rabi*. Two promising cultures [(IR14M124 (GID: 4152780) and IR14M102 GID: 4230360)] with high Zinc content were nominated for AICRIP trial during *kharif* 2018. Ten promising rice genotypes which possess high Zinc content were bulk multiplied.

GEQ/CI/BR/26/Investigation into the role of major metabolites on rice grain quality

The purpose of this project was to understand the variation in similar amylose containing varieties. Expression and shelf-life analysis were conducted on 20 and 31 varieties respectively. The pattern of expression of GBSSI, SBEI, IIa and IIb was similar in Improved Samba Mashuri and Tellahamsa at different stages of grain filling period (Fig.). SBEIIb was not expressed in seven varieties. During the five months aging period, alkali spreading value (ASV) was constant except few varieties, marginal variations in kernel length after cooking (KLAC) and elongation ratio (ER) from first to 5[th] month while more variations were observed in the case of amylose, amylopectin and gel consistency (Fig.).

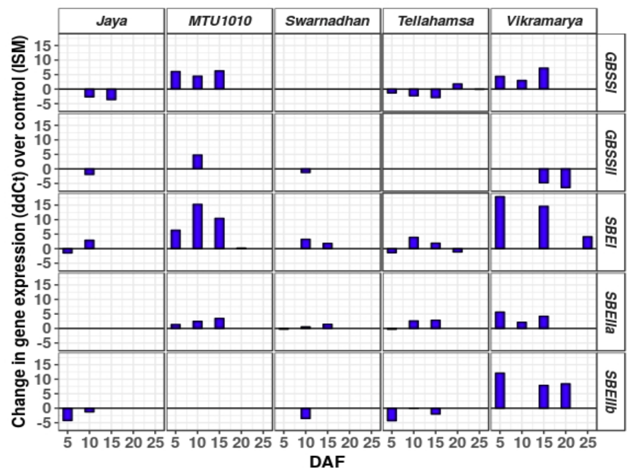


Fig. Pattern of gene expression during various intervals of grain filling

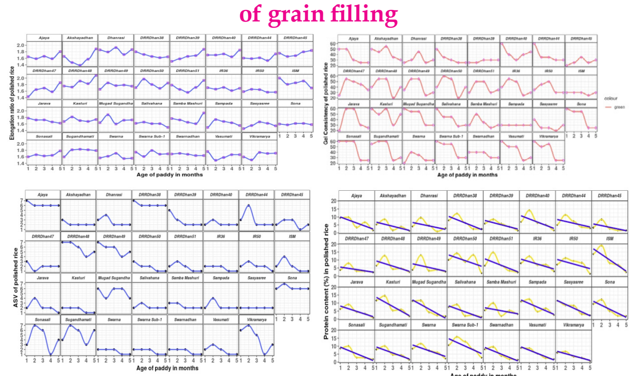


Fig. Effect of shelf-life on the grain quality (KLAC, GC, ASV and protein content) of rice

GEY- Genetic enhancement of yield and stress tolerance

GEY/CI/BR/16: Traditional and molecular approaches for breeding improved rice varieties with resistance to plant hoppers

During *kharif*, 2018, twenty fresh crosses were made wherein three high yielding susceptible varieties Swarna, Gontra Bidhan 3 and Jaya were crossed with five resistant donors namely BPT

2611, CR 2711-149, IET NOs 26661, 26966 and 26752 for developing planthopper resistant varieties. Twenty seven advanced lines from F6 generation involving Sinnasivappu, Vijetha, Pokkali, PHS 17, CSR 3005-2-30-5 and NSN-1-89 as donor parents were screened against planthoppers at Maruteru in Planthopper Screening Nursery. Six Promising lines derived from 4 crosses were observed with moderate field resistance (DS: 5): one line from the cross MTU1081 / Sinnasivappu, 3 lines from JGL 3844 / PHS17 and 2 lines from MTU1010 / CSR 3005-2-30-5.

One entry designated as RP 5690-20-6-3-2-1 derived from the cross Sona mahsuri/SR 26-B was found promising in 9/16 tests evaluated in PHS trial during *kharif*, 2018. It was screened at 13 locations in 16 tests (9 green house and 7 field tests) against BPH, WBPH and mixed populations of planthoppers under both field and greenhouse conditions. The resistant checks PTB 33 and MO1 performed well in 14/16 and 11/16 tests respectively. It was found promising even in 2017 in 9/15 tests with good level of resistance under both field and greenhouse conditions in PHS trial.

Based on station yield performance, six superior cultures out of 15 evaluated in F7- F8 generation with field resistance to planthoppers were identified. Nominated two medium duration cultures derived from MTU1081 / Sinnasivappu and JGL 3844 / PHS17 to IVT-M trial; two late cultures derived from the cross MTU1010/RP-1 and JGL-3844/NSN-1/89 nominated to IVT-Late trial and two cultures from the cross MTU1081/ Sinnasivappu and NLR 40058/WGL32100 to IVT-MS.

Registered a genetic stock (IC 0619226) designated as RP 5316-RIL-243 possessing resistance to combined population of BPH and WBPH during seedling as well as reproductive stages with Plant Germplasm Registration Committee of ICAR in 2019.

GEY/CI/BR/9: Development of Rice Cultivars with High Grain Protein Content (GPC) and Quality Traits

Evaluated 679 germplasm lines and have identified several entries with high grain protein content (≥ 10.0%): JAK 218 (10.1%), JAK 223 (10.3%), JAK 228 (10.2%), JAK 685 (10.6%), JAK 719 (10.6%).

About 800 single panicle selections were made among the evaluated germplasm, will be evaluated in *kharif* 2019.

Eight (8) new crosses between elite popular cultivars (BPT 5204 and ISM) and novel sources of high protein and nutritional quality were generated; and F1s will be planted in *kharif* 2019.

JAK 312 had a long panicle, high grain number (~350) and strong culm with ~9.1% protein.

GEY/CI/BR/22: Identification and introgression of agronomically important traits from wild species of rice

Developed interspecific AB-NAM population from IR64/*O. glaberrima*: The 21 inter-specific BC1F3 populations consisting of 2500 lines derived from O. sativa (IR64) and *O. glaberrima* (20 accessions) was developed to constitute NAM (nested association mapping) population which will serve as important genetic resources to identify and introgress yield enhancing traits, weed competitive traits and abiotic stress tolerance under direct seeded rice.

Developed backcross derived introgression populations from *O. rufipogon*: A total of 3000 BC_1F_3 populations derived from crossing Samba Mahsuri with 25 accessions of *O. rufipogon*

Lead Research

evaluated for yield related traits and nearly 25 promising lines were selected for further testing. Another 1200 introgression lines were screened for blast resistance and 150 resistance lines were identified. Further, BC_2F_1 populations of 25 crosses were evaluated for yield enhancing traits. Further, BC_3F_1 of 25 crosses were developed by backcrossing the BC_2F_1 with Samba Mahsuri. These backcross derived introgression population valuable resources for identification and introgression of yield enhancing traits and biotic stress resistance from *O. rufipogon*. Phenotyping and genotyping of mapping population (BC_2F_2) derived from Samba Mahsuri/*O. rufipogon* is carried and QTL analysis is to be carried out to identify the genomic region associated with yield enhancing traits derived from wild rice.

Screening of wild rice and wild rice derived introgression lines for salinity tolerance: A total of 31 accessions of *O. glaberrima* lines were screened for salinity tolerance (ECe-8.0 and pH-7.5) and one accession showed tolerance salinity at reproductive stage. Besides, 1200 *O. rufipogon* derived lines were screened for alkalinity stress at Bojha farm, Kanpur (ECe-4.0 and pH-9.5) and several lines found promising at reproductive stage.

Screening of wild rice derived introgression lines for BPH tolerance: Nearly 1200 *O. rufipogon* derived lines were screened for BPH resistance at BPH resistance and five lines showed the resistance.

GEY/CI/BR/23: Breeding high yielding rice lines possessing multiple biotic stress resistance/tolerance through conventional and molecular approaches

Out of 260 and 317 rice germplasm screened against blast and bacterial leaf blight resistance, 25 lines resistant to blast disease (score of 3) and 17 lines resistant to bacterial leaf blight (score 1) were identified. Of these, six blast and six bacterial leaf blight resistant lines were selected for crossing and 20 crosses were made during *kharif* 2018.

For marker-assisted introgression of Bacterial blight and blast resistance along with yield-enhancing genes (Gn1a, SCM2, OsSPL14) into genetic background of elite rice variety 'Swarna', the introgressed lines in the genetic background of Swarna (possessing the target yield enhancing genes, Gn1a + SCM2 + OsSPL14) received from IRRI were crossed with the donor line 'Introgressed line of Improved Samba Mahsuri' (IL of ISM; possessing bacterial blight resistance genes, *Xa21+xa13+xa5* and blast resistance genes *Pi2+Pi54*) to incorporate disease resistance in addition to yield enhancing genes. The positive F1s identified during *kharif* 2016, were used to cross with recurrent parent for development of backcross derived lines (BC_1F_1s). During *kharif* 2017, two BC1F1 plants processing grain type similar to recurrent parent were selected and backcrossed with 'Swarna' to develop backcross derived lines (BC_2F_1s). During *kharif* 2018, three BC_2F_1 plants processing grain type similar to recurrent parent were selected and backcrossed with 'Swarna' to develop backcross derived lines (BC_3F_1s). A total of 140 BC_3F_1 seeds were harvested. These 140 BC_3F_1 seeds will be screened using trait linked foreground markers.

Marker-assisted introgression of yield-enhancing genes into genetic background of elite rice variety 'NDR 359', the line Habataki (possessing the target yield enhancing genes, Gn1a + SCM2) received from IRRI were used as donor parent and were crossed to recurrent parent NDR 359 to developed F1s. A total of 80 F1s were developed during *kharif* 2016 and positive F1 plants were identified using polymorphic markers were backcrossed with 'NDR 359' to develop backcross derived lines (BC1F1's). During *kharif* 2017, two BC_1F_1 plants processing grain type similar to recurrent parent were selected and backcrossed with 'NDR 359' to develop backcross derived lines (BC_2F_1s). During *kharif* 2018, two BC_2F_1 plants processing grain type similar to recurrent parent were selected and backcrossed with 'NDR 359' to develop backcross derived lines (BC_3F_1s).

About 200 single plants selections with desirable plant type and high yield were made from segregating materials during *kharif* 2018. Twenty eight fresh crosses were made and evaluated 34 F_2's, 29 F_3's, 20 $_F4$ populations and 15 station trial entries during *kharif* 2018 and eight promising lines (yielding more than 5.0 ton /ha) were identified and will be nominated to AICRIP 2019. Three promoted lines from IVT trials of AICRIP 2017 were nominated to AVT-1 trial of AICRIP 2018, out of three, one entry IET 26803 promoted to AVT-2 ETP. Six new promising entries were nominated to IVT AICRIP 2018, of these three entries IET's 27743, 27981 and 27978 were promoted to AVT-1 and will be tested in AICRIP 2019.

GEY/CI/BR/25: Broadening the genetic base of indica rice and modify plant type by introgressing traits from Tropical japonica

31 crosses involving elite cultivars and novel sources from strong culm and high grain number were made during *kharif* 2018. Simultaneously, 4000 breeding lines were evaluated and ~ 1000 panicle/single plant selections were made for elite plant type and high yield during 2017-19

High yielding advanced breeding lines (34) from three way/backcrosses of elite cultivars/TJP/introgression lines with resistance gene(s) were selected with trait combination of high grain number, strong culm and high biomass (NPT traits). 5 entries (JBC166-10, JBC163-2, JBC173-19, JBC179-21 and JBC159-8) recorded a high yield potential of 7-8 t/ha and 9 (JBC173-15, 173-10, 173-20, 165-5, JBB2943, 2273, JBC173-8, 165-4 and 165-1) with 5-7 t/ha during *kharif* 2018.

IET 27785 (Swarna/ IRGC63248/ Swarna Sub 1) is promoted for testing in central zone in AVT1-IME during *kharif* 2019. It recorded 13% yield advantage over the best check in central zone and 4.93% in eastern zone.

Mapping population (174) in BC2F6 generation from Swarna/*O. nivara* (CR100008) was evaluated for shattering and dormancy related traits. Two putative markers RM488 on chr1 and RM247 on chr12 were found to co-segregate with dormancy and shattering traits.

Advanced elite breeding lines (32) were evaluated for yield traits during *kharif* 2018, of which 6 entries viz., JBB 680-1, JBB 623LF, JBB 680-4, JBB 680-3, JBB 689-1, JBC 166-7-1 were found with high yield potential of 7 t/ha and proposed for AICRIP nominations during *kharif* 2018.

One breeding line JBB 661-1 derived from the cross of RP Bio 226/IRGC 39050//MTU 1081 has been identified as non-shattering type.

Breeding material in F2 generation from eight crosses (JBC366-swarna/ARC10531, JBC392-Sampada/IRGC66645, JBC397-Sampada/SM801, JBC420-DRR Dhan42/ Charongphou, JBC422-DRR Dhan44/IRGC78371, JBC427-DRR Dhan44/IRGC64189, JBC436-DRR Dhan44/ARC10531 and JBC450-IR64/IRGC67846) was evaluated at Kampasagar during *kharif* 2018.

GEY/BR/14: Breeding high yielding rice cultivars tolerant to low soil phosphorus and nitrogen

Selection among breeding lines and identification of new donors for low Phosphorus tolerance: Advance breeding lines (800) in F6 and F7 generation involving donors for low Phosphorus tolerance and agronomically superior varieties were evaluated under low soil phosphorus field and approximately 650 promising lines were selected.

QTL analysis for low soil P tolerance of RIL Wazuhophek x ISM: A total of 78 polymorphic SSR markers were used to construct the linkage map using the program IciMapping version 4.0 and Mapmaker software. A total of 330 RILs of Wazuhophek x ISM was phenotyped for low soil P tolerance. Total 13 QTLs were commonly detected after analysis in both the IciMapping version 4.0 and QTL cartographer software. The region between markers RM22554 and RM8005 on chromosome 8 found as hotspot for QTL as 10 QTLs out of 13 for different traits are present in this region.

QTL mapping for Low Phosphorous Tolerance in Rasi x ISM RIL population: A RIL population of 214 lines of Rasi/ISM population was used for mapping a new QTL for low phosphorous tolerance. The RIL population was phenotypically screened for 3 seasons in the Low soil P plot of IIRR, Hyderabad. A total of 14 traits were recorded for the study. Initially 20 phenotypic extreme lines and 106 SSR polymorphic markers were used for mapping of QTL, which resulted in the identification of 15 QTLs for various traits.

Identification of new source for low P tolerance: The germplasm consisting of land races (39) from Northeastern India were evaluated for low P tolerance and characterized for Pup1 specific markers revealed the presence of Pup1 QTL. Four land races WB-12, WB-22, WB-24 and WB-27 were identified as novel source for low soil P condition and completely devoid of pup1 region.

Gene expression study of NILs of Pup1: qRT-PCR results for gene expression analysis revealed that genotypes carrying the P tolerance gene viz., ISM NIL and MTU1010 NIL showed higher expression of OsPHO1; 2, OsPhT1; 6 and OsSPX1 genes under P- condition.

GEY/CI/BR/10: Breaking the yield plateau in native aromatic short and medium grain rice through classical and molecular breeding

The Aromatic Short grain germplasm was raised for conservation and maintenance and data on agro-morphological traits and germination were recorded for core set.

A total of 50 crosses were attempted between aromatic and aromatic short grain type and also between aromatic and non-aromatic types which include Shobini, Gontra bidhan -3, Narendra lalmati, Muhulakuchi, Neelabati, Kalikati, Kalanamak, Dubraj Bandi, Joha Bora, Joha, Loung choosi B, Champaran Basmati 4, Ganjeikalli, Thakurabhog, Muhulakuchi, Champaran Basmati 1, WGL 14 and Sugandha Samba.

GEY/CI/HY/13: Development and evaluation of three line hybrids with better grain quality and resistance to major pests and diseases

Twenty promising genotypes were identified from the available breeding materials and 46 crosses were attempted between the promising lines. Around 600 test crosses, 250 paired crosses and 94 varietal crosses were made for further evaluation. Of the 220 test crosses evaluated, 20 promising test crosses and 35 promising restorers were identified for further evaluation. One hundred eighty five single plant selections were made from the breeding materials in various segregating generations.

Three hybrid nominations viz., IIRRH-122, IIRRH-123, IIRRH-124 were nominated in AICRIP trials 2018.

In the station trial, 31 hybrids were evaluated and 9 promising hybrid entries were identified.

IR 68897A-35 kg, IR 68897B-80 kg, DR 714-1-2R – 30 kg, DRRH 2-15 kg; APMS-A-30 kg, APMS-6B-60 kg, RPHR-1005-25 kg and DRRH 3-12 kg were produced. Through barrier isolation method, 30 new hybrids were produced and the seed will be used for preliminary evaluation in station trials.

GEY/CI/HY/15: Genetic enhancement of parental lines suitable for aerobic and tolerance to salinity conditions through conventional and molecular approaches

Genetic diversity analysis was done with a set of 64 core abiotic stress restorer lines, 25 lines were identified and will be utilized in recombination breeding programme.

BC1F5 population possessing qDTY12.1, qDTY 3.2/2.3 and fertility restoration (*Rf3*/*Rf4*) of KMR3/Vandana NIL was test crossed and evaluated for drought tolerance. Out of them NRR-1, NRR-5, NRR-13 and NRR-25 were identified as best restorers under drought condition.

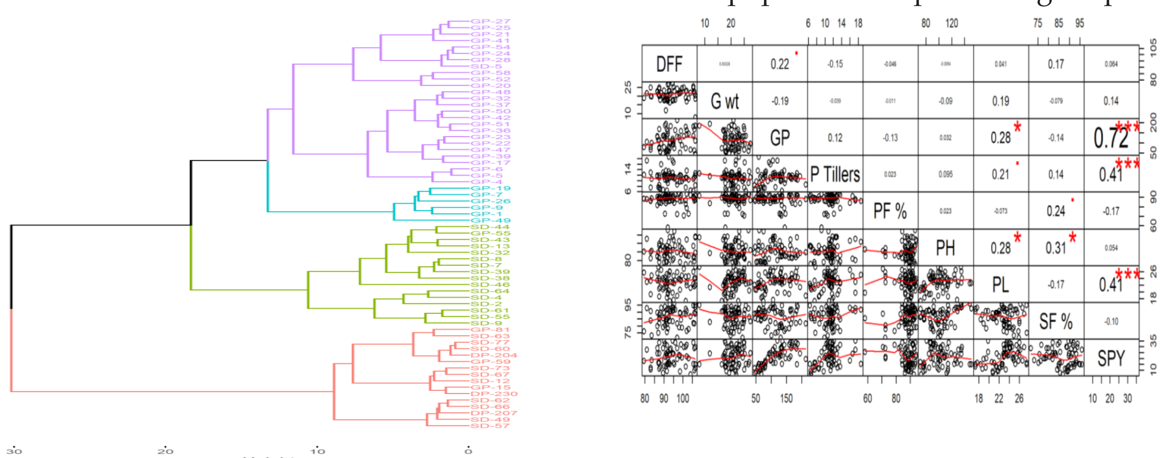


Fig. Morphological diversity and correlation analysis of abiotic restorer lines

Fig. Field evaluation of improved parental lines and derived hybrids under drought and normal conditions (picture to be replaced)

The entry IET 26194 (RP 5591-123-16-2), a product from MTU 1010 / IR 79915-B-83-4-3 cross combination with days to 50% flowering of 82 days and had long bold grain type is promising in Bihar state for aerobic cultivation.

The hybrid IET 27937-IIRRH 124 (APMS6A/AR9-18R) performed well on overall basis and promoted to AVT1 aerobic trial in AICRIP 2018 and the hybrid IET 27847- IIRRH 115 promising in Zone VII in IVT-CSTVT.

Four promising aerobic restorers (PSV24, PSV 250, PSV372 and PSV 375) were evaluated for its performance (station trial), among them, three hybrids viz., APMS6A/PSV375, APMS6A/PSV250, IR 79156A/PSV372 were identified as best combination and nominated for aerobic and salinity trial.

GEY/CI/HY/12: Development of superior restorers and identification of new restorer (Rf) genes for WA-CMS system in rice by conventional and molecular approaches

Hybrid rice seed production was taken up during *rabi* & *kharif* 2018 for the newly identified three rice hybrids viz., CRMS 32A X PRP 192, APMS 6A X PRP 119, IR79156A X PRP 192.

Two hybrid entries viz., IIRRH-133 (IR79156A x PRP 192), IIRRH-135 (APMS 6A x PRP 119) were nominated for IHRT- ME & Medium trial for multi-location testing during Kh-19. Three entries viz., RP 5963-13, RP 5964-82, and RP 5964-92 were nominated for varietal trials like IVT-MS and medium trials.

14 improved restorers viz., RP5962- 3, RP5962-04, RP5962-05, RP5963-11, RP5963-13, RP5963-60, RP5963-63, RP5964-82, RP5964-92, RP5933-123, RP5933-166, RP5933-181, RP5933-206 and RP5933-241 were evaluated for yield and yield related traits viz., plant height, number of tiller, panicle length, No of filled grains per panicle and grain yield.

150 newly developed experimental rice hybrids were evaluated in test cross nursery during Kh-18 & *rabi* 18-19. F1s were evaluated for their pollen and spikelet fertility percentage and identified complete restorers, maintainers and partial sterile/fertile lines.

DRCP-102 (IR 36) restorer genetic male sterile population crossed with donors of BLB, Blast, BPH and gall midge resistance and abiotic stress resistance (drought and salinity).

During *kharif* 2018 GMS 9th recurrent selection cycle was evaluated. Selected fertile plants were crossed with three CMS lines (APMS 6A, CRMS3A and IR 68897A) and F1s were evaluated for their fertility restoration to identify restorers with multiple stress resistance genes for biotic and abiotic stresses.

400 fertile lines selected from 9th recurrent cycle were evaluated in two row pedigree breeding. These lines were evaluated for DFF, plant height, panicle exsertion, duration, phenotypic acceptability, sterility and fertility and culm strength etc. 50 best lines were selected and these selected lines progeny rows were raised during *rabi*-18-19. These lines were subjected to genotyping for the presence of *ms* gene and screening is under progress for identifying lines possessing biotic and abiotic stress tolerance genes. During *kharif* 18, selected 50 MARS fertile lines were screened phenotypically for blast and BLB resistance.

37 BC_1F_1 crosses were generated by crossing *O. rufipogon* accessions with hybrid rice parental lines viz., PRP-73, RPHR-1005, APMS-6B, IR68897B, DR-714-1-2-R and IBL 57. 4 BC_2F_2 populations were evaluated during *rabi*-18-19 and data was recorded for different agro morphological traits.

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GEY/CI/HY/16: Genetic improvement of maintainer for yield and attributing traits with introgression of yield enhancing genes

The improved lines of IR 79156B and IR 58025B for stigma exsertion trait was under conversion process to CMS line, which are in BC1 generation.

To genetic improvement of maintainers lines for yield and yield attributing traits (Grain numbers, number of filled grain number per panicle, grain size, panicle architecture and plant architecture), crossing was attempted between maintainer line i.e., IR 58025B and YPK lines (introgressed improved lines for yield and yield attributing traits). F_1 was generated.

GEY/CP/PP/12/Physiological studies for improving ideotype breeding in rice

A field experiment was conducted in randomized block design with three replications to investigate the performance of 20 promising breeding lines in the genetic background of Samba Mahsuri, Swarna and MTU 1010 possessing yield related genes for grain yield associated traits which includes morphological, physiological, yield attributing and leaf gas exchange traits to identify the superior donors with good morpho-physiological traits for ideotype breeding. Under morphological characters, average tiller number was 12 and LAI and days to maturity varied from 3.3 to 7.4 and 111 to 133 days respectively. Among yield and yield attributes, average grain yield (GY) was 849 g/m^{-2}. Highest GY was noted for YPR-39 with 960 g/m^{-2} yield potential, 55 Harvest Index and 17.5 T/ha biomass. The leaf gas exchange traits revealed that the mean photosynthetic rate was 25 µmol (CO_2) m^{-2s-1} which indicates high photosynthetic rate in most of the lines. Transpiration rate varied from 7.5 to 13 mol (H_2O) m^{-2s-1} and YPR-39 noted close to the highest value (12). The above results indicate that 13 of the 20 lines as good physiological donors (YPR-33, 1107, 1077, 53, 1074, 1103, 1105, 30, 11, 1108, 1073, 48 and 39) with a yield potential of >8.5 T/ha and good ideotype characteristics.

ABR - Application of biotechnology tools for rice improvement

ABR/CI/BT/9: Improvement of rice against biotic and abiotic stresses through transgenic approach inside

Developed activation tagged lines of BPT5204 through *Ac-Ds* system by using pSQ5 construct. After molecular characterization, we identified 31 homozygous lines of *Ac-Ds*, 3 lines of Ac and 1 line of Ds system. Studied the physiological parameters related to WUE of the *Ds-1* stable line in both un-stressed and stressed conditions. The results indicated that *Ds-1* line showed better WUE compared to control plants of BPT 5204. Also developed transgenic lines using En-Bar construct and after molecular characterization, identified several homozygous lines. A few lines, particularly the mutant line En-62 on evaluation under water stress conditions, showed increased water use efficiency. In the process, identified a few candidate genes and their expression analysis was carried out. Expression studies confirmed that mutants with both gain-of function and loss-of-function could be obtained. Interestingly, the loss of function mutant with LOC_Os06g24540 gene was responsible for increased water use efficiency. 1020 out of total 1200 lines are from *AC-Ds*, AC and Ds systems and 1180 lines of En-Bar lines are in homozygous state either in T-5 or T-6 generations.

ABR/CI/BT/6: Identification of genes for grain filling in rice (*Oryza sativa* L.)

Based on candidate gene mapping, a sugar transporter gene LOC_Os11g42430 which was found to be associated with filling of grains on primary and secondary branches of lower portions of the panicle was sequenced from Rasi and IC114927. Validation through transformation is in progress. Analyses of transcription factor binding (TFBS) sites in the promoter region of LOC_Os11g42430 and their comparison with other sugar transporters showed differential distribution of the various motifs. Gene expression of LOC_Os11g42430 of the tissue (10 days after flowering) from upper, middle and lower portions of the panicle has shown differential enhanced expression over Rasi in three genotypes with efficient grain filling across the panicle suggesting the specific spatial regulation of the gene.

ABR/CI/BT10: Genomic studies on grain yield heterosis and WA-CMS trait in rice

Classification of hybrid rice parental lines based on morphological traits and molecular markers into heterotic groups.

A total of 96 parental lines (31 maintainer and 65 restorers) were analyzed with a set of 108 hyper-variable SSR markers. The parental were grouped into B Maintainer group) and R (Restorer group) groups based on genetic distance calculated on the basis of marker analysis (Fig.). Strong correspondence was observed between the pedigree of parental lines with molecular genotyping. From the results of the present investigation, the following can be inferred i) limited genetic diversity existed among hybrid rice parental lines (particularly in the maintainer group), ii) Moderate genetic diversity was ideal for getting better levels of heterosis. Better inferences about the genetic diversity and its correlation with heterosis can be made if genotyping is done using SNP markers (~ 1000 Nos.)

Development and utilization of recombinant inbred line (RIL)/double haploid line (DHL) populations for marker-based heterosis prediction using SSRs/SNPs:

A set of 21 RIL populations have been developed earlier by crossing elite WA-CMS lines and/or their maintainer lines with multiple restorer lines. The RIL population (n = 105) derived from the cross IR58025A/KMR3R (i.e. parents of the hybrid, KRH2) were grown in *kharif* 2018 and *rabi* 2018-19 along with a set of 65 DHLs derived from the same cross to identify high yielding and low yielding RILs. Yield and yield related parameters were calculated from the RILs/DHLs. A major QTL (named qYLD3.1) associated with yield and yield related parameters (vis., panicle length, grain number and grain weight) was identified on Chr. 3 (Fig.), while another QTL and associated with yield (named qYLD6.1) and panicle length was identified on Chr. 6. Further, QTLs associated with panicle weight (qPW8.1) and spikelet fertility (qFGP8.1) were also been identified. Interestingly, the favorable alleles for most of the QTLs have been contributed by the restorer line, KMR3R. Crosses were made between selected high/low yielding RILs (with *Rf3* + *Rf4*) and IR58025A in *rabi* 2018-19 to identify genomic regions possibly associated with heterosis. A promising DHL (RP6301-189-17-2) RP6301-189-17-2 possessing long panicles, more number of productive tillers (inset) along with highly desirable medium slender grain type has been identified and promoted to AVT1-Aerobic trials in 2018 (Fig.).

RNA-seq analysis of WA-CMS line,

IR58025A and its cognate, isonuclear maintainer line, IR58025B

Through an earlier study, we had analyzed the genes, which were differentially expressed between the WA-CMS line, IR589025A and its cognate, isonuclear, male fertile line, IR58025B through RNA-seq in order to identify the pathways associated with male sterility. A set of 496 and 278 genes were observed to be up-regulated and down-regulated, respectively in the WA-CMS lines vis-à-vis the maintainer line. The genes associated with oxidative stress response, defense response etc. were significantly up-regulated, while those associated with respiration, cell wall modifications, pectin esterase activity etc. were significantly down-regulated in the WA-CMS line. As many genes associated with respiration (*Atp6, Cox2, Cox3, Nad1, Nad4, Nad5, Nad7* etc.) and other pathways were down-regulated, we carried out a qRT-PCR to validate some of them. The values obtained in RNA-seq were similar to those observed through qRT-PCR, thus validating the results obtained (Fig.).

Identification of restorer/maintainer lines among rice germplasm

Screening of ~200 germplasm lines with functional markers specific for *Rf3* and *Rf4* resulted in identification of a new set of 83 restorer lines (i.e. possessing the restorer alleles with respect to *Rf3* and *Rf4*) and 12 potential maintainer lines (i.e. devoid of the restorer alleles with respect to *Rf3* and *Rf4*). Significantly, > 75% of the RILs and DHLs derived from the cross IR58025A/KMR3R, which were high yielding, were observed to be complete restorers indicating their possible deployment in hybrid rice breeding.

ABR/CI/BT/16: Exploring the mutant resources for rice improvement

Stable mutants of BPT 5204 were further characterized and 13 mutants which showed the complete panicle emergence (CPE) were identified, in that two mutants (Ti-109 and Ti-110) were selected for Mutmap, a method based on whole genome sequencing of bulked DNA of F2 segregants. Unique SNP peak was found in chr-11 at the region of 20.14 to 20.19 Mb consisting of 36 SNPs in both the mutants. Using linkage mapping approach, the F2 populations derived from cross of mutants with diverse parent for the trait (RPHR 1005) and found the large effect QTL (contributing 40% PV to the trait) at chromosome-11 of the same region where the SNP peak was found. Another QTL contributing 27% was also found at chromosome-12. To identify the differential gene expression during panicle initiation, RNA seq analysis of these two mutants was carried out and correlated the mapping data with transcriptome and found two genes Os11g0603200 coding for ABC- type protein and Os11g0607200 coding for brassinosteroid associated receptor kinase-1 specifically up regulated in the mutants compared to wild type indicating their involvement.

For identification of the mutation conferring sheath blight tolerance using MutMap based approach, in one of the mutants (Shb-6; identified earlier and conferred the tolerance by several times with virulent as well as diverse Shb isolates), SNPs index plots were made based on comparison of sequence of tolerant F2 bulk with wild type sequence (susceptible) and sequence of susceptible bulk with mutant sequence (Resistant). Based on comparisons, a unique peak at chr-1 (40.1 – 41 MB) region in the tolerant bulk and valley in the susceptible bulk was found, which indicates that the region is contributing to the phenotype.

ABR/CI/BT/14: Exploring RNAi Technology for Management of Rice Diseases

To evaluate the effects of knocking down the PG gene in RNAi lines against sheath blight disease, detached cut leaf assay was performed. The assay showed a reduced rate of lesion expansion in transgenic lines compared to the non-transgenic control plants. The PG-RNAi lines showed a clear difference in disease severity as compared to non-transgenic control plant at 48, 72 and 96 h after inoculation. Reduced lesion as well as delayed disease development was observed in the transgenic lines compared to non-transgenic control plants. To further confirm the results of detached cut leaf assay, the plants were inoculated by placing the young sclerotium of the *R. solani* fungus beneath the rice leaf sheath. The symptoms were recorded at 48, 72 and 96 h after inoculation with pathogen. The progress and severity of disease and disease score was significantly lesser in the PG-RNAi lines (score 3.0) as compared to non-transgenic control plant (score 9).

The microscopic studies were carried out by visual observations of infected PG-RNAi lines and non-transgenic control plants. After 24 h of infection, hyphae grew in bunches with numerous hyphae on the leaf surface in non- transgenic control plants while in PG-RNAi plants, hyphae were few in number and dispersed. The hyphae formed side branches and a greater number of infection cushions in control plants, whereas in PG-RNAi plants, infection cushions were scanty and not fully developed. Extensive colonization of fungal hyphae and appressorium formation was observed after 24 h of infection in non-transgenic control plants, while PG-RNAi plants did not show such severe growth of fungal hyphae on leaf surface. The cross-section of leaves after 48 h of infection showed more fungal hyphae and appressorium in non-transgenic plants as compared to PG-RNAi lines. This clearly shows severe fungal infection in non-transgenic control plants than PG-RNAi plants.

To determine the effect of the host induced silencing of PG gene on the targeted *R. solani* PG gene expression, the relative expression levels of PG were measured in fungus infected PG-RNAi and non-transgenic control lines using qRT-PCR. Total RNA was isolated from infected sheath tissue of rice (including the lesion area) after the 96 h of inoculation with R. solani. cDNA was synthesized by reverse transcription and normalized to bring the equal concentration. Real time PCR was performed using AG1IA_04727 gene-specific primers designed from the region used for RNAi constructs development. Quantification of AG1IA_04727 was performed in four biological replicates of fungus infected transgenic and non-transgenic lines. The mean Ct (cycle threshold) obtained from four biological replicates and three technical replicates was used for comparing the relative expression of PG gene in four RNAi lines and non-transgenic control plant. Silencing of PG gene was observed in all the four RNAi lines as compare to non-transgenic control plant, however, level of silencing varied among all the four PG-RNAi lines) (Fig).

ABR/CI/BT/13: Candidate gene identification for manipulating growth related genes in rice through computational and expression studies

Loop length variation and sequence conservation in substrate binding cleft of 53 PME genes belonging to at least 8 subtypes (identified through phylogenetic relationship) from rice were analysed and this act as a base for gene manipulation in PMEs.

In silico maps of Transcription Factor binding sites (TFBSs) on 1Kb upstream regulatory region of these genes have been developed for gaining further insights on gene expression regulation.

A protocol for promoter sequence analysis was developed and 15 genes involved in starch, sucrose and pectin metabolism were analysed in the context of vegetative growth and flowering. TFBSs in the promoter sequences of these 15 genes were predicted and the TFBS distribution patterns were correlated with gene expression pattern. Cis-prosimi algorithm for comparing promoter sequences have been modified suitably to obtain more accurate distance weighted scores. Various subtypes of SPS have been identified through phylogenetic analysis. This data makes the base for re-engineering of this enzyme. Callus induction and transformation of cloned SPS genes in to BPT5204 is being attempted

ABR/CI/BT/15: Molecular and functional characterization of useful root traits in rice

Molecular mechanisms underlying aerobic adaptation in rice were studied through transcriptome sequencing of root and shoot i.e. developing panicle tissues at panicle initiation stage in two cultivars adapted to aerobic (CR Dhan 202) and traditional transplanted anaerobic (BPT 5204) conditions. The aerobic adaptation mechanism partially mimics that of drought tolerance or it shares the common pathway to manifest the desired response in the aerobic adapted cultivar. Thus, the mechanism of aerobic adaptation can be conferred by the combined expression of key candidate genes related to the hormonal signaling, transcription factors, transporters and root trait related genes in AAC.

The transcripts for brassinosteroid insensitive protein BK1, DREB transcription factor, Metallothionein-like protein 2A MT2A, Nicotianamine synthase 1 NAS1, Inorganic phosphate transporter 1;6 PHT1,6, water stress-inducible protein Rab21, Metal-nicotianamine transporter YSL2 along with nutrient uptake genes were highly expressed in root tissue of CRDhan202 under aerobic condition signifying its role in aerobic adaptation.

The highly up regulated transcripts under aerobic conditions were compared for the presence of SNPs and alternative splicing events. Higher number of AS events were observed in shoot and root tissues in both the cultivars in aerobic than in the anaerobic condition. In particular transcripts viz. tetratrico peptide repeat (TPR) domain containing protein (Os03G0308800) and GOLDEN2-LIKE1 (GLK1) transcription factor (Os06G0348800) in the shoot tissue evidenced higher number of AS events which revealed their involvement in post transcriptional regulation under aerobic condition.

The highly up-regulated transcripts under aerobic conditions in CRDhan were in-silico mapped with the identified QTLs which showed two or more than two transcripts underlying QTLs for root traits. MADS4 was mapped with two root trait related QTLs viz. qrfw1b and qbrt1d, HKT8, MDR-like ABC transporter, vacuolar iron transporter homolog 2, MPK7 were co-localized with root trait QTLs viz. qrfw1b, qbrt1d, qrfw4a, qrdw5-1 respectively.

ABR/CI/BR/28: Exploring wild introgression lines and mutants to identify novel genes/QTLs for yield contributing traits

Screening and identifying significant and stable wild introgression lines and mutants for yield contributing traits:

The high yielding BILs from previous crosses of Swarna x *Oryza* nivara (IRGC81848 (S) and IRGC81832 (K)) were screened at IIRR and RC Puram field conditions for yield and physiological traits for five seasons and surveyed for reported genes/ QTLs for yield traits. BILs viz., 14S and 166S showed yield stability across the seasons along with high mean yield performance (Balakrishnan *et al.,* 2016). Leaf photosynthetic characteristics for the introgression lines were measured on flag leaf using *LI6400XT* Portable photosynthesis measuring system (LI-COR Environmental, USA), both in *kharif* and *rabi* seasons to identify lines with high photosynthetic rates (Rao *et al.*, 2018). Same lines were subjected to screening of seedling vigour in field as well as lab conditions for both *kharif* and *rabi* (Addanki *et al.* 2018). Yield and vigour related traits were studied in 166s derived BILs along with their recurrent parent Swarna and two other sib-BILs 148s, 248s (DRR Dhan 40) in field conditions and genotype environment interaction of traits were estimated (Beerelli *et al.*, 2019).

Phenotypic data on 300 EMS induced mutants of Nagina22 (N22), 3 gain of function mutants (NH686, NH787, NH363) and 3 loss of function mutants (NH162, NH210, NH359) for 12 seasons was analyzed for their G×E interaction and stability under low phosphorus, water limited and irrigated conditions. The combined analysis of 12 seasons identified NH363 as the most stable, NH210 under normal condition, NH686, NH363 and NH162 in low P condition and NH363 under water limited condition (Poli *et al.,* 2018; Jadhav *et al.,* 2019). The stable identified lines with significantly high yield levels were used for crossing for the development of mapping populations along with cultivars. 30 crosses were made during *kharif* 2018 involving these superior BILs and mutants and F1s were raised during *rabi* 2019.

Phenotyping the mapping populations and QTL mapping

After screening identified parental lines with desirable yield contributing traits from cultivars, introgression lines and mutants were crossed to obtain F1s. Five promising crosses of C1 (Swarna x 166S), C2 (166S x 14S), C3 (166S x 148S), C4 (65S x 248S), C5 (166-2S x Swarna) from previous study were advanced to F4 and F5 generations and phenotyping was carried out during *kharif* 2018 and *rabi* 2019. These populations were evaluated for plant height, tiller number, productive tiller number, single plant yield, biomass, total dry matter, harvest index and significantly different lines were identified for further multiplication. In F3 of the cross 166s x 14s, 17 lines (9%) out of 177 lines gave 25-33g/plant yield compared to

Fig. KMR3 BILs in normal (left) and low P (right) fields

18-21g/plant yield of 166s, 14s and Swarna. One IL was significantly higher yielding than parents 166s and 14s.

Thousand grain weight data on four F3 populations Swarna x BIL and BIL x BIL populations was collected and compared. 166S x 148S showed a wide range of variation in TGW of F4 seed with a maximum value of 30.44g, while the cross 65S x 248S showed lowest mean among the crosses with lowest minimum 7.14g. Selected significant lines from BIL x BIL crosses were screened at Low P condition along with Swarna, parental lines and check varieties. The genetic variance parameters showed that genotypes showed significant variation in Low P for TN, PTN, PW and GW. Plant height showed significant association with PL, PW and GW positively but with TN and PTN negatively. PW showed positive association with PL and GW.

ICAR-National Professor Project

Developed marker defined chromosome segment substitution lines (CSSLs) as a genomic resource in the background of popular varieties using two wild rice accessions *O. rufipogon* and *O. nivara.*

From the cross, MTU1010/*O. rufipogon* IC309814 (cross RP6166), 154 of 306 BC4F2 lines formed a complete set of CSSLs representing 99% of *O. rufipogon* genome based on genotyping using 161 SSR markers. Based on pairwise comparison of phenotype, 67 CSSLs were significantly different from MTU1010 for one or more of 11 yield related traits.

A set of 298 BC2F4 and 192 BC4F2 lines were developed from the cross Swarna/*O. rufipogon* IC309814. Significantly higher values than Swarna were obtained in 172 lines for plant height, 122 lines for thousand grain weight (TGW), 11 lines for yield/plant in BC2F4 and in 59 lines for plant height, 6 lines for tgw, 2 lines for yield/plant in BC4F2. Several lines were significant for more than one trait.

94 BILs derived from Swarna x *O. nivara* IRGC81848 BC2F8 BILs (NPS lines) were evaluated in field in 2018 for eight traits, out of which, 71 significant BILs were identified over the parent Swarna for 7 traits. For thousand grain weight two common major effect QTLs *qTGW2.1* and *qTGW11.1* were identified.

90 BILs derived from Swarna x *O. nivara* IRGC81832 BC2F8BILs (NPK lines) were field evaluated in 2018 for eight traits, out of which 66 significant BILs were identified over the parent Swarna for 5 traits. One BIL was positively significant for PW and TGW. For thousand grain weight one common major effect QTL qTGW12.1 with average PV of 29% was identified. Seeds of 100 BILs from this cross (NPK) were deposited in NBPGR.

Four years' yield evaluation data of five introgression lines from KMR3 x *O. rufipogon* WR120 BC4F8 BILs (NSR lines) in normal conditions, recorded mean yield 23 to 25g, 65% higher yield potential than KMR3 (17g). Two ILs were identified as high yielding low P tolerant lines when screened low P field for two years.

From the BIL x BIL crosses from Swarna x *O. nivara* 81848 BILs, in F3 of 166s x 14s, 17 lines (9%) out of 177 lines gave 25-33 g/plant yield compared to 18-21g/plant yield of 166s, 14s and Swarna. One IL was significantly higher yielding than parents 166s and 14s (20.87g/plant and 90 days to flower).

RUE – Enhancing resource and input use efficiency

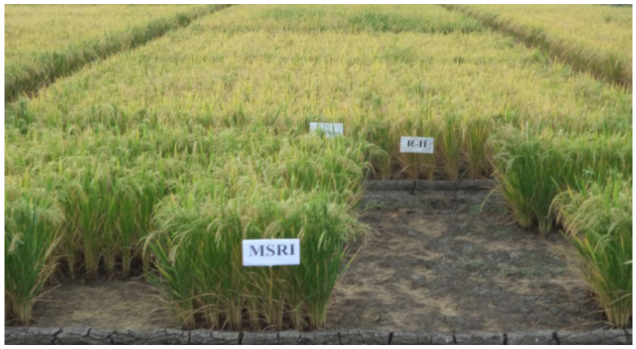
Agro/IUE/11: Strategic research on enhancing water Use efficiency and productivity in irrigated rice system

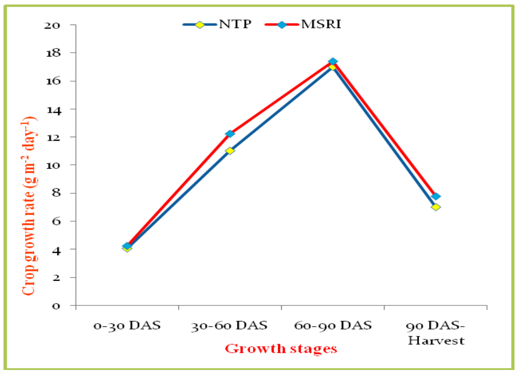
In order to evaluate the water saving potential of different crop establishment methods, studies were conducted for enhancing the resource use efficiency of the rice cultivation. The SRI method was modified by using machine transplanting, motorized weeding to make it labour efficient and enable timely planting.

Mechanized SRI recorded statistically comparable growth parameters, root growth characteristics and yield parameters with normal transplanting during both the years of study and increased the grain yield. Mechanized SRI also recorded lower cost of cultivation and gave higher gross return, net return and benefit: cost ratio over normal transplanting.

Nutrient Expert based recommendation of nitrogen with NCU (75%) + VC (25%) enhanced growth and yield of rice significantly with higher gross and net returns.

Among water management practices, AWD gave significantly higher grain yield of 5.75 and 5.80 t/ha over saturation method (5.38 & 5.49 t/ha). AWD was practiced with Bauman's plastic tubes. Similarly, water productivity and water use efficiency was higher with AWD method.





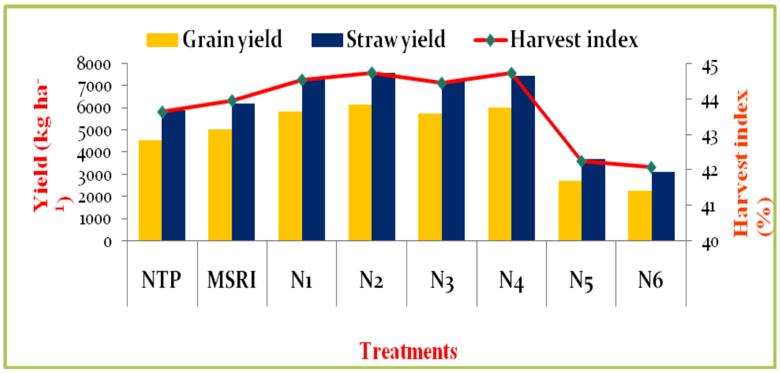
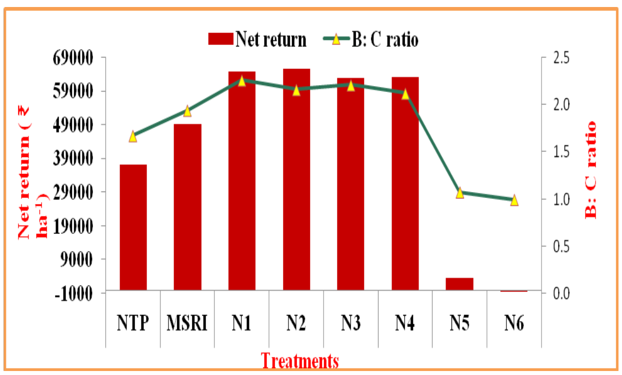


Fig. Growth parameters as influenced by the methods and Nutrient management



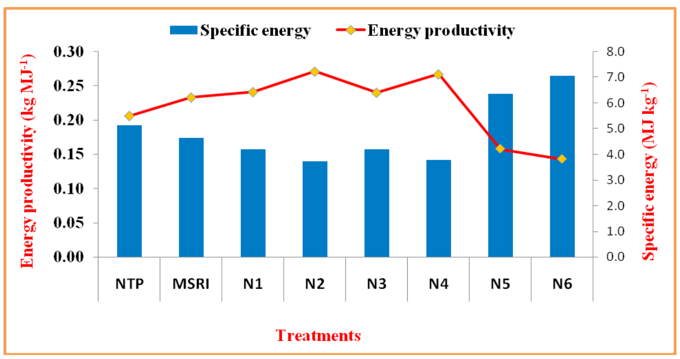


Fig. Grain yield, B:C ratio and Energy productivity as influenced by methods CE and Nutrient management

Lead Research

RUE/CP/AG/13: Development of suitable agronomic management practices for improving the productivity of aerobic rice and aerobic rice based cropping systems

Aerobic rice is water saving rice production system in which potentially high yielding, fertilizer responsive rice varieties are grown in fertile aerobic soils that are non-puddled and have no standing water. Supplementary irrigation however, can be supplied in the same way as to any other upland cereal crop.

Ferti-fortification for post-harvest quality of Aerobic rice

Field experiment was carried out during *kharif* 2018 to study the influence of zinc and iron nutrition (soil application, foliar application, basal application, split application etc.) on quality of aerobic rice with eight treatments in replicated RBD. The results revealed that Nutrient uptake (NPK) was significantly high in the RDF+ZnSo4 soil application, RDF+tank mix spray of Zn and Iron 3 times. Protein content and Zinc content was significantly high with RDF+ tank mix spray of Zn and Iron 3 times. Soil available Nitrogen was high except in Control and RDF+ Foliar spray of Zn and Fe 3 times. Soil available Phosphorus was high in RDF+ Fe soil application. Soil available K was high in Zn and Fe soil application; Post harvest quality analysis showed no significant influence of soil or foliar application on head rice recovery, milling%, hulling%, length /Breadth ratio, gel content etc.

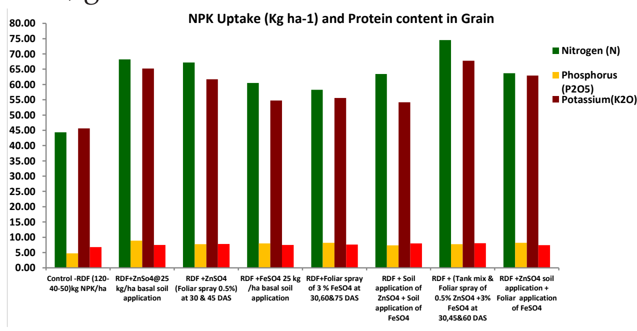


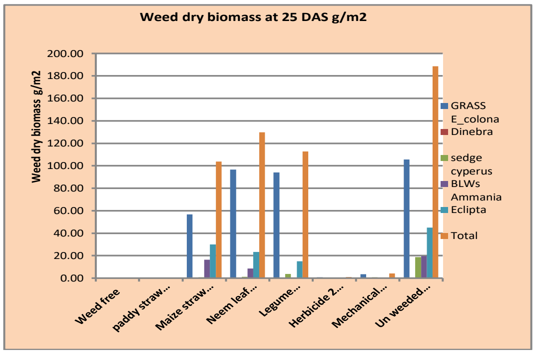
Fig. Nutrient uptake and protein content of aerobic rice as influenced by ferti-fortified micro-nutrients

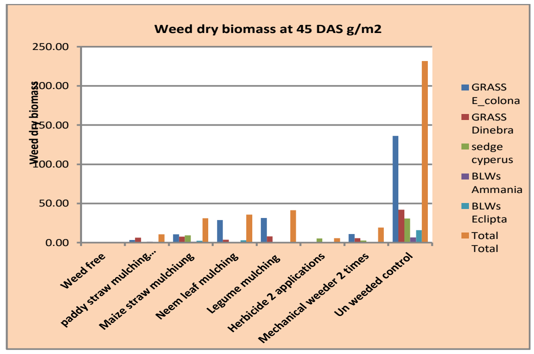
Table: Post Harvest Quality parameters

Treatment details	Hulling	Milling	Head Rice Recovery	Kernal length	Kernal breadth	Length/ breadth	Amylose content	Alkali spreading value	Gel consistency	Grain type	Grain chalk
RDF +ZnSO4 (Foliar spray 0.5%) at 30 & 45 DAS	78.9	70.5	61.10	4.63	1.78	2.61	19.64	4.00	22.00	ms	A
RDF +FeSO4 25 kg /ha basal soil application	79.27	70.67	58.63	4.59	1.79	2.57	21.36	4.00	22.00	ms	A
RDF+Foliar spray of 3% FeSO4 at 30,60 &75 DAS	79.20	70.57	61.37	4.55	1.74	2.61	20.14	4.00	22.00	ms	A
RDF + ZnSO4 soil application + Foliar application of FeSO4	79.37	70.77	61.60	4.55	1.76	2.59	19.85	4.00	22.00	ms	A
CD (0.05)	0.74	0.81	4.27	NS	NS	NS	0.98	-	-	-	-

Mulching for non-chemical weed control in aerobic rice

Field experiment was carried out during *kharif* 2018 to study the comparative performance of different green or dry mulches, mechanical weeding, chemical weed control in aerobic rice for effective and economic weed control. Green Neem leaf mulching @ 5 t/ha has recorded lower weed population and weed biomass at 25 and 45 DAS; better growth parameters, yield attributes and yield and on par with weed free treatment.





Identification of suitable areas where the aerobic system/partially aerobic system is already in practice in Telangana and Andhra Pradesh States

The direct dry seeding in Banavasi and Nandyal areas in Kurnool District, A.P. (dry direct seeding using tractor drawn seed cum ferti drill and pre emergence herbicide application and maintaining aerobic field till tillering stage); Machilipatnam area in Krishna District (broadcast sowing of rice fb pre emergence herbicide application, post emergence herbicide application twice and maintaining aerobic way till canal water is released during maximum vegetative stage); dry direct sowing areas of Khammam, Adilabad, etc., in Telangana State were identified as suitable areas where aerobic system of rice cultivation can be practiced.

RUE/CP/AG/17: Comparative study of organic and conservation agriculture for enhanced resource use efficiency, yield and quality of rice

The experiment was laid out in randomized block design with six treatments T_1-100% RDF through inorganic sources + RI, T_2- Integrated nutrient management + RI, T_3- Need based nutrient application + RI, T_4-100% RDF through inorganic sources - RI, T_5-Integrated nutrient management - RI, T_6- Need based nutrient application - RI. T_2- Integrated nutrient management + RI recorded highest growth attributes, yield attributes and grain yield. Similar trend was observed in case of straw yield. The nutrient contents in grain and straw did not vary much due to the different nutrient management practices. The N and P contents in grain were much higher than that of straw; whereas, K content in straw was higher than that of grain. Nutrient supply through integrated nutrient management and residue incorporation tended to increase the nutrient content in both grain and straw.

RUE/CP/SS/16: Study of rice vegetation in terms of crop stress to model the yield using NDVI

A 230 NDVI images pertaining to water years of 2015-16, 2016-17 and 2017-18 (from 1st June to 31 May next year) were subjected to Time Series analysis using software, TIMESAT. Although entire imagery pertaining to West Godavari district was processed only one point-source of information was focused, which represented the field of a rice grower and derived various phenology metrics of rice vegetation. These phenology metrics were studied with reference to available DUS characteristics of varieties as far as vegetation is concerned. Exploration is on with changing parameters for better understanding of rice phenology metrics. Generated various soil theme maps of West Godavari district from soil health cards (SHCs) and Inverse Distance Weighting method of interpolation was better in majority of soil themes with the lowest RMSE. These theme maps are used as inputs in analysis of NDVI (Fig).

Ground truth survey was organized in West Godavari district during *kharif* and *rabi* of 2018-19 during peak vegetation times (end of September and middle of February) in different rice growing situations namely, canal irrigated

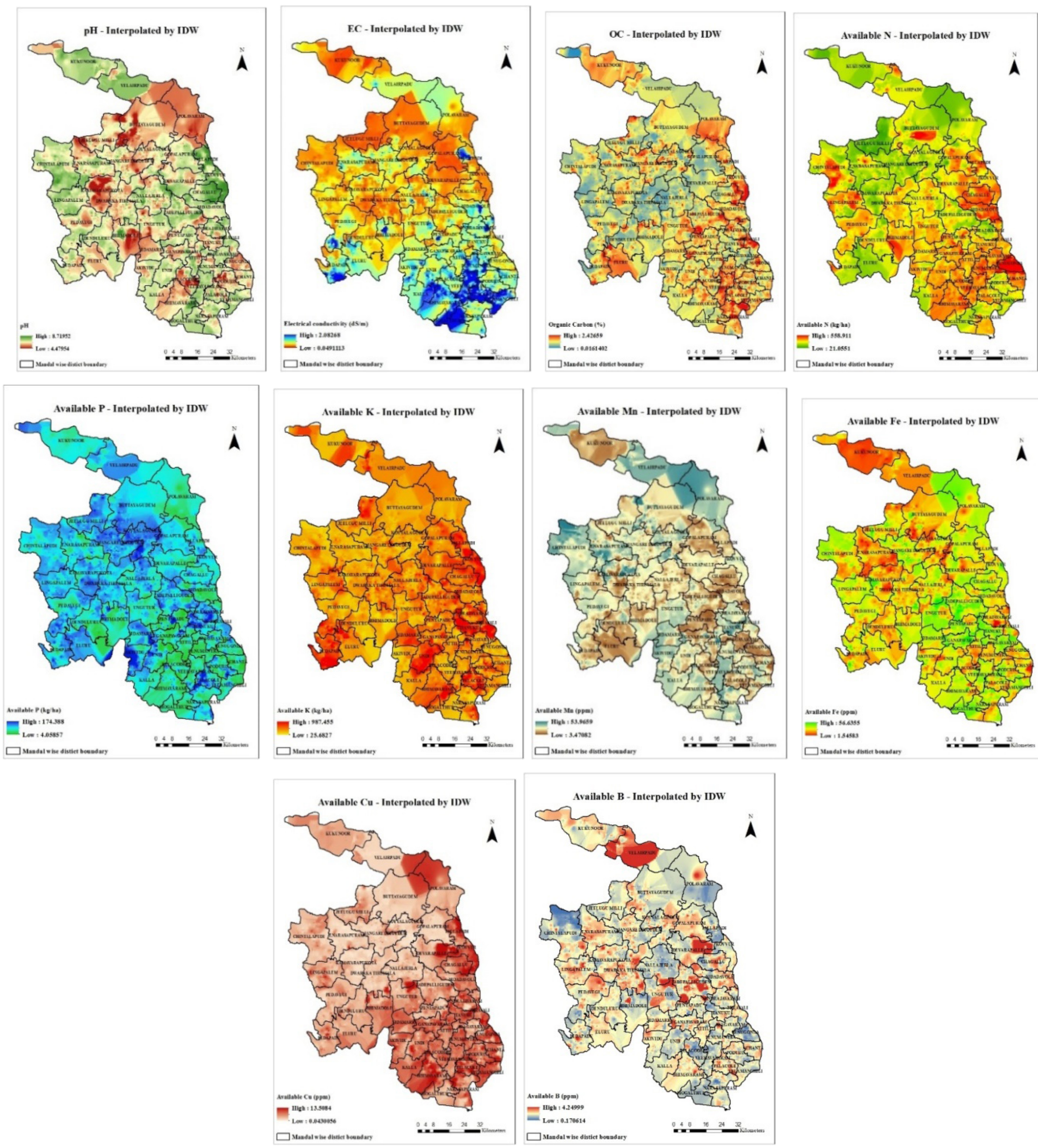


Fig. Interpolated soil theme maps generated from soil health cards

delta region, rainfed rice grown areas & ground water irrigated rice areas and collected required information. Measured NDVI from rice vegetation using an instrument, Green seeker in different fields during *rabi*. Collected leaf and soil solution samples (instead of soil samples) for analysis.

NDVI at the end of September (2018) indicated a significant (at 5%) correlation of 0.192* (n=136) with final rice yield with a coefficient of correlation of 0.192* (n = 136). The low 'r' value was because of ironing out of differences between fields due to averaging of crop cutting experiments at mandal level.

RUE/CP/SS/19: Evaluation of ZnO nano Particles in performance of rice

The ZnO nanoparticles were used for evaluation in seed germination; seedling vigour and seedling length during the year of 2017. Also, ZnO nanoparticles were tested on plant foliage in the controlled environment (Pot culture study). Nano ZnO were taken into three different doses namely, 50, 100 and 150 mg L-1 and bulk ZnO also taken as 500, 1000 and 1500 mg L-1 along with 0.5% ZnSO4 spray (Farmers Practice). Foliar application of nano ZnO at two different intervals (30 and 45 DAT) enhanced the chlorophyll a and b content by 10 and 5% over control but was lower than ZnSO4 treated plants. Whereas, the application of Bulk ZnO has restricted the movement of ZnO into the plant, which was hampered the chlorophyll production over the control plants. And the same was confirmed with the NDVI and SPAD values. In case of plant height, nano ZnO application at 150 mg L-1 significantly increased the plant height by 52 and 20% over the control at 45 DAT and 90 DAT, respectively (Fig).

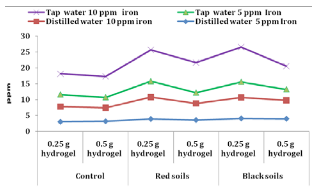
T1:Control (RDF), T2:Bulk ZnO (500 ppm) T3:Bulk ZnO (1000 ppm) T4:Bulk ZnO (1500 ppm) T5:Nano ZnO (50 ppm) T6:Nano ZnO (100 ppm) T7:Nano ZnO (150 ppm)T8:0.5% $ZnSO_4$ (Farmer's Practice)

Fig. Effect of ZnO nano particles on plant height and growth of rice

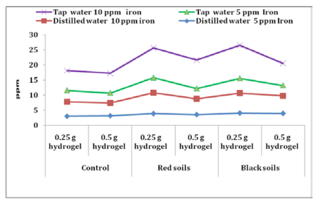
Foliar mediated transport of Zn from nano ZnO build-up soil dehydrogenase and alkaline phosphatase activity in pots where nano ZnO treated at 150 mg L-1. The observed Zn content in straw nano ZnO treated plants was significantly at par with the 0.5% ZnSO4 treated plants confirming that entry of Zn from nano ZnO has been converted in to Zn species and involved in plant metabolism, plant growth and nutrient content. Results are depicting that ZnSO4 and nano ZnO both performed identically with respect to Zn buildup in plants.

RUE/CP/SS/19: Efficacy of hydrogel on yield and soil properties of rice

Water and nutrient absorption of hydrogel in presence of micronutrients (Fe, Zn) with different types of water were tested. Regarding water absorption, for both the nutrients (Fe and Zn), with increasing doses of hydrogel water absorption has been increased. Hydrogel has absorbed more distilled water compared to tap water. Red soils absorbed more nutrient solution in presence of hydrogel compared to black soils. Increased water/solution absorption was recorded with increased concentration of nutrients in case of tap water, but reverse trend was observed with distilled water. In case of nutrient absorption, for both the added nutrients (Fe and Zn), with increasing doses of hydrogel, slight decrease in nutrient absorption has recorded. More nutrient absorption was recorded with higher nutrient concentration (Fig. a & b). Black soils absorbed slightly more zinc compared to red soils. Nutrient solution prepared with tap water was absorbed more by hydrogel compared to nutrient solution prepared by distilled water.



a) Zinc absorption capacity of hydrogel



b) Iron absorption capacity of hydrogel

RUE/CP/ENG/6: Selective mechanization in rice cultivation

Fabricated soil puddling machine using 0.5 hp electrical motor and stand. A specially designed tool for puddling in pots has been fabricated and testing is in progress. In addition, a small auger also is being fabricated. Initial tests indicate requirement of a speed reduction gear box as the present rpm is throwing the soil outside. Riding type drum seeder was tested during *kharif* 2018. Performance is encouraging. There is no yield difference between riding type drum seeder and manual drum seeder. Riding type 8 row Chinese transplanter was successfully used to transplant 18-20 days seedlings. In view of uniform depth of planting the yield was 5-8% more as compared to transplanting. Drum type biochar unit has been fabricated. Testing will be taken up to optimize parameters.

RUE/CP/AC/1: Post Harvest Treatment of Rice and Rice By-Products for Health Benefits and on-farm application

Rice husk (RH) account for about 20% w/w of rice, and it is one of the major agro-industrial under utilized side-product produced worldwide. This is comprised of 35-38% cellulose, 25-30% hemicelluloses, 20-25% lignin and 15-20% silica. All the components of rice husk have commercial importance but in the absence of technology for their separation, the disposal of this under exploited biomass has become a serious problem. To standardize the extraction process, first we screened 31 varieties for silica content. The variety having higher content of silica was used for standardization of process.

Distribution of Silica in Rice grain: Among the three fractions, Husk, bran and endosperm, husk contains highest amount of silica in all varieties ranging from 9.18% to 15.821%. Silica content >15% in husk was found only in two varieties- Jaya (15.43%) and VL-Dhan-65 (15.82%). Silica content in rice bran varied from 0.705% to 3.134%. Jaya is the only variety which bran has average silica content more than three per cent (3.134%). In endosperm, silica content ranged from 0.624% to 2.628%.

Isolation of silica and cellulose from rice husk: Dried and ground rice husk (Jaya) was treated with a mixture of formic acid/acetic acid/ water (50/40/10, v/v) under boiling condition. Insoluble rice husk residue was filtered, washed and dried while the filtrate was discarded. Husk residue was treated with 2M sodium hydroxide solution and then insoluble portion was separated from filtrate through filtration. The residue was washed with distilled water and dried and the combined filtrate was neutralized to precipitate silica which was filtered and washed. Upon drying, 13.5% silica was obtained in white amorphous form.

The alkali treated rice husk residue was subjected to acid hydrolysis by using 64% sulphuric acid (v/v) solution. The hydrolysis produced cellulose (28% yields) in microcrystalline form which was filtered, washed several times to neutralize and dried.

Rice husk Ash (RHA), another rich source of silica (50%-65%), was found most suitable for extraction of silica. Extraction was carried out with different basic materials of different concentration. 1.5 M NaOH was found most suitable solution which produced 94% of silica with a purity of 96% (dwb). Black insoluble materials after removal of silica was washed with distilled water and dried and stored for use as Rice Husk Biochar.

Preparation of hydrogel from cellulose: Isolated microcrystalline cellulose was converted to water soluble sodium carboxymethyl cellulose by known chemical method. Using this water soluble cellulose, four different hydrogels were prepared. Their water absorption efficiency varied from 907.7 g/g to 76.5 g/g during 24 hours in distilled water while in tape water the variations were from 61.27 g/g to 30.81 g/g.

Silica based slow release fertilizer: Four variants of silica based fertilizer have been prepared by the method of silica gelation. Preliminary studies have shown that all the products have urea slow releasing properties in comparison of neem coated urea. Theoretically calculated values of main components of the products are silica (9.44% to 12.29%), potassium as K_2O (12.1% to 15.72%), phosphorous as P_2O_5 (4.69% to 6.11%), and nitrogen (24.2% to 30.07%). Further investigations of the products are in progress which will decide that which product is most suitable for getting optimum yield of a crop.

Preparation and stabilization of silicic acid: Silicic acid is a bio-stimulant, a fertilizer as well as a plant protectant. This is the natural bio-available silicon source for plant. The bottle neck in using silicic acid is its tendency to quickly precipitate and polymerise, thereby, reducing their bioavailability. In our experiments we could prepare a stable silicic acid solution with Silicon concentration of 16300 ppm. For foliar spray, this product can be diluted at least 163 times. This product does not require any stabilizing agent if it is used in 2-3 days and the diluted form is stable for more than six months.

Formulation for slow release pheromone chemicals: Oil/water based formulation was prepared for slow release of pheromone chemicals. The formulation is stable even after 9 months and is ready for testing.

Slow release insect repellent formulation

Essential oils cedar wood, eucalyptus, lemon grass oils which have insect repellent properties were incorporated in fat based formulation and trapped on cotton based ribbon. From the formulation these essential oils will get released slowly and the product will be effective at least for two months.

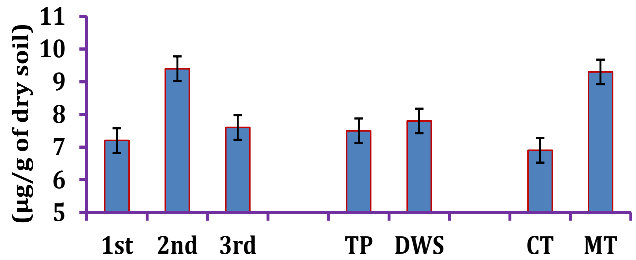
SSP – Sustaining rice system productivity

SSP/CP/AG/15: Sustainable intensification of conservation agriculture practices in rice-maize system to enhance system productivity in Southern India

The present experiment was initiated in rainy season of 2016 to study the effect of different rice establishment methods, mulching stubbles and tillage on system productivity of rice-maize system. In rainy season, the trial consisted of two main treatments i.e. normal manual transplanting and direct wet seeding and 3 sub plots as date of sowing i.e. 1st July, 15th July and 30th July replicated four times. In winter season, two tillage treatments (conventional and minimum tillage) were imposed over the rainy season treatments. Both rice and maize were grown under irrigated condition. All the agronomic package and practices were followed as per recommendation.

Pooled analysis of 3-year (2016-17, 2017-18 and 2018-19) data revealed that in rainy season total weed population and weed dry matter was higher in wet direct seeded rice (24 no./m^2 and 20 g/m^2, respectively at 45 days after sowing). In winter season, higher total weed population (64 no./m^2) and dry weight (36 g/m^2) were recorded in minimum tilled plots. Higher bacteria (193 x 106) and actinomycetes (105 x 104) population were observed under transplanted plots compared to those under direct wet seeded plots. There was no change in soil organic carbon (SOC) content of the soil after 3 years of conservation agriculture (Table). However, higher dehydrogenase activity was observed under 15th July sowing and minimum tilled plots (Fig.). Similarly, higher system energy use efficiency (13.4) was observed in *kharif* transplanted rice followed by conventional tilled *rabi* maize. In initial year of conservation agricultural practices in rice-maize system revealed that *kharif* rice transplanted at 1st July followed by *rabi* conventional tilled maize resulted in the highest system productivity (13.2 t/ha) and weed control efficiency.

Similarly, a comparison study was done between rice-maize and rice-rice system to find out the better sustainable rice-based system in this region. In this regard a brief table was presented to show that rice-maize system has an upper hand than that of rice-rice system.



*Vertical bars indicate LSD at p=0.05

Fig. Effect of establishment methods and tillage on dehydrogenase activity of soil after 3 years of conservation agriculture

Table: Comparison between rice-maize and rice-rice system through sustainability indicators

S. No.	Sustainability Indicator	Rice-maize	Rice-rice
1	System productivity (t/ha)	13.2	11.8
2	Sustainable yield index	0.93	0.90
3	Energy use efficiency	13.4	9.8
4	Water use (mm)	2100	2740
5	Water use efficiency (kg/ha/mm)	6.28	3.58
6	Land use efficiency	69.9	72.6
7	Cost of cultivation (Rs. /ha)	85,619	92,323

SSP/CP/SS/11: Assessment of genotypic variability and improving nitrogen use efficiency (NUE) in irrigated rice

Field experiments were conducted to evaluate N use efficiency of 16 popular rice varieties and 20 RILs to identify efficient rice genotypes during *kharif* and *rabi* seasons of 2018-19 at 2 N levels (@ N-0 and N-100 kg/ha) in a split plot design with 3 replications. Also, the selected variety, Varadhan was evaluated at graded levels of N (0, 50, 75 and 100 kg N/ha) with five different nutrient combinations for improving NUE during *kharif* 2018. In addition, a multilocation trial was conducted with GSR varieties at three locations (IIRR, Purulia and Titabar) during *rabi* 2017-18 and *kharif*-2018.

The results indicated that, out of 16 genotypes, Rasi, Varadhan, TI 93, MTP 5, MTP 3, PUP 221, B/V 243-1695 were identified as promising for both soil and applied N utilization and their responsiveness. In case of RILs of Rasi x ISM, RILs 4, 14, 15 and 16 were found efficient and responsive at two N levels. At graded levels of N (N0, N50, N75 and N100 kg/ha) with different sources of N, grain yield of variety

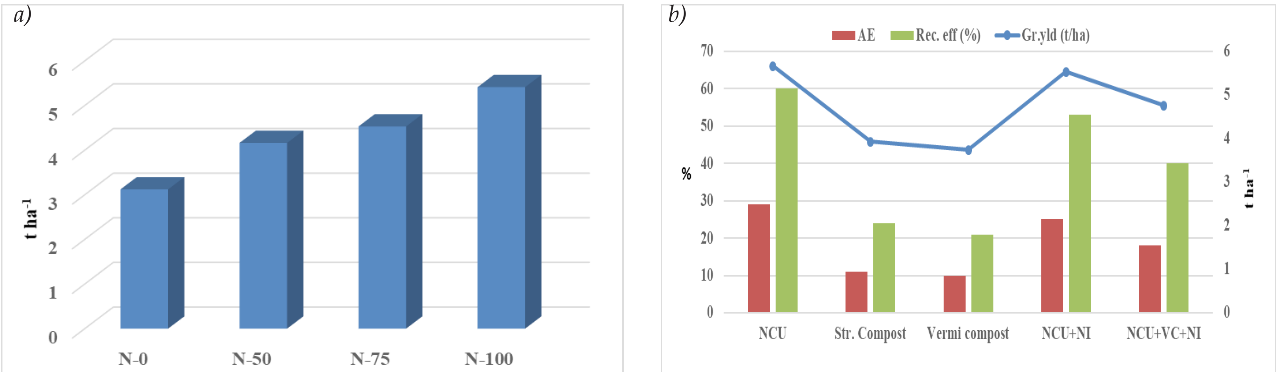
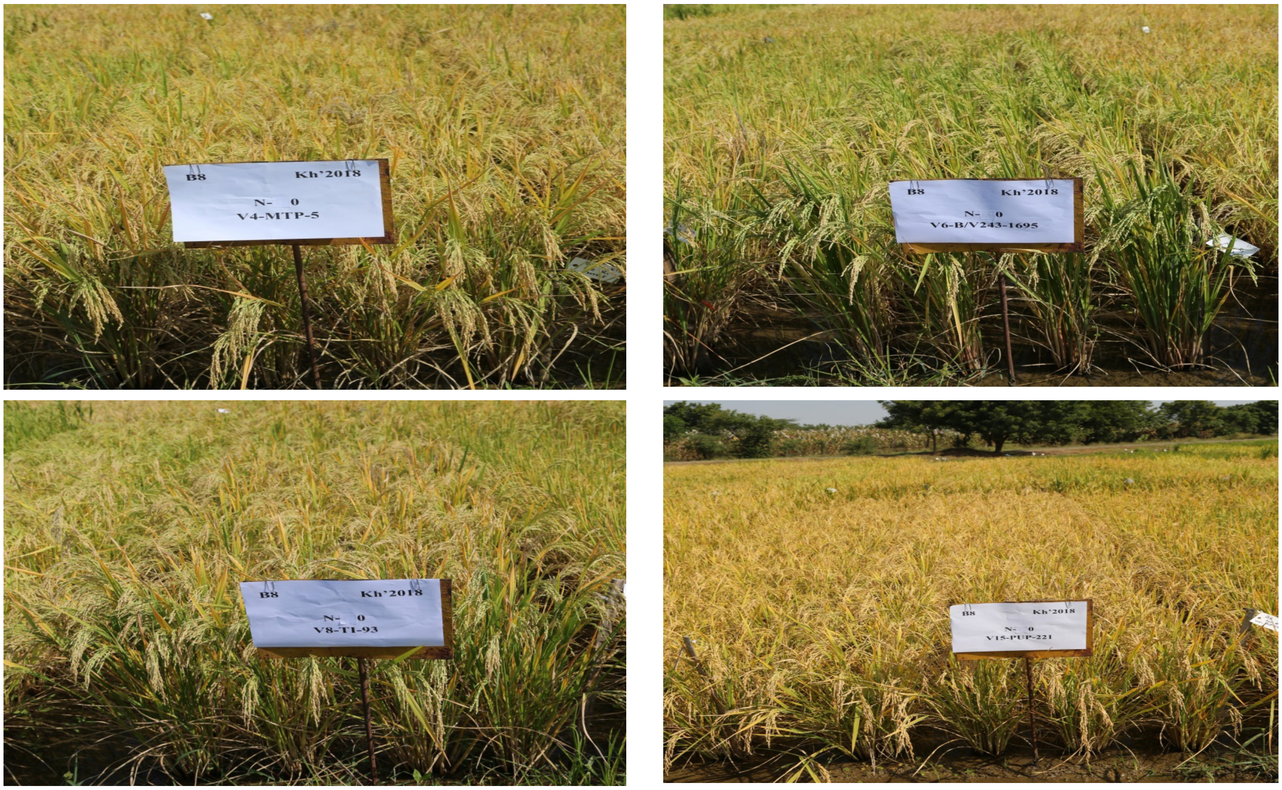


Fig. Influence of N levels and sources on a) grain yield and b) nitrogen use efficiency



Efficient genotypes for NUE without external N application

Varadhan was maximum with 100 kg N/ha while the yield at 50 and 75 kg N/ha was at par. Among the N sources, neem coated urea (NCU) either alone or along with nitrification inhibitor (NI) was superior to combined application of NCU+Vermi compost (VC)+NI, sole organic sources viz., rice straw compost (RSC) and VC at all N levels (Fig.).

SSP/CP/SS/18: Studies on Soil Organic Carbon status mapping and stocks in rice soils of India.

In an attempt to characterize the rice ecologies for its soil organic carbon and their stocks, a large variation up to the tune of >70% was noticed for soil organic carbon percentage and stocks among the four different rice ecologies. This ongoing study indicated that decline in surface soil organic carbon in the rice ecologies of India reduced two times faster than that of the soil carbon storage in the upland/hilly rice ecologies. In the irrigated rice ecologies, especially of the Indo-Gangetic Plains the decline in soil organic carbon was to the extent of 69.6% in comparison to the upland/ hilly rice ecologies. This was closely followed in rainfed shallow lands where decline in soil organic carbon due to cultivation was to the tune of 67.0%. Invariably, cultivation leads to decline in soil organic carbon in the range of 19-70% from the initial value. It is particularly to be noticed that the agricultural soils of northwest India exclusive of the Himalayas have lost about one half to two thirds of their original organic carbon content. In the different ecology wise studies, the mean surface soils carbon content of irrigated areas was 0.39% and it ranged from 0.13% to 0.78%.

SSP/CP/SS/13: Utilization of plant growth promoting microorganisms improving nitrogen and water use efficiency in rice

The nitrite reducing activity of whole cells of *Bacillus amyloliquifaciens, B. brevis, B. brevis-M, B. brevis-P, B. cereus, B. sonorensis, B subtilis* resulting in the release of ammonium was determined. The highest reduction in the concentration of nitrate substrate, measured as µM NO_2 reduced min-1 was observed in the culture filtrates of *B. cereus* (114.36) and *B. brevis* (112.01) followed by *B. sonorensis* (110.76). The highest accumulation of ammoniacal nitrogen in the culture supernatant was however, observed in *B. brevis* (1.28 µg NH_4 -N produced h^{-1}) and *B. subtilis* (0.91 µg NH4-N produced h^{-1}) indicating the efficiency of these isolates in converting nitrite to bioavailable ammoniacal nitrogen. The inoculated soils in comparison to uninoculated control soils, demonstrated reduced nitrate reductase activity by 54.5%, 89.0% and 59.1% respectively.

Table Nitrite reductase activity and ammonium production by whole cells of Bacilli

Treatment	Nitrite reductase activity (µM NO_2 reduced min^{-1})	NH_4 -N produced (µ g/h)
B. amyloliquifaciens	104.12[bc]	0.24[c]
B. brevis	112.01[ab]	1.28[a]
B. brevis-M	98.39[c]	0.80[b]
B. brevis-P	109.58[ab]	0.73[b]
B. cereus	114.36[a]	0.32[c]
B. sonorensis	110.76[ab]	0.83[b]
B subtilis	106.66[abc]	0.91[b]
Mean	107.98	0.73
CV%	3.75	10.5

SSP/CP/SS/15: Microbial population dynamics in different rice establishment methods in relation to nutritional availability and acquisition

Experiments were conducted in *kharif* and *rabi*-2018 with three rice establishment methods as main treatments viz., Aerobic rice, Alternate wetting and drying rice and flooded rice and the soil samples were collected from all the three treatment at tillering stage, flowering stage and also from farmer field from different rice establishment method from different part

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of Telangana to study the microbial population dynamics through enumeration method for total microbial count using various media and Isolated the bacteria colony based on colonies morphology. Aerobic rice method was observed with highest number, Bacteria (280x106 CFU/ gram of soil), Actinomycetes (126x104 CFU/ gram of soil) and Fungi (28x103 CFU/ gram of soil) during flowering stage. These isolates were grown on N-free media to isolate nitrogen fixers. A total of 355 nitrogen fixing bacteria, the purified cultures were screened for ARA (Acetylene Reducing Assay) through GC analysis for nitrogenase activity and among these, seven cultures which are showing high ARA activity were identified as *Stenotrophomonas* sp. *Ochrobactrum* sp. *Paenibacillus* sp. *Burkholderia cepacia*, *Burkholderia cepacia* strain, *Xanthomonas sacchari* and *Rhizobium* sp. Promising nitrogen fixing isolates were characterized for plant growth promoting activity and *Ochrobactrum* sp. and *Rhizobium* sp. were found to be efficient and having the ability to solubilise the insoluble Phosphorous and Zinc.

CCR – Assessing and managing crop response to climate change

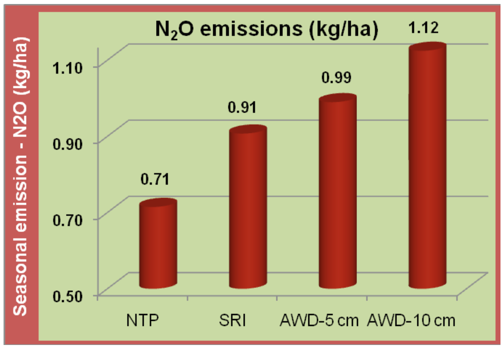
CCR/CP/SS/17: Studies on emission of greenhouse gases (GHGs) from rice soils and their mitigation

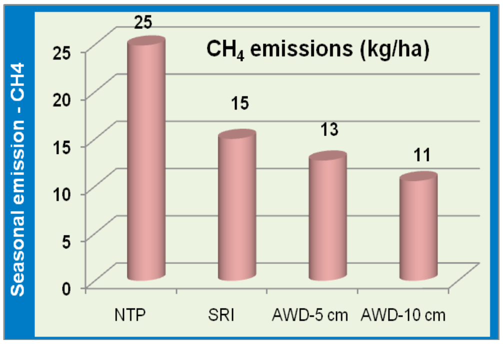
Field experiments were carried out in *kharif* 2018 and *rabi* 2018-19, with four planting/ water management methods viz., conventional transplanted (TPR), system of rice intensification (SRI) and alternate wetting and drying (AWD) at 5 cm and 10 cm depletion of ponded water to study their impact on greenhouse gas emissions. The test variety grown was MTU1153 (Chandra). Periodic gas samples were collected and analysed for nitrous oxide and methane emissions.

The crop establishment methods significantly impacted both the greenhouse gas i.e., methane and nitrous oxide emissions throughout the crop growth period. The highest seasonal integrated flux (SIF) for methane was observed in conventional transplanted (TPR) method (24.92 kg ha^{-1}) followed by SRI (15.03 kg ha^{-1}) while AWD methods resulted in lower flux values of 12.74 and 10.56 kg ha^{-1} with irrigation at 5 cm and 10 cm depletion of ponded water, respectively. Methane emissions decreased by 40 per cent in SRI and by 49 and 58 per cent in AWD at 5 and 10 cm, respectively as compared to TPR.

TPR recorded the lowest N_2O-N emissions. The seasonal integrated fluxes of N_2O-N were the least in TPR (0.715 kg ha^{-1}) as compared to SRI (0.907 kg ha^{-1}) and AWD methods (0.990 and 1.125 kg ha^{-1}). N_2O-N emissions were higher by 27 per cent in SRI and 38 and 57 per cent in AWD at 5 and 10 cm, respectively over TPR.

The GWP per unit of grain yield varied from the highest of 0.160 kg CO_2 eq. ha^{-1} kg^{-1} grain in TPR to the lowest of 0.116 kg CO_2 eq. ha^{-1} kg^{-1}





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grain in SRI. The grain yield varied significantly with the different planting methods. The highest grain yield was recorded in SRI (5569 kg ha^{-1}). TPR recorded a grain yield of 5234 kg ha^{-1}, which was lower by 6 per cent as compared to SRI. There was a grain yield penalty of 13 and 28 per cent in AWD at 5 and 10 cm respectively over TPR.

Evaluation of genotypic variability in leaf photosynthetic efficiency and its associated factors in rice

Leaf gas exchange traits were measured flag leaves using *LI6400XT* two sets of genotypes. In the first set (28 genotypes), photosynthetic efficiency (PN), stomatal conductance (gs) and *intercellular* CO_2 concentration *(Ci)* significantly (p<0.01) varied from 29.4 (Azucena) - 15.3 (Jamir) µmol (CO_2) m^{-2}s^{-1}, 0.658 (Jamir) - 0.241 (Rayada) mol (H_2O) m^{-2}s^{-1} and 175 (DZ 193) - 243 (Rayada) respectively (Fig.).

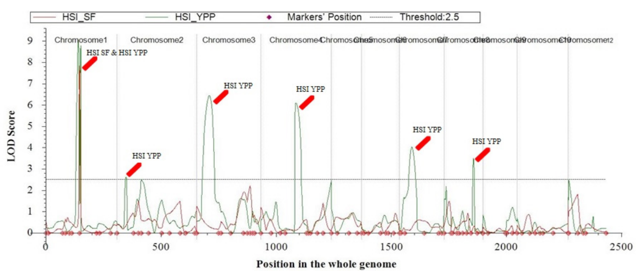


Fig. QTLs Identified from Vandana x N22 population

The 2[nd] set (40) includes 23 IVT-E-TP (2018) and 17 popular rice varieties. In the entries, PN and gs showed significant (p<0.01) variation. The ranges of PN and gs were 21.7 (IET26576) to 27.9 (IET2680) µmol (CO_2) m^{-2} s^{-1} and 0.603 (IET26480) to 0.360 (IET24994) mol (H_2O) m^{-2}s^{-1} (Fig.) respectively. In case of released varieties, PN and gs ranged from 28.35 (CO-1) - 21.7 (N22) µmol (CO_2) m^{-2} s^{-1}) and 0.501 (Rasi) to 0.372 (BPT5204) mol (H_2O) m^{-2}s^{-1}. Both the sets showed significant (p<0.01) variation in intrinsic water use efficiency (iWUE) which is the ratio of photosynthetic efficiency and stomatal conductance (PN/gs) and Carboxylation Efficiency (PN/Ci).

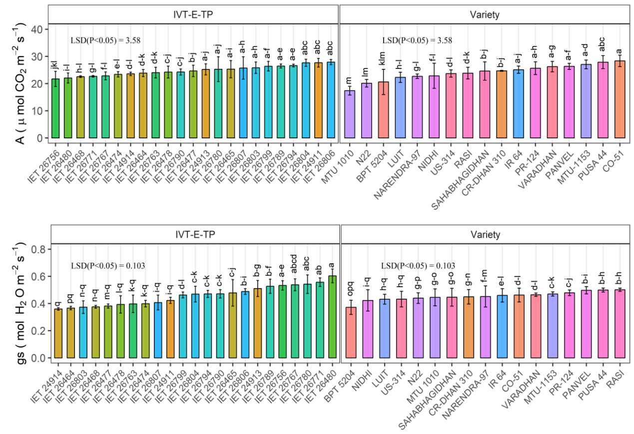


Fig. Variation in leaf photosynthetic traits in diverse rice genotypes during *kharif*-2018 season. Each bar represents mean of 3 replications ± SD. Bars with similar letters are not significantly different

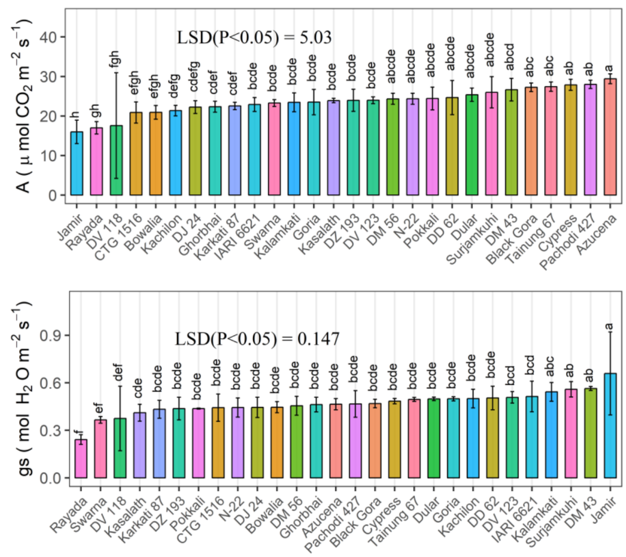


Fig. Variation in Rate of Photosynthesis (PN) and Stomatal conductance (gs) in diverse rice genotypes during *kharif*-2018 season

In multiple correlation analysis (Fig.) combining the two sets, PN showed significant positive association with PN/Ci SPAD value (chlorophyll) and positive but non-significant association grain yield and TDM. Ci and Ci/Ca (*intercellular* and ambient CO_2 concentration ratio) showed negative association with PN./Ci. The contribution of each gas-exchange parameter and leaf pigment content to PN was determined by multiple regression analysis (PN as independent variable and all other parameters as dependent variable). The data revealed that carboxylation efficiency (CE) contributed >30% to the R^2 (regression coefficient) value followed by gs Ci and Ci/Ca to the R2 when "lmg" method was used. However, the "pmvd" method indicate that >42% was contributed by CE to R^2 during *kharif* season. Ci/Ca showed strong negative association with PN and along with Ci it played a significant role in determining the photosynthetic efficiency in rice.

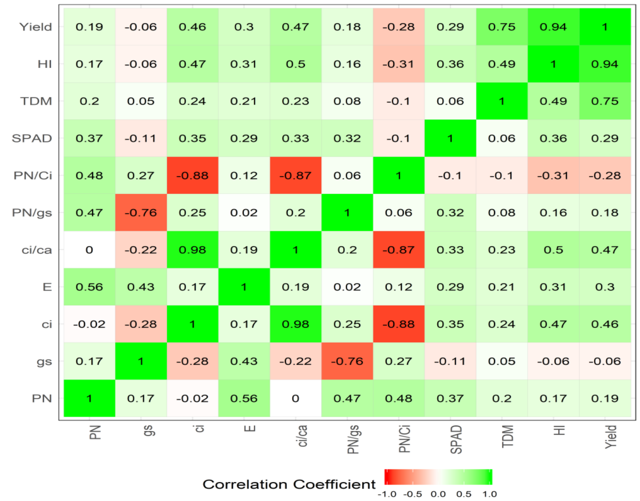


Fig. Relationship between leaf photosynthetic traits and yield traits in diverse rice genotypes. Total number of genotypes is 68 (28+40). correlation coefficient=p=0.05 (2.232) & p=0.01 (0.303)

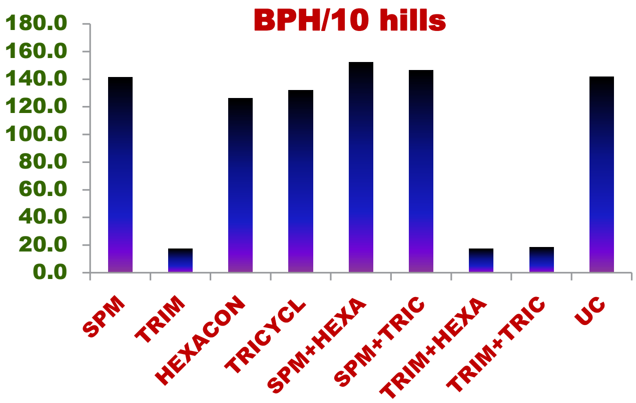
IPM – Integrated pest management

IPM/CPT/ENT/3: Chemical control of rice insect pests as a component of rice IPM

A field trial on Pesticide Compatibility consisting of nine treatments viz., spinetoram 6% w/v (5.66% w/w) + Methoxyfenozide 30% w/v (28.3% w/w) SC @ 0.75 ml/litre, triflumezopyrim @ 0.48 ml/litre, hexaconazole @ 2.0 ml/litre and tricyclazole @ 0.6 ml/litre applied alone as individual treatments and also in four possible combination treatments was conducted in Randomized Complete Block Design with three replications. All the pesticides were applied twice at 45 and 69 DAT except triflumezopyrim which was applied only once during 45-60 DAT as high volume sprays @ 500 litres of spray fluid/ha. Stem borer and leaf folder were observed and stem borer incidence ranged from 10.2 to 13.5% (DH during 50 to 74 DAT) and 15.3% (white ears). There were no discernible differences among the treatments including control.

Analysis of the data across 28 centres in the country (including IIRR) revealed that there were no significant differences in the proven efficacy of the two newer insecticide formulations spinetoram+methoxyfenozide and triflumezopyrim when applied alone or in combination with fungicides. Spinetoram+methoxyfenozide performed better against stem borer and leaf folder, while triflumezopyrim showed superiority against plant- and leafhoppers. Insecticide treatments applied in combination with fungicides were on par with triflumezopyrim applied alone and superior to remaining treatments including control in terms of yield.

Overall, the results revealed that there was no adverse impact on the efficacy of either of the insecticides when applied with fungicides or vice versa confirming the compatibility of the chemicals when used as tank mix in field.



IPM/CPT/ENT/21: Botanicals for sustainable management of major pests of Rice

Four essential oils viz., cedar wood oil, lemon grass oil, Camphor oil and Eucalyptus oil at 2% and 4% in emulsified form were tested in field by treating water in the rice beds in a randomized block design for their efficacy against major pests of rice during *kharif*, 2018. Cedar wood and lemon grass oils at 4% recoded lower dead heart damage (14.9-15.1%) compared to control (16.1%). There was no reduction in white ear damage. Camphor oil (2%) recoded lowest leaf folder damage (9.13%) followed by eucalyptus oil at 4% (10.68%) compared to control (13.38%). Highest grain yield (9.64 kg/ 20 sq.m) was recorded in eucalyptus oil (4%) treatment followed by lemon grass oil (9.55 kg) as compared to control (8.73 kg).

When the olfactory response of mirid bug *Cyrtorhinus lividipennis*, a brown planthopper predator was tested to leaf extracts of 5 species of *Ocimum*, *O. sanctum* attracted highest number of mirid bugs (32.5) compared to *O. gratissimum* (19.5 mirid bugs). Main compound present in *Ocimum spp* i.e. Eugenol 50-56% is responsible for the activity.

Essential oil formulations (emulsion and enriched strips) were tested for their efficacy against yellow stem borer in farmers field. The campor oil emulsion treatment reduced stem borer damage (7.3% dead hearts and 15.3% white ears) compared to untreated control (11.8 DH and 19.6 WE). The essential oil enriched strips have no effect on dead heart incidence but white ear incidence was reduced (11.89%) compared to control (16.17% WE).

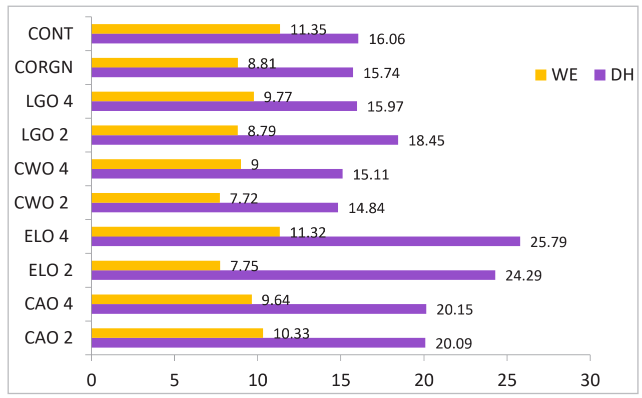


Fig. Efficacy of essential oils against yellow Stem borer

IPM/CPT/ENT/24: Bioecology and Management of Emerging Insect and Mite Pests of Rice

For the management of swarming caterpillar, *Spodoptera mauritia* chemical and botanical insecticides were tested under the laboratory conditions by leaf dip method with ten day old larvae. Insecticides included acephate 75SP, chlorpyriphos 20EC, rynaxypyr 20SC, cartap Hydrochloride 50WP, fipronil 5SC, flubendiamide 20WG, triazophos 40EC at recommended doses. All the treatments were found effective at recommended dosages causing complete mortality within 72 hours after treatment. In azadirachtin treatment complete mortality was observed 4 days after treatment.

Among the botanicals, neem products were found to be effective in causing mortality. Neem seed kernel extract (NSKE) (5%) and neem azal 1EC @ 20 ppm spray concentration caused 25.7 and 20.1 per cent reduction in the food consumption respectively compared to the untreated control.

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However, neem azal was highly effective and resulted in complete mortality of the treated populations 48 hrs after treatment whereas in NSKE mortality was 40 per cent.

IPM/CPT/ENT/22: Investigations on Nematodes of Importance to Rice Cultivation

Fifty-eight rice entries were screened for resistance to rice root-knot nematode Meloidogyne *graminicola*, out of which six entries viz., SM 363, SM 669, MAS 946-1, NPS 5, NPS 14, DB 9 were found resistant to the nematode based on root gall index.

The genetics of root-knot nematode resistance was studied in the cross between highly susceptible cultivar TN1 and highly resistant cultivar Khao Pahk Maw (KPM). The hybridity of F1 plants was confirmed using morphological and molecular markers. Phenotyping of 200 F2 plants for resistance to root-knot nematode indicated that resistance is governed by a dominant gene.

The rice root-knot nematode sick plot in IIRR farm was transplanted with highly susceptible rice cv. TN1 to build up the Nematode population which was monitored periodically and it was found that the incidence of root galls was 90%; the number of root galls/plant ranged from 0-45 and nematode population density in soil was 57 nematodes/100 cc soil after the third season.

Among the five granular insecticides Chlorantrinipole (0.4G), Cartap hydrochloride (4G), Phorate (10G), Fipronil (0.3G) and Carbofuran (3G), Cartap hydrochloride and Carbofuran were effective in suppressing the root galls by root knot nematode.

Weed management practices such as neem leaf mulching and application of herbicide bispyribac sodium effectively suppressed plant parasitic nematode population in aerobic rice field.

Total nematode abundance was more in rice under SRI system with 100% organic fertilizers compared to transplanted rice. However, relative abundance was low in the plots receiving organic sources compared to those receiving inorganic fertilizers.

Moderate incidence of rice root-knot nematode was observed in A, B, F and D blocks, left over nurseries and grassy weeds *Echinocloa* sp of IIRR farm and rice root nematode *Hirschmanniella* spp. was most prevalent in the farm.

IPM/CPT/ENT/26: Bio-intensive pest management with emphasis on biological control of rice pests

Bio-intensive pest management and ecological engineering techniques for enhancing biological control of rice pests were evaluated involving the treatments such as organic manuring, seed treatment with bio-agents, alleyways, monitoring with pheromones and increasing floral diversity by growing border crops viz., marigold, cow pea, black gram, green gram and bhindi.

Flower borders of marigold integrated with safer chemical was remunerative to the farmer (in Nalgonda, Telangana) and enhanced bio-control of rice hoppers with a benefit cost ratio of 5.25 as compared to 2.64 in farmer practice. Bund crops enhanced stem borer egg parsitisation by *Tetrastichus schoenobii* (40-90%) and marigold crop resulted in highest parsitisation (90%). Egg parasitization by *Tetrastichus schoenobii* alone and in combination with *Trichogramma japonicum* reduced stem borer damage (42.8% dead hearts and 72.2% white ears). Low cost Owl perches reduced rodent damage.

Two BIPM modules varying in the seed treatment with *Triochoderma asperellum* IIRRCK1 and Pseudomonas fluorescens at IIRR field resulted in reduction of stem borer damage (7.4-9.8% dead hearts) compared to untreated control (13.3%) and farmers practice (13.3%). Stem borer egg parasitization varied between 18.9%-22.3%, while spiders ranged between 5.7 to 7.5/10 hills among the treatments.

The predation capacity and functional response of *Amyotea malabarica* (Fabricius) (Fig.) adults on the rice hispa, *Dicladispa armigera* revealed that the predator fee on 1.67±0.60 hispa adults/ day with a type III curvilinear response (disc equation: Y'= 0.10 (1.7-0.8y) x).

Fig. A malabarica nymph and adult feeding on rice hispa

IPM/CPT/ENT/25: Development of Entomopathogenic Nematodes (EPN) for Biointensive Integrated Pest Management in Rice

The morphological and morphometric characterization of four newly collected entomopathogenic nematode isolates was done by processing by slow glycerin method. The examinations of infective third juvenile stage (IJ3), hermaphrodites and second generation males and females revealed the identity of isolates IIRREPNHI1, IIRREPNHI2 and IIRREPNHI3 as *Heterorhabditis indica* (Poinar *et al.*, 1992). The female and male specimens of IIRRMa4 isolate matched with the original descriptions of the species *Metarhabditis amsactae* (Ali *et al.*, 2011) Sudhaus, 2011.

Mass production of EPN *Heterorhabditis indica* (New isolate IIRREPNHI3) was carried out on susceptible insect host *Galleria melonella* and on artificial media, Bedding medium (Wouts, 1981). One g of Galleria larvae yielded 11.5 lakh IJs while the bedding medium yielded 32 lakh IJs from 250 ml conical flask containing 40 g medium.

Pathogenicity of three EPN species viz., *Heterorhabditis indica, Steinernema glaseeri* and *Metarhabditis amsactae* was tested against rice army worm *Spodoptera mauritia*. All three EPN species tested were found pathogenic to the insect larvae with 100% mortality of *H. indica*. In a lethal dose analysis, the LD50 of *H. indica* against *S. mauritia* was 41, 26 and 19 IJs/larvae at 24, 48 and 72 h of exposure respectively.

HRI – Host-plant resistance against insect pests and its management

HRI/CPT/ENT/11: Host plant resistance against insect pests and their management.

Assessment of host plant resistance to rice planthoppers viz., brown planthopper *Nilaparvata lugens* and white backed Planthopper *Sogatella furcifera* and their management

2000 entries evaluated for BPH resistance, out of which 251 entries were promising with low damage score (< 5.0). Twelve entries viz., IC 76013, RP 5690-20-6-3-2-1, IET 26565, IR 64, IET 27274, PY74, HWR 30, HWR 19, AYT 31, OYT 5, OYT 15 and OYT 23 were highly resistant to brown planthopper with a damage score of < 1.0. out of 1000 germplasm accessions evaluated, two accessions viz., AGBD 2018-173 and 401 were highly resistant to BPH. Fifteen hundred entries from screening nurseries, and breeding lines were evaluated against WBPH in greenhouse through mass screening tests out of which 9 entries viz., IET 27284, HR 12, PTB-33, IET 27498, IET 26578, IET 27406, IET 27571, IET 27882, IET 27599 were moderately resistant with a damage score of 3.0 to 5.0. Six germplasm accessions viz., IC75975, IC 76057, IC76013, IC216750, IC216735, IC377051, IC300168 were resistant in the planthopper hotspot area in Kampasagar Nalgonda District and can be used as donors for BPH resistance.

Thirty gene differentials were evaluated for their reaction to the brown planthopper populations of Khammam and Nalgonda districts of Telangana. Three gene differentials viz., PTB 33, RP 20168-18-3-5 and RP Bio 4918-230S showed resistance to both the populations.

Fig. Screening of STRASA material for brown planthopper resistance

HRI/CPT/ENT/23: Insect-plant interactions with special reference to rice pests – yellow stem borer and gall midge.

Field screening of material at vegetative and reproductive crop growth stages through multi-location testing, identified BK39-179 and BK35-155 as promising for yellow stem borer.

Evaluation of breeding lines derived from RP5587 at vegetative phase and reproductive phase for stem borer damage suggested that there is a negative correlation between grain yield and dead heart incidence (r=-0.3857, p=0.0388). Grain yield (12-15 g/plant) was not affected in some lines even though dead heart incidence (19-23%) was noticed.

Eight lines derived from *O. glaberrima* were found resistant to gall midge. The breeding lines with two and/or three R gene (Gm4, Gm8 and gm3) pyramided lines for gall midge resistance in the background of Swarna, Naveen, MTU1010 and WGL14 were evaluated in the greenhouse and lines promising for gall midge Biotype 1 identified. It is evident that though promising lines have been identified through marker assisted selection, phenotyping alone can confirm the resistance for gall midge.

HRI/CPT/ENT/19: Assessment of host plant resistance to leaf folder and Semi-chemical approaches for the management of insect pests of rice

A set of 92 BILs (BC_2F_8), derived from a cross between Swarna (*O. sativa*) and *O. nivara* (Acc. N0. 81848) were phenotyped for resistance to rice leaf folder by rapid field screening method for two seasons during *kharif* 2016-17 and 2017-18. The mean damaged area varied from 62.7 to 346.5 mm^2. Thirteen BILs were identified as resistant with a damage area of < 100 mm^2. Leaf length ranged between 26.67 and 57.37 cm and leaf width varied from 0.80 to 1.63 cm among the BILs. Trichome density was more on adaxial surface (0–463/ objective area) compared to abaxial surface (0-80/ objective area).

QTL analysis using Inclusive Composite Interval Mapping (ICIM) software identified 21 QTLs including one for damaged area on chromosome 4, three for leaf length on chromosome 5 and 7 and rest for leaf width. Two major QTLs for qDA4.1 and qDP4.1 were found in the same chromosomal location between RM273- RM248 with a LOD value above the threshold level of 2.5 with a phenotypic variance of 15.16. This is a candidate region for further investigation into leaf folder resistance.

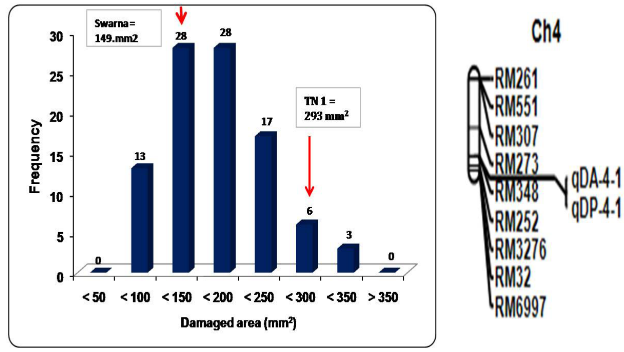

Fig. Frequency distribution of damaged area caused by rice leaffolder in BIL population and QTL map

For leaf width, 16 minor QTLs were identified. Three major QTLs; qLL5.1, qLL7.1 and qLL7.2 were detected for leaf length on chromosomes 5 and 7 with phenotypic variance ranging from 13.76 to 6.86.

Field evaluation of 29 Introgression lines of wild rices resulted in identification of two lines viz., HWR 3 (IR71031-9-7-B) and HWR 24 (IR73382-7-12-1-1-3-B) as resistant to rice leaf folder.

Six pheromone blends (two blends for *Sesamia inferens*, two blends for *Mythimna separata* and one commercial lure) were formulated and evaluated for their efficacy at Ludhiana, Punjab. Of these, Blend III was effective with 50% catches of *Mythimna* followed by Blend IV (45% catches). Four leaf folder pheromone blends (two for *Cnaphalocrocis medinalis* and two for *Marasmia patnalis*) were evaluated at Coimbatore and IIRR and Blend II was found effective with 38% catches of *C. medinalis*.

HRP - Host-plant resistance against pathogens and its management

HRP/CPT/PATH/15: Assessment of host plant resistance to rice blast disease and its management.

DRR Dhan 51 (IET 25484) is a Near isogenic line (NIL) of Swarna having *Pi-2* (a blast resistant gene). The proposed NIL is tall plant type, erect, high tillering and non-lodging plant habit. Resistant to blast disease whereas recurrent parent Swarna showed the susceptible reaction. It was released as DRR Dhan 51 through CVRC.

Host Plant Resistance: Out of the 10 blasts NILs developed through MAS nominated to AICRIP, two were promoted to AVT2 NIL trial: IET 27285 and IET 27286. Six rice blast NILs developed through MAS were nominated in AICRIP under AVT1 NIL trial for evaluation in multi-environment. They are RP Bio Patho 2-8-12, RP Bio Patho- 2-8-24, RP Bio Patho 5-156-24-7, RP Bio Patho 5-156-24-10, RP Patho 1-40-21-86 and RP Patho 3-8-47-22. A total of 4957 rice lines comprising of Donors, RILs, NILs, Differentials and wild rices were evaluated against rice blast disease under artificial inoculation in Uniform blast nursery pattern. Out of these 670 recorded resistant reactions. Developed the artificial inoculation technique for the neck blast.

Management of rice blast disease through chemicals

The combination fungicides viz., flusilazole 12.5% + carbendazim 25% SC (1.0 ml/l), azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC (1.0 ml/l), azoxystrobin 11% + tebuconazole 18.3% w/w SC (1.5 ml/l), tricyclazole 18% + mancozeb 62% WP (2.5 g/l), zineb 68% + hexaconazole 4% WP (2.5g/l), trifloxystrobin 25% + tebuconazole 50% WG (0.4g/l), mancozeb 50% + carbendazim 25% WS (2.5g/l) and fluxapyroxad 62.5g/l + epoxiconazole 62.5g/l EC (1.5ml/l) were evaluated against blast disease. The fungicide trifloxystrobin 25% + tebuconazole 50% WG (0.4g/l) was superior in checking the disease and increased the yield.

HRP/CPT/PATH-13: Assessment of resistant sources and monitoring of pathogen virulence in bacterial leaf blight of rice

Host Plant Resistance: Ninety five entries from OYT (observation Yield Trial) and 48 entries from AYT (Advanced Yield Trial) from STRASA project were evaluated for their resistance to BB under glasshouse condition. Out of 95 OYT entries, 11 entries viz., Ent # 7 (IRSAH - HL15WS - 32 - 3 -1-2), 9 (IRSAH - HL15WS - 133 - 15 - 1 - 2), 13 (IRSAH - HL15WS - 32 - 3 - 1 - 3), 15 (IRSAH-HL15WS- 133-41-1-1), 16 (IRSAH - HL15WS -15-1-1-1), 17 (IRSAH-HL15DS-03-2-1-1-1), 29 (IRSAH-HL15WS-133-57-1-1), 46 (IR16L1861), 65 (IRSAH-HL15WS-133-41-1-1-1), 73 (IR 127367-107-1-B-B) and 82 (IR 125026-73-1-1-B). showed high level of resistance with score 1-3. Another 7 entries showed a moderate score of 5 which included entry # 2 (IRSAH-HL15WS-62-7-1-1), 14 (IR16L1453), 44 (IR16L1849), 48 (IR16L1632), 51 (102783:2-70-1-2-1-1), 59 (IR 102818-10-276-1-2-11) and 68 (IRSAH-15DS-23-3-1-1-1-1). However, none of the AYT entries showed resistance to BB. In another study, a set of 99 Nagina mutants were evaluated under glasshouse for their resistance to BB and of the 99 entries, only 2 entries (Entry # 40 and 86) showed moderate resistance to BB with a score of 5.

Developed bacterial blight (BB) resistant lines in the background of ISM by introgressing one additional dominant BB resistance gene, *Xa38*. Four entries were nominated in the AVT1 NIL trial during 2018 and one entry, IET 27294 has been promoted to AVT2. Similarly, developed advanced backcrossed lines in the background of APMS 6B (maintainer line) by pyramiding two BB resistance genes, *Xa21* and Xa38. Selected 5 lines were tested in Donor Screening Nursery (DSN) in All India Coordinated Plant Pathology program.

Characterization of isolates of *Xanthomonas oryzae* pv. *Oryzae*: Sixty isolates of *Xanthomonas oryzae* pv. *oryzae* collected from different rice growing districts of Chhattishgarh were characterized for their pathogenic variation. The virulence profile of these isolates was done by inoculating each Xoo isolates on a set of rice differentials (IRBB-1 to IRBB-66) under glass house condition. Based on the reaction of the Xoo isolates on the rice differentials, 60 isolates were grouped into 9 pathotypes (Table). Pathotype 2 which did not show virulence on any major gene was most frequent. However, we got few strains in pathotype 17 which were avirulent on xa8 and *xa13* but virulent on *Xa21*. we also got 9 strains belonging to pathotype 21 which were virulent on *xa13* and *Xa21* but avirulent on xa8. Pathotype 22 virulent on 21, 13 and 8 was less frequent. Isolated 88 new isolates of Xoo from 8 different rice growing states.

Table: Pathotype grouping of *Xanthomonas oryzae* pv. *oryzae* isolates based on their reaction pattern on BB differential

Differentials	BB resistance genes	IXoPt-2	IXoPt-2-a	IXoPt-3	IXoPt-5	IXoPt-15	IXoPt-17	IXoPt-19	IXoPt-21	IXoPt-22
IRBB-1	Xa1	R	MR	S	S	S	S	S	S	S
IRBB-3	*Xa3*	R	MR	S	S	S	S	S	S	S
IRBB-4	*Xa4*	R	MR	MR	MR	S	S	S	S	S
IRBB-5	*xa5*	R	MR	MR	S	MR	S	S	S	S
IRBB-7	*Xa7*	R	MR/ MS	S	S	S	S	S	S	S
IRBB-8	*xa8*	R	MR	S	MR	MR	MR	S	MR	S
IRBB-10	*Xa10*	R	MR/ MS	S	S	S	S	S	S	S
IRBB-11	*Xa11*	R	MR	S	S	S	S	S	S	S
IRBB-13	*xa13*	R	MR/ MS	R	R	MR	R/ MR	R/ MR	S	S
IRBB-14	*Xa14*	R	MR/ MS	S	S	S	S	S	S	S
IRBB-21	*Xa21*	R	MR	R	R	S	S	S	S	S
IRBB-50	*Xa4+xa5*	R	MR	R	MR	S	S/ MS	S	MR/ MS	S
IRBB-51	*Xa4+xa13*	R	MR	R	R	R	R	R/ MR	MR/ MS	MR/ MS
IRBB-52	*Xa4+Xa21*	R	MR/ MS	R	R	R	MR/ MS	MR/ MS	R/ MR	MR/ MS
IRBB-53	*xa5+xa13*	R	MR	R	R	R	R	R	R/ MR	R/ MR
IRBB-54	*xa5+Xa21*	R	MR	R	R	R	MR/ MS	MR/ MS	MR/ MS	MR/ MS
IRBB-55	*xa13+Xa21*	R	MR	R	R	R	R	R/ MR	MR/ MS	MR/ MS
IRBB-56	*Xa4+xa5+ xa13*	R	MR	R	R	R	R	R	R/ MR	MR/ MS
IRBB-57	*Xa4+xa5+Xa21*	R	MR	R	R	R	R/ MR	MR/ MS	MR	MR/ MS
IRBB-58	*Xa4+xa13+Xa21*	R	MR	R	R	R	R	R	R/ MR	R/ MR
IRBB-59	*xa5+xa13+ Xa21*	R	MR	R	R	R	R	R	R/ MR	R/ MR
IRBB-60	*Xa4+xa5+ xa13+Xa21*	R	MR	R	R	R	R	R	R	R/ MR
IRBB-61	*(Xa4 + xa5 + Xa7)*	R	MR	R	R	MR/ MS	R	R	R	S/ MS
IRBB-62	*(Xa4 + Xa7 + Xa21)*	R	MR	R	R	R/ MR	R	R	R	MR/ MS
IRBB-63	xa5 +Xa7 + *xa13*)	R	MR	R	R	R/ MR	R	R	R	R/ MR
IRBB-64	Xa4 + xa5 + Xa7 + Xa21)	R	MR	R	R	R/ MR	R	R	R	R/ MR
IRBB-65	*Xa4 + Xa7 + xa13 + Xa21)*	R	MR	R	R	MR/ MS	R	R	S/ MS	R/ MR
IRBB-66	Xa4 + xa5 + Xa7 + *xa13 +* Xa21)	R	MR	R	R	R/ MR	R	R	R	S/ MS
ISM		R	MR	R	R	R/ MR	R	R	R	R/ MR
IR24/ TN1		S	MS/ S	S	S	S	S	S	S	S
No of Xoo isolates		**16**	**11**	**2**	**2**	**5**	**9**	**4**	**9**	**2**

In addition, isolated 88 new Xoo isolates from BB infected leaf samples collected from 8 different rice growing states. These include 32 isolates from Telangana, 6 isolates from Odisha, 8 isolates from Maharashtra, 29 isolates from Uttarakhand, 1 isolate from West Bengal, 6 isolates from Bihar, 5 isolates from Andhra Pradesh and one isolate from Tamil Nadu.

Effect of selected essential oils on bacterial blight disease severity

The effect of 7 essential oils (citronella, eucalyptus, cedarwood, nirgundi, lemon grass, clove and neem oil) along with antibiotic check (Plantomycin) on bacterial blight disease severity was evaluated under field condition. Observations were taken by measuring the lesion length 18 days after inoculation. However, none of the essential oils were highly promising in suppressing BB disease severity under field condition (Table).

Table: Evaluation of selected essential oils against bacterial blight of rice under field condition

Treat-ment	Treatment details	Dose	Mean lesion length (cm)
T1	Citronella oil	2 ml/l	17.32a
T2	Eucalyptus oil	2 ml/l	12.98c
T3	Cedarwood oil	2 ml/l	16.41 ab
T4	Nirgundi oil	2 ml/l	14.99bc
T5	Lemon grass oil	2 ml/l	13.85c
T6	Clove oil	2 ml/l	13.11c
T7	Neem oil	2 ml/l	15.03bc
T8	Emulsifier	2 ml/l	16.84ab
T9	Plantomycin	250 ppm	13.48c
T10	Uninoculated control	-	13.14c
CV (%)		8.38	
LSD (5%)		2.11	

Monitoring of BB and blast infected area of Nizamabad district of Telangana

Visited the bacterial blight affected fields in Nizamabad district of Telangana along with colleagues from PJTSAU during September' 2018. We visited the rice fields in several villages in Varni mandal. The rice variety BPT 5204 was severely affected with bacterial blight of rice (Fig.). Other varieties affected were Ganga Kaveri, MTU 1010, Jai Sreeram etc.

Fig. Severe bacterial blight infection in rice variety, BPT 5204 in Varni Mandal in Khammam district of Telangana

We interacted with the farmers and many farmers told that they applied Plantomycin. However, it was not very effective. We collected the disease samples of different diseases for our regular research purpose.

HRP/CPT/PATH-14: Assessment of host plant resistance and development of diagnostic tools for rice tungro virus disease

Host Plant resistance: Four national screening nurseries (1418) were evaluated at IIRR against RTD and the promising entries identified were: The entries in NSN-1, NSN-2, NHSN and DSN were evaluated at 2 locations for rice tungro virus disease. The promising entries identified in different nurseries were: IET # 25909, 26487, 28030, 28020 and JKRH 3333 in NSN-1; 27566, 27871, 27900, 27668, 27715, 27937, 27957, 27968, 27974, 27823 and 28063 in NSN-2; 26573, 26579, 27467, 27472, 26598 in NSN-H; 27377, 27376, 27400, 27330, 27345 in NHSN and CB 14161, TPL-58-1, NWGR11048, Tetep and CB 15 144 in DSN.

A total of 273 MAGIC populations were phenotyped against rice tungro disease and 3 lines (201/318, 343/366 and 164/397) were found to be resistant by expressing disease score 3.

In order to study the effects of the tungro disease in the photosynthesis of rice, various parameters were studied in four different replications. The net photosynthetic rate was 10.360 ± 0.628 and 2.317 ± 0.102 in control and infected plants, respectively. Similarly, transpiration rate was also reduced in infected plants as compared to control. The mean value of transpiration rate was 2.686 ± 0.405 in control plants and 1.567 ± 0.567 in infected plants. Interestingly, the *intercellular* CO_2 concentration was increased in the infected plants. The mean value of *intercellular* CO_2 was 219.847 ± 32.008 ppm and 313.544 ± 26.278 ppm in control and infected plants, respectively. The mean Fv/Fm ratio, representing the efficiency of the PSII, was significantly reduced (17%) in infected leaf compared to control leaf. Whereas, other parameters like apparent electron transport rate (ETR), photochemical quenching (qP), non-photochemical quenching (qN), and photochemical quantum yield did not show the statistically significant difference

HRP/CPT/PATH/20: A consortia approach to the biological management of diseases in rice

The application methodology of *T. asperellum* IIRR1 (TAIK1) has been standardized. Seed treatment method was standardized. 24 hrs of presoaking the seeds followed by 24 hrs soaking with mixing 6 g/Kg of seed of Sorghum grain formulated TAIK1 produced better results. The plants were treated as seed treatment followed by field application of 4kg/ha at 50 DAS prevented the early incidence of blast diseases in the blast nursery. Field studies were conducted in both the IIRR farm and in the farmers field. Results from the farmers field study indicated that the treated plants had improved growth (43% over control) and early flowering (8-12 days) when compared to the untreated control.

In the trials conducted along with BIPM trails in the IIRR farm it has been observed that since initial germination, establishment and growth of the plants in the nursery were more than the untreated plants, the area for nursery shall be kept at least 1.5 times the area required for untreated plants. This will avoid the competition between plants at the initial stages leading to chlorosis and stunting in the nursery. Treatment was taken with only *T. acervulum*. Observations regarding germination, initial development (root and shoot length), days to flowering and maturity, incidence of pests and diseases were taken.

The metabolites from TAIK1 was extracted using ethyl acetate and the rude filtrates were fractionated using HPLC. Three major components were obtained. The fractions have to be characterized and purified further. TAIK1 strains were used for accelerated composting of rice straw for the trails in the soil science. The data obtained is being analysed.

HRP/CPT/ PATH/23: Variability in Ustialginoidea virens and management of false smut disease

Collection of *U. virens* isolates: In *kharif* 2018, isolated different *Ustilaginoidea virens* isolates from false smut infected samples collected from Northern part of India (13 isolates) and in January 2019, false smut incidence was low in the surveyed areas of Chidambaram talk of Cuddalore district. Sample collection of False smut was done from blocks of the rice growing areas of Chidambaram Taluk of Cuddalore District, Tamil Nadu and isolated 9 isolates of U. virens.

Screening of different genotypes under field conditions: In, *kharif* 2018, 162 genotypes belonging to different categories viz., HWR lines (wild rice introgression lines), selected germplasm entries (2017 & 2018) and NPS lines were screened through artificial inoculation under field conditions. Pure culture of the false smut pathogen was mass multiplied in potato sucrose broth in a rotary shaker at 27 ± 2OC with 125 rpm for 2 weeks. Conidia were harvested through centrifugation and suspended in sterile distilled water and 2 ml of conidial suspension (2 x 105 conidia/ml) was injected into the boots of individual tillers using a sterile hypodermic syringe during evening hours. For each genotype, 2 - 4 tillers were artificially inoculated. Plant inoculation was done during middle

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of August' 2018 to first week of September 2018 (due to difference in maturity period of different genotypes). The plants were observed for symptom expression from 15 DAI (days after inoculation) onwards till maturity. Out of 162 genotypes that were artificially inoculated with false smut pathogen, 92 genotypes showed varied level of susceptibility (with number of smut balls/panicle ranging from 1-31). The genotypes viz., GP 235 (2018) and HWR 4 showed highest level of susceptibility with number of smut balls/panicle ranging from 28 to 31. Percentage of infection among different categories of genotypes ranged from 40-80%. The selected genotypes were again artificially screened, under the field condition during *rabi* 2019. As there was a comparatively higher temperature during flowering stage of the plants, the inoculated plants were protected from high temperature using green shade net and water spraying during morning and evening hours. Though the inoculated plants expressed the symptom, the infection intensity was less compared to wet season. It can be concluded from the study that the standardized artificial screening technique can be adopted under field conditions to identify the resistant sources against false smut disease of rice (Fig. & Table).

Fig. Screening of different germplasms under artificial disease pressure at field conditions during *Kharif* 2018 and *Rabi* 2019

Table: Details of rice genotypes inoculated artificially with *U. virens* and percentage of infection

Details of genotypes	Total no of genotypes inoculated	Total no. of genotypes expressed symptom	Percentage of infection	Maximum no. of smut balls per panicles
HWR lines	33	28	84.84%	31
Germplasm lines 2017	12	10	83.33%	17
Germplasm lines 2018	67	38	56.17%	28
NPS lines	50	20	40%	20

Screening of Selected Pseudomonas isolates against *U. virens*

Selected isolates of Pseudomonas sp were tested for their antagonistic activity against *U. virens* under in vitro. Among the six isolates were selected, isolate Scag-2 and FYM-9 were effective and reduced the growth of the pathogen and per cent of inhibition was recorded as 70.77% and 52.83% respectively (Fig.).

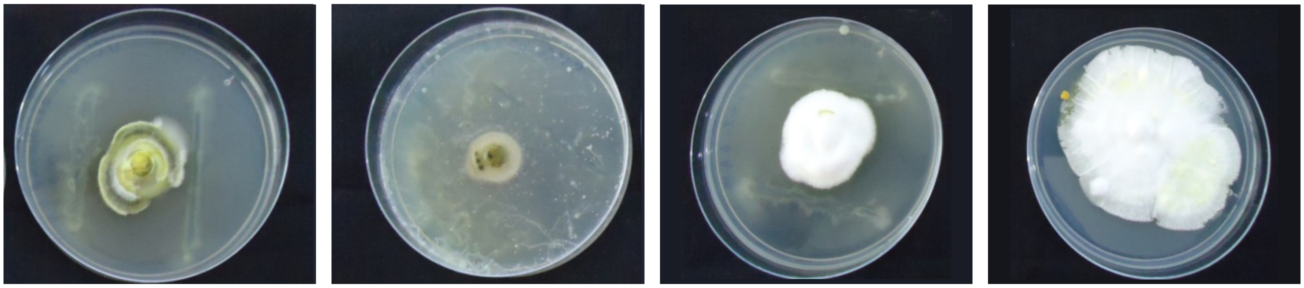


Fig. Antagonistic activity of Pseudomonas isolates against *U. virens* under in vitro

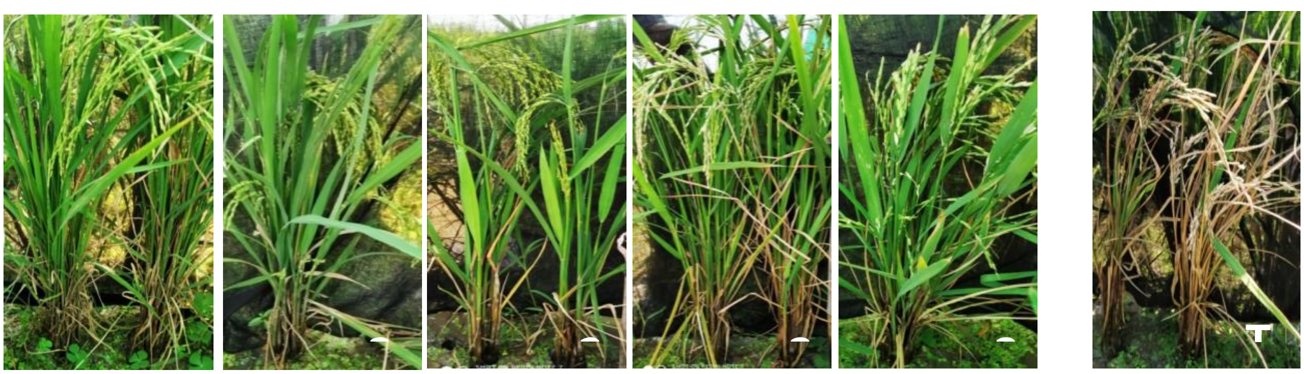
HRP/CPT/PATH/22: Population dynamics of rice sheath blight pathogen and sustainable disease management

Characterization of *R. solani* isolates

Sheath blight disease samples were collected isolated and characterised the 23 *R. Solani* isolates from different rice ecosystems. Till now about 120 isolates of sheath blight pathogen characterized by using different methods and 70 isolates were preserved in long term (-20 °C) storage. Isolates are studied for their pathogenic nature and identified the virulent namely, RS-TS-2, RS-TS-6, RS-TS-9, RS-TS-14, RS-TS-17, RS-TS-23, RS-TS-27, RS-TS-30, RS-CG-2, RS-CG-10, RS-CG-21 and RS-CG-40.

Host Plant Resistance against sheath blight

Forty three HWR entries from IRRI were artificially screened at field during *Kharif*-2018 and glass house during *Rabi*-2019. Among them five entries were showed tolerant reaction score of 5. Tolerant entries are namely HWR-15 (IR 64 x *O. glaberrima*), HWR-22 (NPT x O. officinalis acc. 100896), HWR-23 (NPT x *O. officinalis* acc. 100896), HWR-35 (NPT x *O. longistaminata* acc. 110404) and HWR-35 (IR69502-6-SRN-3-UBN-1-B x *O. glaberrima*) were identified based on disease reaction at field during K-2015, K-2016, K-2018 and R-2019.



F8 population (330) of improved Sambha Mahsuri X Wazuhopehk artificially screened at field condition (IIRR and RC Puram) during *Kharif*-2018. In final scoring (21 DAI) out 330 F6 plants were categorized based on SES score (25 plant-3 score, 251 plant-5 score, 53 plant-7 score).

About 380 lines of magic lines were screened and found that 96 lines of 5 score and remaining lines with 7/9 score.

Rice cultivars viz., Whazhuophek, Ngonolosa, Gumdhan and Phogak and AICRIP promising entries namely 22769, 23616, 26027, 25998, 25512, 23929, 24518, 24519, 25196, 26326, 26647, 26652, 25912, 27022, 26985, 26500, 26510, 26493, 26518, 26547, 26554, 26552, 24202, 24217, 23542, 26593, 26600, 26603, 25819, 26573, CB-05-022, CB-11-107, DRR-BL-155-2, DRR-BL-155-2, RP2015D198, CB14156, CB13168, MS-M-93-55-2-3-4-3-2-555, RP-Bio-patho-3-35, swarnadhan, wazuhophek, CB14161 were shown moderately resistant/ tolerant reaction during K-2018.

Tolerant mechanism in rice against *R. solani*

Defense responses of tolerant (Whazhuophek, Ngonolosa and Tetep) and susceptible (TN-1 and IR-50) rice were monitored using biochemical analyses and expression analyses of selected defense related genes over a time course during different infection stages. The pathogen *R. solani* induced Phenylalanine ammonia lyase (PAL), Superoxide dismutase (SOD), Peroxidase (POX), Polyphenol oxidase (PPO) in tolerant cultivars (Whazhuophek, Ngonolosa and Tetep) whereas in susceptible cultivars (TN-1 and IR-50), it had suppressed POX and SOD enzymes. Distinct difference was observed in activity of these enzymes in different cultivars at different times of course. The enzyme activity was observed peaks at 24 and 48 hours post inoculation mostly in all cultivars.

The expression rate of selected defense related genes in two cultivars i.e., Whazhuophek as tolerant and IR-50 as susceptible were studied. The expression transcripts of defense related genes viz., PR-1, PR-2, PR-3, PR-4, PR-5, PR-9, PR-10, PR-13, CHS, LOX, PAL and PPO were studied by using quantitative Real-time PCR (qRT PCR). Results showed that the expression of all genes in tolerant cultivar were higher than that of susceptible cultivar, post inoculation.

Fungicidal management of sheath blight

In the study on evaluation of combination fungicides against sheath blight, azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC (1.0 ml/l) sprayed plot showed less disease severity (DS: 27.5%) and higher yield when compare to other treatments. In another study new molecule mefentrifluconazole (0.35 ml/ 0.4 ml) showed low disease severity compare to other standard check hexaconazole.

HRP/CPT/PATH/24: Survey, Host plant resistance to brown spot disease of rice and its management

During *Kharif* 2018, surveyed the farmer's field at Jagtial, Kamaredyy, Masipet and Nalgonda districts of Telangana to observe the incidence and severity of brown spot disease. It was observed that brown spot disease incidence and severity was very low to low in areas surveyed. The fungus *Bipolaris oryzae* being a fungi *imperfecti*; rarely sporulate in artificial media/ natural media and sporulation is complex process governed by many factors including the light and nutritional factors. So, the different light sources and nutritional sources were tested in the present investigation in order to induce the sporulation in the fungus. The fungus was exposed to different light sources like UV radiation, Near UV and visible light at different regimes and duration of alternate light and dark conditions in order to trigger the sporulation in fungus.

The results of exposure of fungus to UV light indicated that there was a gradual increase in the production of number of conidia with increased exposure duration from 30 seconds to 3 minutes. The maximum number (12.6 x 104 and 13.3 x 104 respectively in IIRR and Lonavala isolates) of conidia was obtained when the fungus was exposed for 3 minutes of UV light followed by incubation of fungus at 26 ^{o}C under dark condition. As the exposure period increased to 5 min and 10 min, there was gradual decrease in the production of number of conidia in the fungus. The effect of exposure of fungus to near UV radiation at different duration of light and dark conditions (12h L+12h D, 12h L+24h D, 24h L+12h D; 24h L+24h D; complete light and complete dark condition) showed that, all the light regimes could induce the sporulation in fungus; however the maximum sporulation (22.8x104 and 15.5x104 in IIRR and Lonavala isolates) was obtained when the exposed to 12 hours of near UV light and 12 hours of dark conditions. Neither the complete NUV exposure nor complete dark condition could induce the sporulation in the fungus.

The exposure of fungus to different durations of visible light did not induce sufficient sporulation in fungus. The fungus *B. oryzae* was also subjected to different stresses to trigger the sporulation and that includes exposure of fungus to sunlight (12 noon) for 30 min, hot water shock for 5 min & 10 min and cold water shock for 30 min. None of these stresses could trigger the good sporulation in the fungus. Hence, out of the different light sources and different regimes of light exposure tested it was concluded that, 12 hours of near UV light and 12 hours of dark conditions was standardized for triggering the sporulation.

Nutritional sources on growth and sporulation of fungus

The growth and sporulation of the isolates of *B. oryzae* was evaluated on different synthetic/ semi synthetic media (PDA, Rabbit food agar, Corn meal agar, Corn meal peptone agar, Malt extract agar, Rice hull agar, Rice leaf extract agar, Rice straw extract agar, Saboured agar, Richard's medium, V8- vegetable juice agar, Czepek Dox agar and Oat meal agar). To create a nutritional stress in fungus different strengths of Potato dextrose agar (0%, 10%, 25%, 50% and 100% PDA) was also tested. Sporulation was also tested on chopped sorghum grains, rice grains, maize grains, leaves of different weed hosts and rice leaves. With regard to growth of fungus, Czepek dox agar (8.7 cm) followed by rabbit food agar (8.3 cm) supported the good growth of the fungus and fungus could cover the entire plate in 8 days. The colour of the mycelia in different plates varied from white to dark greyish) (Fig.).

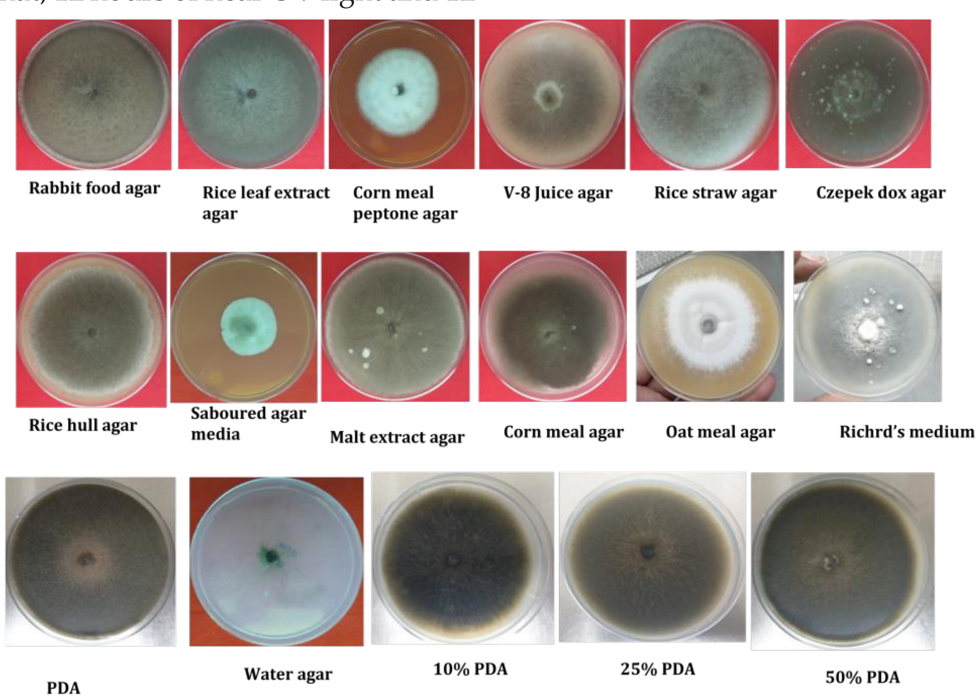


Fig. Radial growth and colour variation in *B. oryzae* on different media

The rabbit food agar medium supported the maximum sporulation (55.9 x 104 and 36.2 x104 in IIRR and Lonavala isolates respectively) followed by corn meal agar (24.8x104 and 18.5x104 respectively in IIRR and Lonavala isolates) induce the good sporulation in fungus after exposing the 12h of Near UV and 12 h of dark condition for three days. Czepek dox agar supported very good vegetative growth of the fungus but failed to support good sporulation of the fungus. Sorghum grains and maize grains could also induce the good sporulation in fungus and which may be identified for mass multiplication of fungus for screening large number of genotypes. The nutritional stress could also induce the very good sporulation in fungus. As the concentration of dextrose and potato decreased in PDA from 100% to 10%; there was gradual increase in number of conidia and maximum sporulation was observed at 10% strength PDA (45.2 x104 and 33.2 x104 respectively in IIRR and Lonavala isolates). Out of the different weed hosts used; most of them supported the good mycelial growth of the test fungus however; none had supported the good sporulation. However, rice leaves and paddy straw could induce sporulation some extent.

HRP/CPT/PATH/25: Host plant resistance and Characterization of pathogens of Sheath rot and Stem rot diseases of Rice

Survey of Sheath rot and Stem rot affected areas of Andhra Pradesh and Telangana, collection of diseased samples and isolation of test fungi

A survey was conducted to know the status of sheath rot and stem rot diseases in the states of Telangana and Andhra Pradesh and collected the diseased samples from different places. The diseased samples were taken to the laboratory, ICAR-IIRR for isolation of test pathogens. Some isolates were collected from other regions of the country. Total 17 isolates of sheath rot and 6 isolates of stem rot fungus were collected and morphological characters were studied for their colony growth, colony colour, type of growth and sporulation.

Pathological and molecular characterization of isolates collected from diverse geographical regions

The isolates vary significantly in morphology from one region to other. The colour of the fungal growth of isolates vary from white to pale orange. Mycelium growth with fluffy, flat and circular. The isolate Karjat showed the maximum radial growth (8.07 cm) and the isolate Varanasi showed the minimum radial growth (6.10 cm). From Telangana, the isolate DRR showed the maximum radial growth (7.9 cm) and the isolate Adilabad showed the minimum radial growth (6.97 cm). *Sarocladium oryzae* taking more than 35 days to fill the entire petri plate (Tables & Fig.).

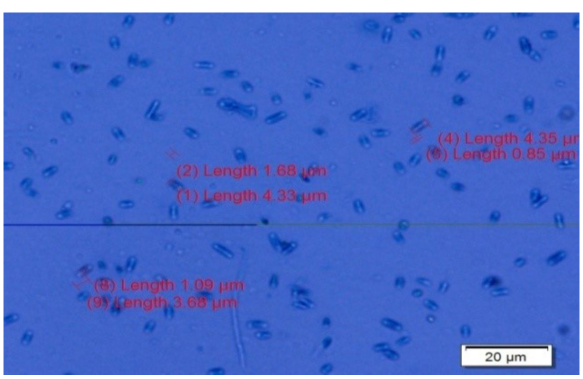


Fig. Morphological characterization sheath rot fungus isolates and Spores of sheath rot

Table: Morphological characterization of the sheath rot fungus from different regions

S. No.	Isolate	Mean Radial Growth			Colour	Type of Growth	Sporulation
		10 DAI	20 DAI	30 DAI			
1	**DRR**	2.77	6.07	7.90	White with pale orange tinge	Fluffy, circular, Irregular	****
2	**Narsipatnam**	2.90	5.40	7.57	White	Flat, circular	***
3	**Ragolu**	2.33	5.40	7.70	Pale orange	Fluffy, circular	****
4	**Rajahmundry**	3.17	6.47	7.53	White	Flat, circular	****
5	**ICRISAT**	2.37	5.57	7.40	White	Fluffy, circular	****
6	**Maruteru**	3.10	6.77	7.87	White and pale orange	Flat, circular	****
7	**Bapatla**	1.97	4.50	7.00	Pale orange	Sparse, circular	****
8	**Jagityal**	2.47	4.90	7.23	White	Fluffy, circular	****
9	**Rajendranagar farm**	2.23	5.37	7.87	White	Fluffy, circular	****
10	**Nizamabad**	2.10	5.10	7.53	White	Fluffy, circular	***
11	**Adilabad**	1.90	4.53	6.97	White	Fluffy, circular	**
12	**Nellore**	2.13	4.90	7.57	White	Sparse, circular	***
13	**Yalamanchili**	2.87	5.43	7.90	Pale white	Flat, circular	****
14	**Varanasi**	1.97	4.00	6.10	Pale orange	Flat, circular	****
15	**Patna**	2.40	5.20	7.43	White	Fluffy, circular	****
16	**Naira**	3.17	6.27	8.00	White	Fluffy, circular	****
17	**Karjat**	3.13	5.80	8.07	White	Fluffy, circular	****

Table: Growth of *Sarocladium oryzae* on different media

Media	Mean radial growth of Isolate DRR (cm)			Sporulation	Mean radial growth of Isolate Rajahmundry (cm)			Sporulation
	10th DAI	20th DAI	30th DAI		10th DAI	20th DAI	30th DAI	
PDA	**2.60**	**5.80**	**7.47**	****	**2.93**	**6.40**	**7.83**	****
CZEPOX DOX	**2.43**	**3.47**	**5.30**	**	**2.10**	**5.13**	**6.37**	**
RICHARDS	**2.03**	**5.07**	**7.17**	**	**2.53**	**5.40**	**6.80**	**
CORNMEAL	**2.37**	**3.90**	**5.77**	**	**2.17**	**4.53**	**6.10**	**
OATMEAL	**3.17**	**5.57**	**8.63**	***	**3.43**	**6.93**	**8.13**	****
CD	0.612	0.559	0.574		0.409	0.399	0.511	
SE(m)	0.185	0.169	0.173		0.123	0.12	0.154	

dai=days after inoculation

Morphological characterisation of stem rot fungus isolates from different regions of Telangana

Six isolates were collected from Telangana state and they differ significantly one from the other. They differ in sclerotia formation and place of sclerotia formation in the plate and days to form the sclerotia. The Rajendranagar isolate form the sclerotia at center of the plate and remaining isolates formed the sclerotia all over the plate and the Adilabad isolate take 7 days time to initiate the sclerotial formation and remaining isolates take 4 days to sclerotial initiation (Fig.).

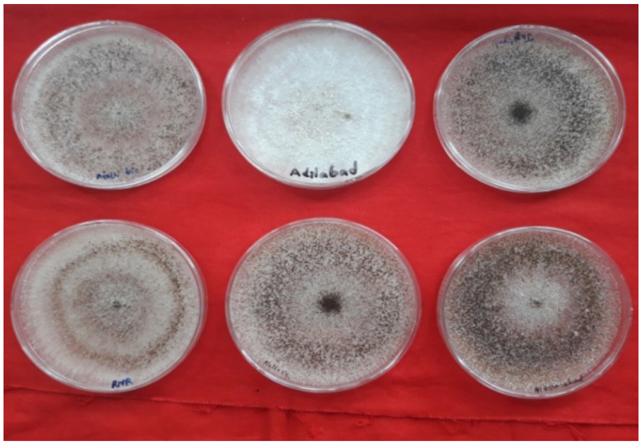


Fig.: Growth of *Sclerotium oryzae* at 6 days after inoculation

Lead Research

TTI – Training, transfer of technology and impact analysis

TTT/EXT/15: Climate change and rice farming: Farmers perception and adaptation strategies

Farmers perception and adaptation strategies on rice farming in the context of climatic change was studied in four villages viz., Aloor, Earlapalle, Ramanthpur and Govindapalle representing two mandals (Jadcherla and Kothakota) and two districts Mahaboobnagar and Wanaparthy. Based on both primary and secondary data collected from the published and field based sources, about 200 farmers representing small, medium, big and very big landholding were surveyed. The sample districts and villages were witnessing the climate change pressure tremendously for two decades and the impact was very severe on the rice farmers. The study revealed that the farmers, irrespective of the operational landholding size, experienced climate change in the last two decades (90%). Almost all the farmers expressed that they had inordinately delayed the *kharif* sowing of rice and at times cultivated dry crops in the wetland due to delay in monsoon and the depletion of ground water. As much as 40% of the farmers even witnessed terminal droughts in the *kharif* samba season (Aug-sep) leading to poor yield and at times total crop failure.

Due to severe climate change the ground water source was thoroughly exploited by the rice farmers by immersing bore wells (64%) down to 1000 feet deep which resulted in depletion of aquifers at alarming levels. Due to free electricity the farmers used the power to extract more ground water and now facing acute water crisis.

The sample farmers perceive the threat of climate change over the period of time through the prism of fluctuation in the rainfall pattern (80%), decreasing quantum of rainfall (78%), decreasing number of rainy days (74%), occurrence of drought very frequently (67%), low rice yield (43%), stunted growth of rice crop (30%), non-availability of fodder and water (29%) and some of the government interventions to provided livelihood (23%).

The prevalent adaptation measures followed by the rice farmers to mitigate the climate change related to rice farming are: 1) cultivation of early maturing varieties (78%), 2) early planting (65%), 3) migration of male members (59%), 4) direct sowing (57%), 5) usage of wells and pumps for irrigation (52%), 6) reducing the area (51%), 7) alternative crop cultivation (49%), 8) direct seeding of rice (27%), 9) agricultural insurance (18%) and 10) stoppage of farming (11%).

TTT/EXT/12: Maximizing the Impact of Rice Technologies through ICT applications

Study on Automated Pump starters

The present study was carried out in Telangana state of India to critically analyse the grass root factors that helped use of smart phone based auto starters. The study was conducted among 111 farmers from Jagatyal district of Telangana, who have currently installed and using the auto starters for irrigating their fields during 2018.

For all the farmers using auto pump starters, the perceived benefits included: relative easiness to operate/ irrigate compared to earlier, time saving, safety (personal safety, pump set safety) and the flexibility of irrigating. More than 74% of the farmers opined that remote accessibility of pump sets using the auto starters was a striking feature. Another advantage that was reported by 73% of farmers was that the technology could be operated by any family member.

Update about status of irrigation was perceived as an excellent option by 96.3% farmers. Ease in planning irrigation cycles was also seen as an added advantage by 94.5% of farmers. The ability of these pump starters to bypass into manual mode option in case of non-working of auto starter was much appreciated by the users. Update about the status of water in a tank/well without being physically there was one of the best benefits of these pump starters, as perceived by 92.7%.

Studies on Digital Startups and Marketing

A survey conducted in Telangana revealed interesting findings about the digital market interventions. More than 75% of the extension personnel were completely aware about the uses of digital marketing applications, i.e., they provide a platform to sell and buy agriculture produce from any place, easier to make price comparisons, reduce market imperfection, help in real time price discovery, price transparency and price dissemination, remove information asymmetry and provide selling options to farmers. The extension personnel were partially aware that digital marketing applications reduced time and increased the market revenue, by improving transparency in marketing system.

About the digital agricultural startups, the study revealed that overall majority (55.5%) of the extension personnel fall under medium level of awareness about the uses of digital marketing applications followed by high (24.4%) and low (20.0%) level of awareness. Perception of stakeholders about the activities of the startups was categorized into three categories based on the score obtained by the respondents. Around 57% of the respondents had high and favorable perception about the activities of the startups followed by medium (36.6%) and low perception (6.7%).

Digital Start Ups - Meta Analysis

A critical review of 32 digital start-ups was carried out to understand the functional core areas of digital services. The core areas were broadly classified into Precision Agriculture, Financial Inclusion, Data Driven Agriculture and Knowledge Sharing & Delivery. A qualitative Disruptability Index was worked out on a specific extension function based on Performance, Efficiency, Innovation, Defences (barriers to adapt). These start-ups were judged qualitatively for indicative results, not empirically. Finally, based on the desk study, current status of public EAS was given (1 for presence of similar initiative 0 for absence).

Out of 32 digital start-ups, 11 focused on precision agriculture tools, 3 focused on Financial Inclusion, 23 on Data Driven Agriculture and 12 on Knowledge Sharing & Delivery of inputs (multiple core areas). A qualitative assessment of various disruption dimensions in EAS was also worked out. Disruption ideas from digital start-ups on x axis and the scope for redesign of EAS process on y-axis is given in Figure.

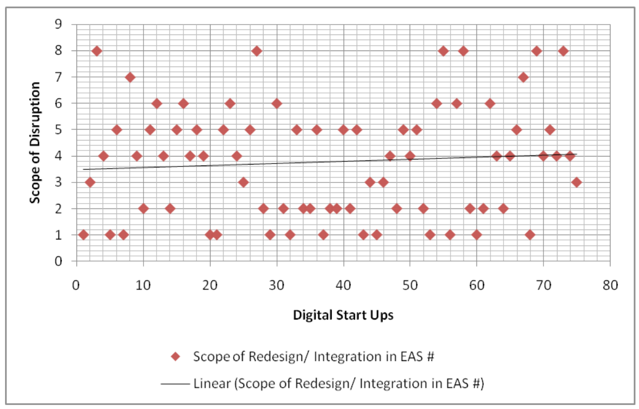


Fig. Scope of redesign/ Integration in EAS from Start ups

Legend: PA = 1, Mkt = 2, KT = 3, Acc = 4, Agg = 5, FI = 6, SN = 7, Aes = 8.

If we need to incorporate digital start-up ideas in EAS in knowledge sharing, data driven agriculture, financial inclusion and precision agriculture, Fig. will give an idea as which start-up would give best suited strategy to readily embrace. In terms of digital disruption, public sector is uniquely positioned in terms of scale, reach and data, if only proper strategies are adopted. To realise digital disruption in public EAS we need to create avenues for redesigning the extension processes (work on the frameworks not on the guidelines), stimulate new thinking (capturing innovations and start-ups within the system) and include crowd sourced extension innovations (allowing partnerships and local redesigning to certain extent).

TTT/EXT/12: Dissemination of climate resilient rice production technologies to farmers in selected Districts of Telangana State

Farmer to Farmer Extension (E2FE) methodology was employed to disseminate and demonstrate Knowledge smart, Water smart and Nutrient smart Climate Resilient practices on farmers' fields in Mootakondur and Gundala mandal of Yadadri, Bijenepally mandal of Nagarkurnool and Deverkonda mandal of Nalgonda districts in Telangana State.

SRI as a Water Smart intervention was demonstrated on farmers' fields in Pallepahad Village of Yadadri district of Telangana State during 2018 *kharif*. The average yield reported by adopting the SRI method was 6.42 t/ha as against 5.11 t/ha in farmers practice. Demonstrations on problem soil management with incorporation of paddy straw, multi variety green manure seeds and application of vermin-compost were taken up on farmers' fields which improved rice yields to an extent of 11.1 to 41.2% over check plots.

Early maturing variety, planting of improved variety and change in planting date were disseminated as knowledge smart climate resilient practices on farmer's fields. Telangana Sona variety (RNR 15048) was popularized for late sown conditions and the farmers achieved a yield advantage of 13.7% compared to check Samba Mahsuri.

Weighted average index (WAI) was employed to assess farmers perceived important adaptation strategies in rice cultivation and crop diversification (2.42), INM (2.4), green manure crops (2.38) and direct sown rice (2.05) were ranked as first, second, third and fourth respectively as important adaptation practices.

The dissemination of selected climate resilient rice production technologies on farmers' fields resulted in social learning and helped to build on the existing social learning frameworks. It resulted in capacity building, as a number of skill based training programs and demonstrations were organized to properly implement the selected climate resilient practices.

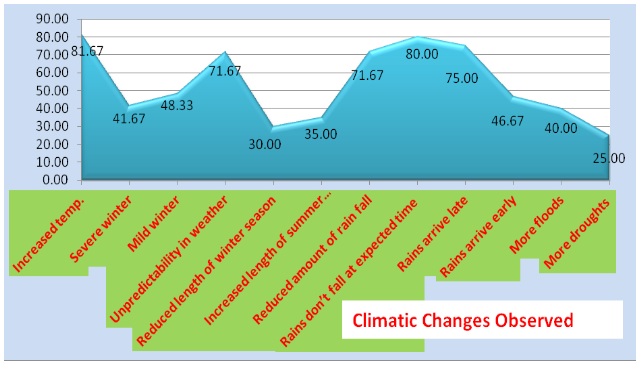


Fig: Climatic changes reported by farmers

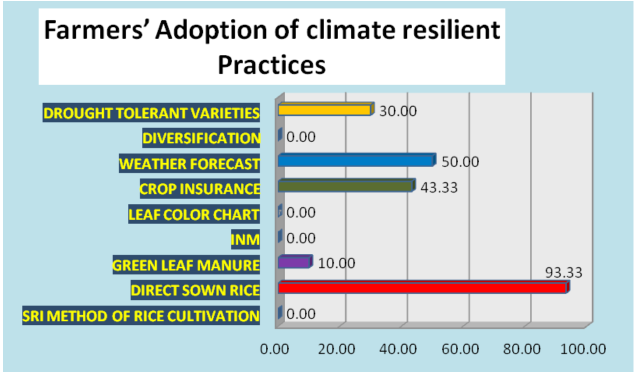


Fig: Farmers' adoption of climate resilient practices

TTT/ECON/4: Economic, Energy and Sensitivity Analysis of selected Rice production technologies

A study on the energy economics of Direct Seeded Rice (DSR) was conducted with a sample size of 250 DSR adopter farmers of Andhra Pradesh in 2018. The adoption of DSR has resulted in reducing the total cost of cultivation per hectare by 15%. The net returns obtained by the sample farmers for conventional and DSR method were Rs. 21,916/ha and Rs. 29,780 /ha respectively. The adoption of DSR ensured higher productivity with higher energy efficiency and returns. The energy use efficiency for DSR method was 7.5, while for the conventional method it was 5.8. The average energy productivity was 0.24 kg/MJ for DSR method and 0.19 kg/MJ for conventional method. The results indicated that the DSR method is more energy-efficient as compared to conventional method.

TTI/TTT/ECON/3: IPR - Competition interaction in rice seed sector – Emerging scenario-implications for enhancing quality seed use

Till the end of year 2018, 1839 rice varieties were registered for Plant Variety Protection (PVP) with PPVFRA (Protection of Plant varieties & Farmers' Rights Authority), constituting 52% of total plant varieties registered. Out of these, share of farmer's varieties, private sector varieties and public sector varieties was 83%, 7% and 10% respectively. Out of the rice varieties registered for PVP, only 74 were hybrids, 34 new hybrids and 40 extant hybrids. Out of 74 hybrids, 64 were private sector hybrids. While, in private industry rice PVP portfolio, share of hybrids was 48%, but in the case of public sector it was only 5%. As on 31-12-2018, out of the rice varieties registered for PVP, for 66 rice varieties statutory protection period was over and among them only 3 were hybrids, one private hybrid and two public hybrids.

Examination of dynamics and diversity in rice seed sector through analysis of breeder seed indent for selected years yielded the following insights. In seed indent for 2019-2020, there were 304 varieties against 113 varieties in seed indent for 2006-2007. Number of common varieties in both the indents was 55. Out of these 55 varieties, only in case of 17 varieties, quantity of seed indented for 2019-2020 was more compared to quantity of seed indented in 2006-2007. Share of top 10 varieties indented was 58 and 37 per cent in 2006-2007 and 2019-2020 seed indents respectively. Among top 10 varieties in both the indents, only 3 were common varieties. Indenter wise breeder seed analysis for 2014-2015 and 2019- 2020 was carried out. In 2014-2015 the number of varieties indented ranged from 2 to 106 varieties across different indenters. The corresponding range in 2019-2020 indent was 1 to 134.

TTI/TTT/EXT/13: Effectiveness of farmers' field school in dissemination of IPM strategies in rice

The IPM technology in rice was disseminated through selected farmers (5) in rice growing villages viz., Ankushapur, Bheemapally, Kanagarthi, Ellanthakuntha and Korapalli of Karimnagar district of Telangana. The farmers were trained at Prakasam KVK, Jammikunta in IPM technology in rice. They were advised to follow IPM strategies and given recommendations at regular intervals based on monitoring the field. These farmers further disseminated the IPM technologies to the neighbouring farmers. The study showed that farmers perceived, stem borer, plant hoppers, gall midge, bacterial leaf blight, brown spot, blast, *Echinocloa, Cyperus, Eclipta* and *Panicum* as key insect pests, diseases and weeds. The IPM strategies ranked by farmers in the order of the usage were pesticides, summer ploughing, alleyways formation, crop rotation, pheromone traps, biological control, light traps, removal of affected plants/weeds and resistant varieties.

All the farmers (both IPM trained and others) agreed that pesticides were the most important inputs for the crop protection in rice though pesticides had adverse effects on the environment. The IPM and other farmers agreed that use of pesticides varied according to the pests (100% and 40%), pests could be controlled without the use of pesticides (60% and 10%) and pesticides were the only solution to control the pest damage (40% and 75%). The IPM farmers felt that non availability of materials as the main difficulty in adoption of resistant varieties, pheromone/light traps and biological control. They also felt that cultural control, biological control and chemical control as labour intensive strategies. Whereas the other farmers mentioned lack of knowledge for non adoption of resistant varieties and pheromone traps and also felt that the resistant varieties, cultural and biological control as not effective.

TTI/TTT/EXT/14: Innovations in group based extension approaches: Accelerating rice technology transfer through farmer based organizations

Among various group based extension approaches, based on the various case studies and success stories, the Farmer Producer Organizations (FPOs) have been identified as the one of the significant approaches to accelerate the rice technology transfer and a framework is designed for accelerating rice technology transfer through farmer based organizations (Fig.).

The Malaikottai Farmer Producer Company Ltd, Lalgudi, Trichirapalli, T.N., was purposively selected for undertaking project interventions. An intervention matrix comprising of demonstrations on IIRR technologies, Seed Production of IIRR varieties, need based Information sharing (through Social media and white boards), Rice Check Meeting, Exposure visits to IIRR and other FPCs was designed based on insights from Successful FPC Cases. Two varieties – ISM and DRR Dhan 45 were demonstrated in 10 member farmer fields. Innovative evidence hub demonstrations were conducted in the year 2018-19 to accelerate the spread of 17 varieties. The evidence hubs also demonstrated the superiority of the IIRR varieties like DRR Dhan 39, DRR Dhan 42 and DRR Dhan 44 in the farmers' fields. The visiting farmers had expressed their happiness and willingness to grow these varieties.

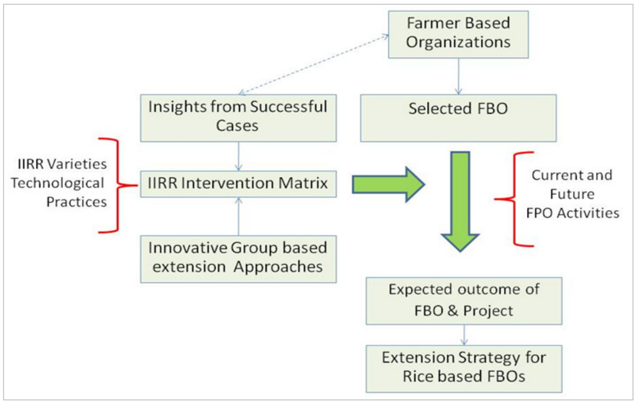


Fig: Framework for Accelerating rice technology transfer through farmer based organizations

TTI/CP/CA/4: Wireless Sensor Networks integrating with Rice DSS model for real time advisories

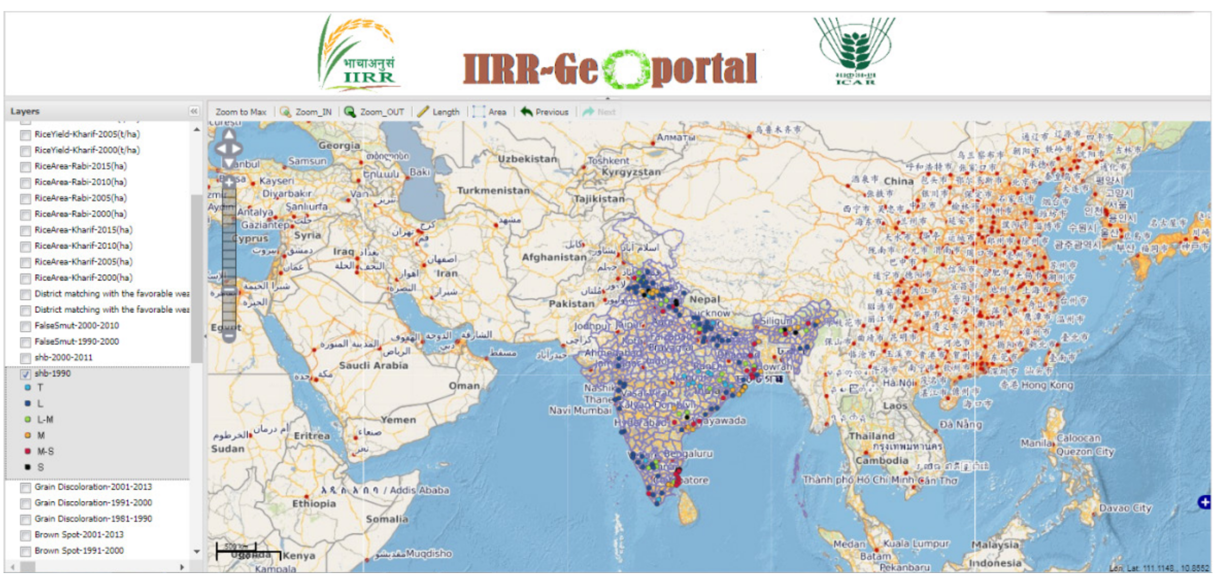
In continuation to analyzing Electronic Crop (E-Crop) model developed by ICAR-CTCRI, during this year, optimum sowing dates were estimated through Rice DSS and Mobile based Rice DSS farmer interface was developed to register farmer details, location and variety details.

Radiation and Nitrogen Use Efficiency experimental data of 2017 was used for this estimation. MTU1010 (130 days) variety was chosen and IIRR weather data of 2017 was given as input to Rice DSS. Sowing dates and seedbed duration were entered through DSS interface. Rice DSS was executed with several combinations of sowing dates (before one week and after one week from sowing date 173), seedbed duration (20 and 25), application of nitrogen (0,50 and 100 kgs) and compared the dry weights and yields and optimum crop sowing period was estimated. The combination of sowing date i.e. Julian day number 173 one week before the actual sowing date with seedbed duration 20 and application of nitrogen 100 kg gives optimum yield for MTU1010 variety for the location IIRR, Hyderabad. Mobile based Rice DSS farmer interface was developed to register farmer, location and variety details. These details will be stored in database of Rice DSS at IIRR server and other model modules will be executed and advisories will be sent to the farmers mobile in local language.

Portals and Mobile Apps

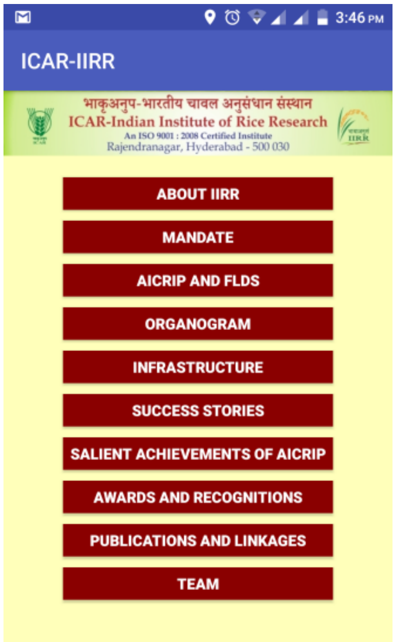
Portals- IIRR Geoportal- http://www.iirr-geoportal.in.

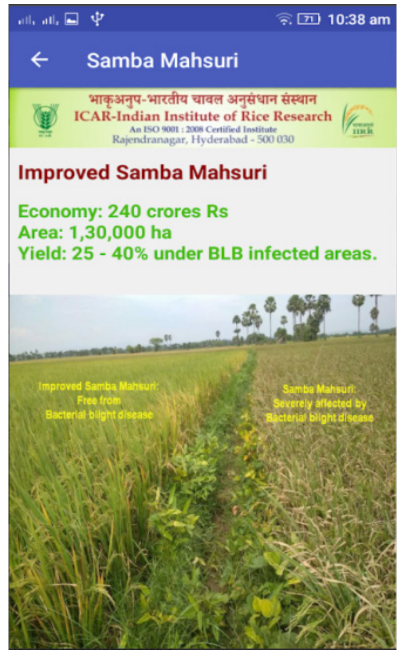
✓ IIRR geoportal was developed using open source technologies GeoServer and GeoExt. Geo-referenced maps can be easily published in this portal. Since there are many GIS based applications developed in IIRR, the entire work was effectively visualised through this portal. Initially there are few base maps, geo-referenced maps of AICRIP funded centers, Rice Area and Yield maps and Rice Pest and Disease distribution maps, rice yield map generated from SRDSS, suitable areas for hybrid seed production, heat zones identified during flowering period of rice crop, soil quality maps, agro-climatic zones maps were successfully published in this portal.



Mobile Apps

1. Developed Mobile App on "IIRR Profile" using android application and published successfully on Google Play Store and link is available in IIRR and Krishi Portal sites. This App highlights the highlights the success stories and significant achievements of IIRR. This can be downloaded and installed on all android mobiles. (https://play.google.com/store/apps/details?id=in.iirrmobapp.hava.myapp5_4_18).





2. Developed a mobile App on Rice IPM in Telugu language, demonstrated and installed successfully for 75 farmers. This is currently available in google play store https://play.google.com/store/apps/details?id=org.iirr.varipirusasyarakshana&hl=en.

Lead Research

Institutional Activities

Technologies assessed and transferred

Human Resource Development

Extension Activities

Frontline Demonstrations (FLDs)

Intellectual Property Management and Revenue generation

Awards and recognitions

Patents/Copy rights/Registrations/Mobile Apps

Deputations/Linkages and collaborations

Significant events

Personnel

Publications

Appendices

Technologies Assessed and Transferred

Transferable Technology generated.

- A new, co-dominant marker, named K 20-1-1 has been developed and validated and employed successfully for foreground selection of *Pup1* locus
- A protocol for rapid and reliable estimation of genetic purity of seed-lots of rice hybrids, parental lines and also for fingerprinting varieties and hybrids developed using functional markers and hyper-variable SSR markers.
- Breeding lines in the genetic background of Improved Samba Mahsuri, MTU1010 and IR64 possessing the major QTL associated with tolerance to low soil phosphorus, viz., *Pup1* developed and validated through AICRIP trials 2018
- Breeding lines in the genetic background of Improved Samba Mahsuri possessing the major bacterial blight resistance genes, *Xa21* + *xa13* + *xa5* and *Xa33* or *Xa38*, blast resistance genes, *Pi2* + *Pi54*, low P tolerance QTL, *Pup1* developed and validated through AICRIP trials 2018.
- Germplasm (N22 mutant) NH686 (RP Bio 5477-NH686) of rice (INGR18003) was registered by Plant Germplasm Registration Committee of ICAR on June 02, 2018. The genotype has low P tolerance trait.
- N22 mutant lines possessing useful agronomic traits like low P tolerance, PUE, and heat tolerance.
- RNAi gene constructs targeting sheath bight and tungro disease pathogens of rice.
- Line RPBio4918-228S (INGR18002) Swarna x *O. nivara* IRGC81848 derivative with multiple pest resistance including high resistance to brown plant hopper identified in AICRIP registered with NBPGR.
- Nagina 22 mutant named "Robin" (herbicide tolerant mutant) (INGR19002) registered with NBPGR by TNAU.
- Backcross introgression lines derived from cross of Swarna / *Oryza nivara* IRGC81832 (BC_2F_{10}) - 90 Lines and MTU1010 / *Oryza rufipogon* IC309814 (BC_4F_4)-306 lines were registered with National Biodiversity Authority to share with JIRCAS, Japan under MTA and these were deposited in the National repository of ICAR- NBPGR during 2018-2019.
- 21 elite lines developed in NP Project were nominated in different AICRIP trials in 2018. Three introgression lines from KMR3/*O. rufipogon* were promoted to next year of testing. IET27641[RP Bio 4919-377-24] was promoted to AVT-1 Late trial and IET 27838 [RP Bio 4919-7] and IET28070 [RP Bio 4919-13-7] were promoted to AVT-1 CSTVT.
- AWD method was tested and popularized under water scarcity condition especially in Borewell irrigated Telangana State.
- DSR yields can be improved with iron coating (under Farmer field trials).
- Released and Popularised Nutrient Expert for Rice (IPNI) for site specific nitrogen management for enhancing the Nitrogen Use Efficiency (IPNI – Agronomy and Soil Science).
- Improved Package of Practices for Aerobic Rice cultivation and Sprinkler irrigation as water source for Aerobic rice cultivation were Successfully demonstrated in Farmers fields at Nandaram Village, Vikarabad, Telangana during 2016, 2017, 2018. Refined as partially aerobic system for suitable areas in tail end areas of Canal Irrigation in Kurnool District, Andhra Pradesh.

Human Resource Development

During the year 2018-19, three training programs were organized on various aspects of Rice Production technologies, through which 67 participants were trained. IIRR also conducted eight one day training programmes for the farmers on various need based topics like importance of quality seed, Quality Seed Production, Integrated weed management, preparation and use of Bio-fertilisers, Rice based cropping system and totally 388 farmers were trained.

S. No.	Training Title	Training Duration	Sponsored by	Number of Participants
1	Certified Farm Advisor Program	24th September to 8th October, 2018	MANAGE, Hyderabad	17
2	Rice production technology	6- 9 August 2018	ATMA, Valsad	25
3	Quality Seed Growers for the unemployed youth/farmers	6th February to 3rd March, 2019	ASCI, Hyderabad	25

IIRR also conducted eight one day training programmes for the farmers on various need based topics like importance of quality seed, Quality Seed Production, Integrated weed management, preparation and use of Bio-fertilisers, Rice based cropping system and totally 388 farmers were trained.

Trainings organized

S. No.	Title of the training programme	Duration & Venue	Sponsored by	Participants
1	A training program on 'Rice Production Technologies'	1st October, 2018 Valsad district of Gujarat (43 farmers).	ATMA, Valsad	43
2	Awareness program on the "Importance of quality seed" to Tribal farmers.	8th June, 2018, at Deverakonda, Nalgonda district, Telangana.	ICAR-IIRR, Hyderabad.	56
3	Training program on 'Quality Seed Production'	26th July, 2018 at Hardaspally, Yadadri Bhuvanagiri district, Telangana	ICAR-IIRR, Hyderabad.	43
4	Off-campus training program on 'Integrated weed management'	31st July, 2018 at Deverakonda, Nalgonda district, Telangana	ICAR-IIRR, Hyderabad.	21
5	Training program on 'Preparation and use of Bio-fertilisers' for tribal farmers.	18th August, 2018, at Deverakonda, Nalgonda district, Telangana.	ICAR-IIRR, Hyderabad.	51

6	Off-campus training program on 'Quality Seed production'	6th September, 2018, at Gummakonda village, Nagarkurnool district, Telangana.	ICAR-IIRR, Hyderabad.	38
7	Training program on 'Rice based cropping system'	7th February 2019 at Deverakonda, Telangana.	ICAR-IIRR, Hyderabad.	60
8	Visit cum Training for Farmers of Sanga Reddy, Telangana.	8th January 2019 at ICAR-IIRR, Hyderabad.	ICAR-IIRR, Hyderabad.	76

Trainings attended

S. No.	Name of the Scientist	Name of the training/ workshop participated	Venue & Date
1	Dr. P. Revathi	2nd International Workshop & Training on Advanced R & R-QTL	Dec 3rd to 7th, 2018, ICRISAT, Patancheru, Hyderabad
2	Dr. B. Sreedevi	Training on 'Information and Communication Technologies for Empowering Farm Women'	February 1-6, 2019 at ICAR-NAARM, Hyderabad
3	Dr. B. Sailaja	DST sponsored training program on 'Integrated Nutrient Management and Nutrient Budgeting through Advanced Models to improve Crop Productivity'	October 22-26, 2018 at ICAR- Indian Institute of Soil and Water Conservation, Udhagamandalam, T.N.
4	Dr. P.A. Lakshmi Prasanna	Intellectual Property Valuation and Technology Management	August 24-29th, 2018 at ICAR-NAARM, Hyderabad
5	Dr. P.A. Lakshmi Prasanna	Socio-Economic Impact Assessment of Research Programs	October 25-27th, 2018 at ICAR-NAARM, Hyderabad
6	Dr. S. Arun Kumar	Winter School training programme on: ICT Interventions for Agricultural Development	Nov 28th – Dec 18th, 2018 at ICAR-NAARM, Hyderabad
7	Dr. P.A. Lakshmi Prasanna	Workshop on preparation of EFC/SFC	March 11-13th, 2019 ISTM, New Delhi
8	Mr. U. Chaitanya	Workshop on preparation of EFC/SFC	March 11-13th, 2019 ISTM, New Delhi

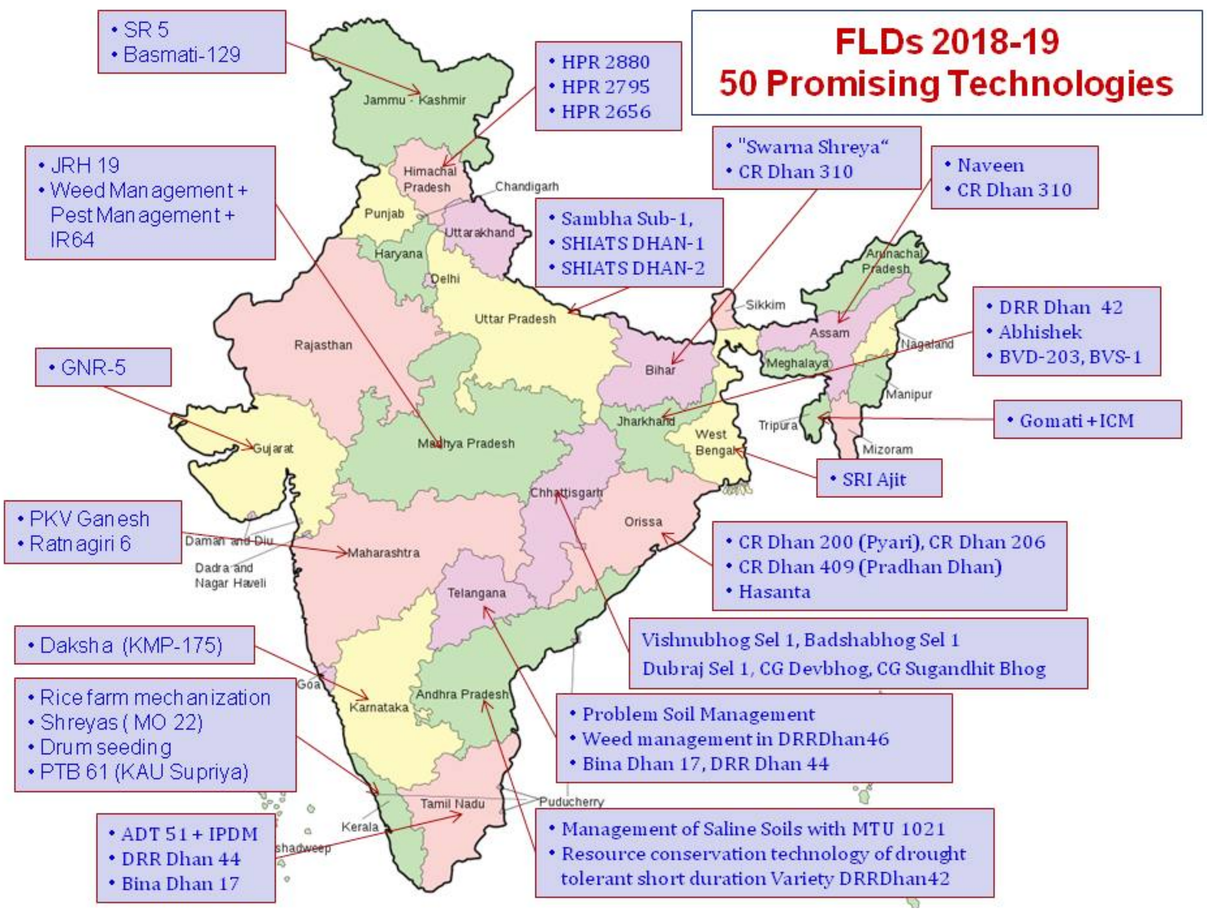
Extension Activities

Frontline Demonstrations (FLDs)

During the year 2018-19, a cafeteria of rice technologies were demonstrated in 870 hectare area covering 18 states and five major rice ecosystems of the country. FLDs organized during the year was effective in creating the awareness about the potential of new rice varieties, hybrids and other management technologies. In majority of the cases the yield advantages recorded by the FLD technologies were significant.

Out of 870 FLDs reported, about 67.6% were conducted in irrigated rice ecosystem; 6.9% in rainfed uplands; 16.9% in shallow lowlands and 6.3% in hill ecologies. The summary statement reveals that the mean yield advantage was the highest in rainfed ecologies (37.28%). There is a tremendous scope to bridge the yield gaps (particularly Yield gap-II) in case of rainfed uplands, irrigated ecologies (18.03%) and Shallow lowlands (18.43%). For this, proper extension strategies need to be deployed for large scale adoption of these technologies. FLD technologies demonstrated in irrigated ecosystems recorded mean yield of 5.63 t/ha whereas shallow lowlands recorded an average yield of 5.01 t/ha. Average demonstration yields in rainfed uplands was 4.52 t/ha.

In total 50 technologies have been identified from 18 states. These technologies will help either in withstanding abiotic stresses (such as submergence - Samba Sub-1), improving the field productivity (Naveen, Swarna Shreya, JRH-5, Shiats Dhan -1), solving the local problems (Problem soil management, Indira Aerobic-1), labour scarcity (Demonstrations of Paddy Thresher, mechanical transplanting), early harvest for facilitating *rabi* crops (CO 51 and Sahbhagi dhan), better basmati options for farmers (Pusa 1509 and Basmati 564), consumer preferences (RC Maniphou-13, RNR 15048, Gangavathi Sona), replacing the popular varieties (CO 51, Tripura Chikan Dhan, CR Dhan 909).



Seed & Farmers' Day

IIRR organized 'Seed and Farmers Day' on 3rd Nov, 2018. About 500 farmers from Andhra Pradesh, Telangana and Karnataka states participated in the event. Technologies developed by IIRR including 52 high yielding rice varieties, rice germplasm, mechanised transplanting, INM and IPM technologies, various crop establishment methods along with water saving techniques were displayed and explained to the farmers.

Tribal Sub-Plan activities

Under the Tribal sub-plan, a total of 200 farm households from the two districts viz., Mahabubnagar and Ranga Reddy were supported with improved rice production technologies to enhance their livelihood. The technological interventions undertaken were the introduction of improved rice varieties like Improved Samba Mahsuri and DRR Dhan 45. The package of practices in local language was printed and distributed to the target farmers. Two on-farm training programs were also organized to educate the farmers. The critical inputs hitherto the tribal farmers were not using were distributed to them viz., Zinc sulfate, neem cake, insecticides, botanical pesticides, tarpaulins and soil test based nutrient management. Due to the interventions, yield increase was observed to the level of 8-13% with minimum cost of cultivation. Increased awareness about the improved and cost effective rice production practices and adoption of technologies were also observed.

Blightout Program

Under the 'blightout' programme, jointly implemented by ICAR-IIRR and CSIR-CCMB, seeds of Improved Samba Mahsuri were sent to the states of Andhra Pradesh, Chhattisgarh, Karnataka, Tamil Nadu, Telangana and Uttar Pradesh. Overall, 3200 demonstrations were conducted in the BLB endemic areas. In case of Tamil Nadu, the state Department of Agriculture was involved to popularize this resistant variety covering the districts of Kaur, Thanjavur and Trichy. The extension information were proved in the form of video films and information brochure in Tamil, English, Telugu and Hindi languages. In Kakinada, A.P., Farmers Day was organized. In the states of Andhra Pradesh, Telangana, Chhattisgarh, Karnataka and Tamil Nadu the program was implemented through the State Department of Agriculture and AICRIP centers and yield increase was observed to the extent of 20-23%.

SC Sub Plan

During 2018-19, 670 SC farmers of Telangana were given paddy seeds. The productivity of rice was expected to increase with the adoption of quality seeds, one of the most crucial inputs of rice production. Training programmes were also organised to SC farmers through various KVKs in Tamil Nadu, AP and Telangana.

Media Coordination

Overall, 20 radio talks and 10 television talks on various rice production technologies were delivered by the IIRR scientists through AIR, and Doordarshan Kendra, Hyderabad.

Visitors' Services

During the year 2018-19, about 4540 visitors comprising students, farmers, extension officials, executives from private input agencies, foreigners, policy makers and scientists visited IIRR and were acquainted with the ongoing activities and achievement of IIRR.

Exhibition of IIRR Technologies at Various Events

IIRR Participated in the farmers day organized by IIOR, IIMR, NRRI, Cuttack by installing exhibition stalls on rice production technologies.

Intellectual Property Management and Transfer/Commercialization of agricultural technology Scheme

During 2018-19, More than 100 entries of seed was provided to various institutes and private companies through MTA. Several applications for germplasm registration were screened and certified by ITMU members for soft registration with NBPGR, New Delhi. As an authorized institute, IIRR received several import permit applications which were scrutinized and forwarded to NBPGR and EXIM committees for processing.

Revenue Generation

An amount of **Rs. 1,84,40,489.00** was received through testing of varieties and hybrids, contractual services for the evaluation of breeding lines for quality, diseases, insects and also assessing the efficacy of new molecules/chemicals.

Revolving Fund

IIRR is actively involved in production of quality seed in research farms and farmers' fields and supplying it to Pvt. Seed companies, Govt. seed agencies and also to farmers earning huge revenue. A profit of Rs. 13,15,294 was generated for the financial year 2018-19.

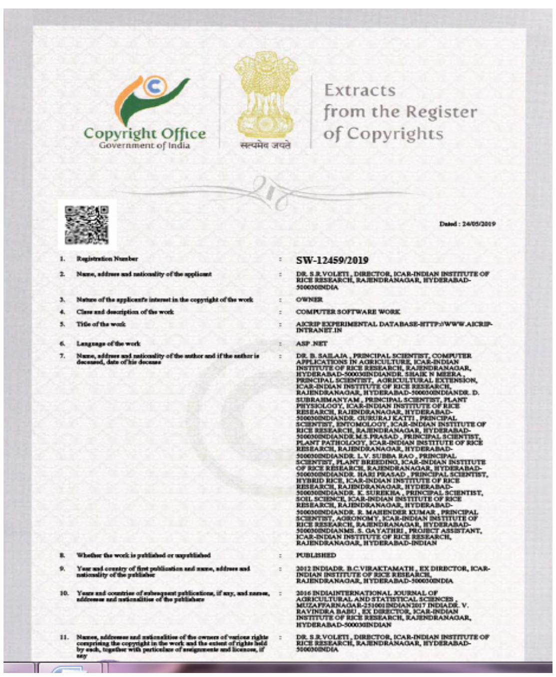
Awards and Recognitions

- Dr. A.P. Padmakumari has been elected as Life Fellow of Entomological Society of India, New Delhi.
- Dr. B. Sreedevi received Outstanding Scientist Award 2018 by The Society of Tropical Agriculture at 7th International Conference on Agriculture, Horticulture and Plant Sciences 28-29 June, 2018 at Shimla, Himachal Pradesh India.
- Dr. Brajendra received a Certificate of appreciation by UNFAO, Rome, Italy, Certificate of appreciation as Outstanding Contribution Scientist award in recognition of his exceptional contribution to the work of the Global Soil Partnership and serving in the international Technical Panel on Soils for the term June, 2015 to June, 2018, Soil Conservation GSP,UNFAO Rome, Italy,
- Dr. Brajendra was awarded by the two Chinese Government departments: Beijing Soil and Fertilizer Extension Service and Beijing Municipal Bureau of Agriculture, during Asian Soil Partnership Meetings & the International Symposium on Soil Health held from 24th to 27th May, 2018, at National Convention Centre, Beijing, China.
- Dr. R.M. Sundaram elected and inducted as Fellow, Indian Society of Genetics and Plant Breeding, New Delhi.
- Dr. R.M. Sundaram elected as Executive Council Member- Federation of Asian Biotech Associations (2019)
- Dr. R.M. Sundaram elected as Vice-President, Association of Rice Research Workers, India (2019 onward)
- Dr. R.M. Sundaram nominated as Treasurer, Hyderabad Regional Chapter of National Academy of Agricultural Sciences (2018 onwards)
- Dr. R.M. Sundaram selected as Member, EDV Committee of PPV & FRA (since Nov. 2018 onwards)
- Dr. R.M. Sundaram selected Team Member/ Expert, Crop group (Rice) for developing DNA fingerprinting protocol constituted by ICAR (2018 onward)

- Dr. R.M. Sundaram was elected and inducted as a Fellow, National Academy of Agricultural Sciences (2019)
- Dr. Satendra Kumar Mangrauthia received Publons Peer Review Awards 2018 for placing in the top 1% of reviewers in plant and animal sciences.
- Dr. Satendra Kumar Mangrauthia received the ICAR Lal Bahadur Outstanding Young Scientist Award.

Patents/Copy rights/Registrations/Mobile Apps

- Indian Patent (No. 285360) has been granted to ICAR for our invention entitled" Preparation and Method of processing Aloe Candy from Aloe species on 19/07/2017. Inventors: Azam MM & Meghwal PR
- Indian Patent (No. 290217) has been granted to ICAR for our invention entitled "A novel method for isolating Aloin by extraction from yellow sap of Aloe vera" on 04/12/2017. Inventor: Azam MM.
- One copyright has been received – SW-12459/2019- AICRIP Experimental Database (http:// www. icrip-intranet.in)


Copyright Office
Government of India
सत्यमेव जयते
Extracts from the Register of Copyrights

Dated : 24/05/2019

1.	Registration Number	:	SW-12459/2019
2.	Name, address and nationality of the applicant	:	DR. S.R.VOLETI , DIRECTOR, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIA
3.	Nature of the applicant's interest in the copyright of the work	:	OWNER
4.	Class and description of the work	:	COMPUTER SOFTWARE WORK
5.	Title of the work	:	AICRIP EXPERIMENTAL DATABASE-HTTP://WWW.AICRIP-INTRANET.IN
6.	Language of the work	:	ASP .NET
7.	Name, address and nationality of the author and if the author is deceased, date of his decease	:	DR. B. SAILAJA , PRINCIPAL SCIENTIST, COMPUTER APPLICATIONS IN AGRICULTURE, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANDR. SHAIK N MEERA , PRINCIPAL SCIENTIST, AGRICULTURAL EXTENSION, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANDR. D. SUBRAHMANYAM , PRINCIPAL SCIENTIST, PLANT PHYSIOLOGY, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANDR. GURURAJ KATTI , PRINCIPAL SCIENTIST, ENTOMOLOGY, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANDR.M.S.PRASAD , PRINCIPAL SCIENTIST, PLANT PATHOLOGY, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANDR. L.V. SUBBA RAO , PRINCIPAL SCIENTIST, PLANT BREEDING, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANDR. HARI PRASAD , PRINCIPAL SCIENTIST, HYBRID RICE, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANDR. K. SUREKHA , PRINCIPAL SCIENTIST, SOIL SCIENCE, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANDR. R. MAHENDER KUMAR , PRINCIPAL SCIENTIST, AGRONOMY, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIANMS. S. GAYATHRI , PROJECT ASSISTANT, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-INDIAN
8.	Whether the work is published or unpublished	:	PUBLISHED
9.	Year and country of first publication and name, address and nationality of the publisher	:	2012 INDIADR. B.C.VIRAKTAMATH , EX DIRECTOR, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIA
10.	Years and countries of subsequent publications, if any, and names, addresses and nationalities of the publishers	:	2016 INDIAINTERNATIONAL JOURNAL OF AGRICULTURAL AND STATISTICAL SCIENCES , MUZAFFARNAGAR-251001INDIAN2017 INDIADR. V. RAVINDRA BABU , EX DIRECTOR, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIAN
11.	Names, addresses and nationalities of the owners of various rights comprising the copyright in the work and the extent of rights held by each, together with particulars of assignments and licenses, if any	:	DR. S.R.VOLETI , DIRECTOR, ICAR-INDIAN INSTITUTE OF RICE RESEARCH, RAJENDRANAGAR, HYDERABAD-500030INDIA

- IIRR geoportal was developed using open source technologies GeoServer and GeoExt. (***http://www.iirr-geoportal.in.).***
- Developed Mobile App on "IIRR Profile" using android application and published successfully on Google Play Store and link is available in IIRR and Krishi Portal sites. This App highlights the highlights the success stories and significant achievements of IIRR. This can be downloaded and installed on all android mobiles. (https://play.google.com/store/apps/details?id=in.iirrmobapp.hava.myapp5_4_18).
- Developed a mobile App on Rice IPM in Telugu language, demonstrated and installed successfully for 75 farmers. This is currently available in google play storehttps://play.google.com/store/apps/details?id=org.iirr.varipirusasyarakshana&hl=en.
- Developed blast and bacterial blight disease resistance rice variety RP Bio Patho-2 of Rice (INGR18001) identified as germplasm by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research on June 02, 2018.
- Two rice blast disease resistant germplasm lines i.e., IC No. 121865 and IC No. 199562 proposed for Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research.

Deputations

- Dr. Amtul Waris presented paper at the 5th International Rice Congress 2018 (IRC2018), Organised by IRRI, Philippines, 14-17 October 2018 at Marina Sands Bay, Singapore.
- Dr. B. Sailaja presented a paper on "Wireless Sensor based Decision Support System for Rice Crop Management" in the "3rd International Conference on Food & Agriculture" during November 26-28, 2018.
- Dr. B. Sailaja, participated and presented a paper on "Wireless Sensor based Decision

Support System for Rice Crop Management" in the "3rd International Conference on Food & Agriculture" during November 26-28, 2018 at Kuala Lumpur, Malaysia.

- Dr. C.N. Neeraja visited University of Aberdeen, Scotland, UK as Senior Research Fellow Under Nitrogen Efficiency of Whole-Cropping Systems (NEWS India-UK), DBT - BBSRC Project, during the period April 23 to May 22, 2018. She did work on the topic: "Genetic mapping of rice – GWAS".
- Dr. Chitra Shanker attended the 5th International Rice Congress – Singapore, 15 to 17th October 2018 (IRC 2018) and presented a paper on Ecological engineering.
- Dr. D. Krishnaveni participated and presented a paper in 3rd International Conference on Food and Agriculture Organized by Universiti Putra Malaysia, Selangor, Kuala Lumpur and Endling Conferences Pvt. Ltd, from November 26-28th, 2018.
- Dr. Divya Balakrishnan attended 5th International Rice Congress (IRC2018), Singapore organized by International Rice Research Institute (IRRI), during 15-17, Oct. 2018.
- Dr. Divya Balakrishnan received INSA_DST_JSPS post-doctoral fellowship under Indo-Japanese Joint Project on "Establishment of Young Researcher Fellowship Program 2018-2019" to work at JIRCAS, Okinawa Jan 28-July 28, 2019.
- Dr. G Padmavathi attended 3rd International Conference on Food & Agriculture held during 26th to 28th November at Malaysia.
- Dr. L V Subba Rao and Dr. Jyothi Badri participated in International Rice Congress (IRC 2018) organized by IRRI at Marina Bay Sands, Singapore during 15-17 Oct, 2018.
- Dr. M. Mohibbe Azam was deputed to Queen's University, Belfast, United Kingdom for participation in "Fingerprinting Rice: Implementing a system to Monitor and Manage Food Fraud Training and workshop" for a period of 12 days with effect from January 29, 2018- February 09, 2018.
- Dr. M.N. Arun attended and presented a paper as invited Lead Speaker at the conference "Annual Congress on Plant Science and Bio Security" with the theme "A Legislative Framework of Science Protecting Plant Health" in the session "Plant and Climate Change – Overcoming Measures" held at Valencia, SPAIN from July 12th to July 14th 2018.

- Dr. R. Mahender Kumar visited University of Edinburgh (Prof. Saran Sohi) for working on Biochar and its utilization for enhancing the Rice productivity (April-May 2018).
- Dr. Satendra K Mangrauthia was invited as keynote speaker and delivered a talk on "Molecular basis of high temperature stress tolerance in rice to develop climate smart genotypes" in 3rd International Conference on Food and Agriculture held at Universiti Putra Malaysia, 26-28 November 2018.
- Dr. Satendra Kumar Mangrauthia visited to Heinrich Heine University, Dusseldorf, Germany (March 30th – June 28, 2019) for international training under the ICAR Lal Bahadur Outstanding Young Scientist Award Project.
- Dr. Shaik N. Meera participation in 5th International Rice Congress, Singapore and

presented paper on "Tipping Point in Digital Extension Advisory Systems: Empirical Evidences from Indian Digital Pilots", 14-17 October 2018.

- Dr. Shaik N. Meera, attended GSR Conclusion meeting organized by IRRI, Philippines in collaboration with Chinese Academy of Agricultural Sciences, Beijing, China. 1-3 April 2018.
- Dr. Surekha visited University of Aberdeen, Scotland, UK as Senior Research Fellow Under Nitrogen Efficiency of Whole-Cropping Systems (NEWS India-UK) Project, during the period April 25th to May 25th, 2018. She did work on the topic: "A systematic analysis on Agronomic and Environmental benefits of Neem Coated Urea."
- Dr. V. Jhansi Lakshmi, participated and presented a paper on "Bioclimatic Thresholds and Thermal Constants for the development of the Indian Population of Rice Brown Planthopper, *Nilaparvatalugens* (Stål) (Hemiptera: Delphacidae) at the 3rd International Conference on Food and Agriculture during November 26-28, 2018, at Kaula Lumpur Malaysia.
- Dr. V. Prakasam participated and presented a paper on "Significance of rice sheath blight in India and its management through host plant resistance/tolerance" in International conference on "Role of soil and plant health in achieving sustainable development goals" at Bangkok, Thailand during 21-25 November, 2018.

Externally funded projects

Four new externally funded projects have been sanctioned during 2018-19 (Appendix 5) with a budget outlay of 200 lakhs. A total of 58 externally funded projects are currently being handled at the Institute (Appendix 6) with an approximate budget of Rs. 2727 lakhs.

Significant Events

Institute Research Council Meeting organized

Institute Research Council (IRC) Meeting was held during 4-7th June 2018. ICAR-IIRR Director, Dr.S R Voleti chaired the meeting. In the meeting all the Scientists of IIRR made presentations about research work carried out during 2017-18 under various projects approved by the Institute. Eight new projects were approved in the meeting.

International Day of Yoga'

International Day of Yoga' was celebrated at ICAR-IIRR on 21 June 2018. On this occasion, Dr. G. Katti, Director In-charge welcomed the chief guest Smt. N. A. Laxmi, a yoga expert and in his opening remarks highlighted the role of yoga in improving professional and personnel development of staff.

Hindi Week Celebrations

As part of official language programs "Hindi Karyashala" was conducted on 30th June 2018 with good participation from administrative staff. A month long event "Hindi Chetanamass" was celebrated at the Institute during 14th September to 12th October 2018. Various events and competitions were organised during the month to motivate the staff to adopt Hindi in official work as well as research purposes. Dr. S R Voleti, Director of the Institute distributed trophies, certificates and cash awards to the winners of various competitions.

Swacch *Pakhwada*

As a part of the Swachh Bharat Mission, *Swacchata Pakhwada* was observed at the institute from 15th September- 2nd October, 2018. The staff voluntarily undertook various activities such as cleaning the institute premises and R C Puram farm. As a part of the programme various competitions were held to school children and on the closing day prizes were distributed to the winners. Staff, who contributed towards the maintenance and cleanliness of the institute, were also awarded.

Rashtriya Ekta Diwas (National Unity Day)

NATIONAL UNITY DAY Celebrations were organized on 31.10.2018 to commemorate the 143rd birth anniversary of the Iron Man of India Sri Sardar Vallabh bhai Patel the Rashtriya Ekta Diwas was celebrated at IIRR on 31stOctober, 2018. The staff of IIRR assembled in large number at 11.00 a.m. in the morning to take the pledge. Mr. B. Sathish, SAO, IIRR informed the staff about the sanctity of the day outlining the importance of objective of making IIRR united, united with its uniqueness in religion, language and culture and in turn to help the country stand united. The speech was followed by the Rashtriya Ekta Pledge which was administered by Dr. S.R. Voleti, Director (A) and the pledge was taken in English & Hindi.

Quinquennial Review Teams (QRT meeting:

The Indian Council of Agricultural Research (ICAR), New Delhi constituted QRT of IIRR vide Order FNo. CS/16/06/2011-IA-IV dated October 16, 2018 to review the research work done by the IIRR and Centres of AICRP-Rice during the five year period from 2012-13 to 2017-18 under the chairmanship of Dr HS Gupta, Formerly Director General, Borlaug Institute for South Asia (BISA) and other members.

Dr HS Gupta: Former Director General, Borlaug Institute for South Asia (BISA)	**Chairman**
Dr JL Dwivedi: Former Professor and Head (Plant Breeding), ND University of Agricultural Science and Technology	
Dr Somaresh Kundu: Principal Scientist and Head, Division of Environmental Soil Science, Indian Institute of Soil Science, Bhopal	**Member**
Dr R. Sridhar: Former Principal Scientist and Head (Plant Pathology), National Rice Research Institute (formerly CRRI)	

Dr PS Birthal: National Professor, National Institute of Agricultural Economics and Policy Research New Delhi-110012	**Member**
Prof TVK Singh: Former Dean of Agriculture, PJTSAU and ANGRAU	
Dr LV Subba Rao: Principal Scientist and Head (Plant Breeding) ICAR-IIRR, Hyderabad	**Member Secretary**

Five QRT meetings are held in different zones to review the progress of ICAR-IIRR and AICRIP funded centres. Committee appreciated the efforts of IIRR scientists in addressing most of the issues with good progress.

ICAR-IIRR	27th-28th Nov, 2018. IIRR Hyderabad
North East	10-11th Dec, 2018 Upper Shillong
Central zone	7-8th Jan, 2019 at Raipur
Southern Zone	28-30th January, 2019 at Bangalore
Hill Zone	14-15th Feb, 2019 at Shalimar, J & K

Vigilance awareness week

Vigilance Week was observed at this Institute during 29th October to 3rd November, 2018. On this occasion, the Director (A) administered oath to all the staff on the vigilance awareness. An essay and poster competitions were organized on the occasion. Prizes were distributed to the winners.

Sports Meet-Medals' galore

- IIRR staff performance in Sports was commendable. Dr. K. Surekha and Dr. G. Padmavathi won gold medal in Table Tennis (Women-doubles) during ICAR Inter-zonal sports meet-2017 held from 21st April - 25th April, 2018 at ICAR-NAARM.

Launching of Pradhanmantri Kisan Samman Nidhi

Launching of 'Pradhanmantri Kisan Samman Nidhi' a programme was organised at ICAR-IIRR on 24 February, 2019. Hon'ble Member of Parliament, Shri. Bandaru Dattatreya graced the occasion. Dr. Ch. Srinivasa Rao. Director, NAARM; Dr. A. Vishnuvardhan Reddy, Director, IIOR; Dr. Y. G. Prasad, Director, ATARI; Dr. Ravindra Chary, Director (A), CRIDA; Dr. R. N. Chatterjee, Director, DPR; Dr. S. Vaithiyanathan, Director, NRC on Meat; Dr. R. Jagadeeswar, Director of Research, PJTSAU and Dr. P. Ananda Kumar, Emeritus Scientist, IIRR also present on the occasion. Dr. S.R. Voleti (Director-Acting, IIRR) welcomed the guests. Hon'ble member of the Parliament spoke about the salient features of the scheme and felicitated the progressive farmers in recognition of their services. Scientific fraternity of Hyderabad and farmers attended the programme in large numbers.

Inauguration of Women's Cell

On 1 January 2019, 'Women's Cell was inaugurated at ICAR-IIRR for the benefit of women staff of the Institute. Essential facilities for women staff shall be provided in the cell.

Smart Rice Hackathon (SRH 2019) on artificial intelligence module for Rice Pest Detection

Smart Rice Hackathon 2019 (24 hours continuous) has been organised at ICAR-Indian Institute of Rice Research during 9-10th February 2019 in connection with National Science Day. This was the First Hackathon in ICAR involving engineering students for developing IT based solutions to farmers using Artificial Intelligence. The problem statement was "Mobile based AI module for rice pest detection". Totally eleven abstracts were received and five teams comprising of 4 students and one mentor each were shortlisted for participating in the Hackathon.

National Science Day celebrations at ICAR-IIRR

National Science Day was celebrated at ICAR – Indian Institute of Rice Research, Rajendranagar, Hyderabad on 28th February 2019. Sixty students from local engineering colleges along with mentors and 20 scientists from IIRR participated in the science day celebrations. The chief guest, Dr. S. K. Soam, Joint Director (Acting), NAARM, Hyderabad delivered a special lecture on "Artificial Intelligence in Agriculture". He elaborated on potential areas for development of AI based applications in Agriculture. He emphasised the need to focus on image analysis based applications and block chain technologies. The awards for winning teams in "Smart Rice Hackathon" were distributed on this occasion.

International women's day celebrated

International Women's Day was celebrated on March 8, 2019 by ICAR-IIRR on March 8, 2019 at the Institute. The theme for International Women's Day, 'Think Equal, Build Smart, Innovate for Change', puts innovation by women at the heart of efforts to achieve gender equality. Speaking on the occasion the Director (A), Dr. S.R. Voleti appreciated and highlighted the significant contribution of all the women personnel of the institute representing the scientific, technical, administrative and supporting farm staff cadre. The need for celebrating women's achievements, raising awareness against bias and committed action for equality for a better and balanced world was stressed upon.

As a special feature the work of women scientists was highlighted on 'Jaikisan' program of ETV channel for farmers. The strength and power of mentoring, coaching for collective growth of women was reiterated upon by Dr. Amtul Waris, the coordinator of the Women's Day celebrations.

Pre-Rice Group Meeting for hill Region

The 6th Annual Hill Rice Research Group Meeting" was held on 16th February, 2019 at SKUAST, Srinagar. It was organized by Indian Institute of Rice Research (ICAR), Hyderabad in collaboration with AICRP (Rice) group of SKUAST. On the behalf of Hon'ble Vice-Chancellor and as the Director Research of the SKUASTKashmir, Prof. M.Y Zargar welcomed the participants of the workshop. In his opening remarks, the worthy Director expressed the scope of hill rice in the context of its potential to improve economic and livelihoods of the marginal/ tribal farmers under hill rice ecology. He also briefed about the role and potential of "All India Coordinated Rice Improvement Programme (AICRIP)", its widespread impact on the regional and niche specific varietal adaptation in different hill zones. The technical session was formally started by Dr. L.V. Suba Rao (Principal Scientist & Head, Plant Breeding, ICAR-IIRR Hyderabad), who presented the consolidated progress report on varietal development under Hill trials conducted during 2018-19.

54th Annual Rice Research Group Meetings

54th Annual Rice Group Meeting (ARGM) took place during 30th May, 2019 to 2nd June, 2019 at ICAR-National Rice Research Institute, Cuttack. Discipline wise group meetings with cooperators were conducted on 30th May, 2019. The results of the AICRIP trials conducted during *Kharif* 2018 were discussed and finalized the technical program for ensuing *Kharif* on 1st June, 2019. In the inaugural session on May 31st, 2019, Dr. Himanshu Pathak, Director, ICAR-NRRI mentioned about genesis of AICRIP and its contribution towards the service of farming community despite the plethora of challenges of climate change, low income and other issues. Dr. S.R. Voleti, Director, ICAR-IIRR briefly presented the research highlights of AICRIP and IIRR. He thanked the support and cooperation of all the members of AICRIP who contributed to the success of AICRIP for more than five decades. Several publications were released on the occasion. In the 3 day group meetings Scientists across the disciplines deliberated on the results of the trials and proceedings were brought out

Personnel

Scientific Staff

Name	Designation
Dr. S.R. Voleti	Director (A)
Plant Breeding	
Dr. L.V. Subba Rao	Principal Scientist
Dr. G. Padmavathi	Principal Scientist
Dr. Aravind. J	Sr. Scientist
Dr. Gireesh. C	Scientist
Dr. Suneetha Kota	Scientist
Dr. R. Abdul Fiyaz	Scientist
Dr. Jyoth Badri	Scientist
Dr. M.S. Anantha	Scientist
Dr. Suvarna Rani Chimmili	Scientist
Hybrid Rice	
Dr. A.S. Hari Prasad	Principal Scientist
Dr. P. Senguthuvel	Scientist
Dr. P. Revathi	Scientist
Dr. Kemparaju K.B	Scientist
Ms. K. Shruti	Scientist
Biotechnology	
Dr. S.M. Balachandran	Principal Scientist
Dr. C.N. Neeraja	Principal Scientist
Dr. R.M. Sundaram	Principal Scientist
Dr. Seshu Madhav	Principal Scientist
Dr. Divya P.S	Scientist
Dr. S. Kumar Mangrauthia	Scientist
Dr. Kalyani Kulkarni	Scientist
Agronomy	
Dr. R. Mahendra Kumar	Principal Scientist
Dr. B. Sreedevi	Principal Scientist
Dr. Mangal deep tuti	Scientist
Mr. S. Saha	Scientist
Dr. Aarti Singh	Scientist
Soil Science	
Dr. K. Surekha	Principal Scientist
Dr. M.B.B. Prasad Babu	Principal Scientist
Dr. D.V.K. Nageswara Rao	Principal Scientist
Dr. Brajendra	Principal Scientist
Dr. P.C. Latha	Principal Scientist
Dr. Bandeppa	Scientist
Mr. R. Gobinath	Scientist
Ms. V. Manasa	Scientist
Physiology & Biochemistry	
Dr. D. Subrahamanyam	Principal Scientist
Dr. P. Raghuveer Rao	Principal Scientist

Name	Designation
Dr. D. Sanjeeva Rao	Scientist
Agril. Engineering	
Dr. Vidhan Singh	Principal Scientist
Agril. Chemicals	
Dr. M.M. Azam	Principal Scientist
Computer Applications	
Dr. B. Sailaja	Principal Scientist
Entomology	
Dr. G.R. Katti	Principal Scientist
Dr. B. Jhansi Rani	Principal Scientist
Dr. V. Jhansi laxmi	Principal Scientist
Dr. N. Somashekar	Principal Scientist
Dr. A.P. PadmaKumari	Principal Scientist
Dr. Chithra Shanker	Principal Scientist
Dr. Ch. Padmavathi	Principal Scientist
Dr. Y. Sridhar	Principal Scientist
Mr. S. Chavan	Scientist
Plant Pathology	
Dr. M. Sreenivasa Prasad	Principal Scientist
Dr. G.S. Laha	Principal Scientist
Dr. D. Krishna Veni	Principal Scientist
Dr. C. Kannan	Principal Scientist
Dr. Lakshmi Ladha	Scientist
Dr.V. Prakasam	Scientist
Sh. K. Basavarj	Scientist
Mr. S. Jasudas Gompa	Scientist
Transfer of Technology & Training	
Dr. P. Muthuraman	Principal Scientist
Dr. Amtul Waris	Principal Scientist
Dr. Shaik N. Meera	Principal Scientist
Dr. Jeya kumar	Principal Scientist
Dr. Lakshmi Prasanna	Sr. Scientist
Dr. B. Nirmala	Scientist
Dr. S. Arun Kumar	Scientist
Dr. Santosha Rathod (Transferred from IASRI, New Delhi)	Scientist Joined on 15th June, 2018
National Professor	
Dr. N Sarla	National Professor
Dr. Divya Balakrishnan	Scientist
Emeritus Scientist	
Dr. P. Ananda Kumar	Joined as Emeritus Scientist on 1st October 2018

Institutional Activities

Technical Staff

Dr M N Arun	*ACTO*
C. Sadanandam	Senior Technical Officer
Uddaraju Chaitanya	Senior Technical Officer
Srinivasan Amudhan	Senior Technical Officer
Kuntamukkala Chaitanya	Senior Technical Officer
M Ezra	Senior Technical Officer
Chirutkar Prakash	Senior Technical Officer
M Vijay Kumar	Technical Officer
Mohd.Tahseen	Technical Officer
A. Narsing Rao	Technical Officer
Emkolla Nagarjuna	Technical Officer
CH.Sivannarayana	Technical Officer Retired
Mohd. Sadath Ali	Technical Officer
K. Ramulu	Technical Officer
U.Pullaiah	Technical Officer
P.Vittalaiah	Technical Officer
Puramsetty Chandrakanth	Senior Technical Assistant
A Venkataiah	Senior Technical Assistant
Tupakula Venkaiah	Senior Technical Assistant
C. Muralidhar Reddy	Senior Technical Assistant
Chilukoori Anantha Reddy	Senior Technical Assistant Retired
Y Roseswara Rao	Senior Technical Assistant
Kova Shravan Kumar	Senior Technical Assistant
K Janardhan	Senior Technical Assistant
Bidyasagar Mandal	Technical Assistant
S. Vijay Kumar	Technical Assistant
K.H. Devadas	Technical Assistant
B. Venkaiah	Technical Assistant
M. Chandrakumar	Technical Assistant
T. Narender Prasad	Technical Assistant
Koteswara Rao Potla	Technical Assistant

Administrative Staff

Sathish B	*Senior Administrative Officer*
Ajay Maheshwari	Finance & Accounts Officer
K. Kumara Swamy	Asst. Administrative Officer
K Kousalya	Assistant Administrative Officer
R. Udaya Kumar	Private Secretary
Aparna Das	Private Secretary
Uppalapati Rama	Assistant
P Lakshmi	Assistant
S Prabhakar	Assistant
B Vidyanath	Assistant
T.D. Pushpalatha	Assistant
K. Sudhavalli .T	Assistant
Sudha Nair	Assistant
Sk. Ahmed Hussain	Assistant
Vijaya Kumar, JAO	Transferred to NIVEDI, Bangalore
S. Hemalatha	Personal Assistant
S. Rama Murthy	Personal Assistant
B. Ramesh	Personal Assistant
Vanitha	UDC (Upper Division Clerk)
Bharath Raju	UDC (Upper Division Clerk)
G. Satyanarayana	UDC (Upper Division Clerk)
K Mallikarjunudu	UDC (Upper Division Clerk)
Kota Jashwanth	LDC (Lower Division Clerk)
S. Rekha Rani	LDC (Lower Division Clerk)
K. Janardhan	Technical Officer
K Narasimha	Technical Assistant
V Srinivas Rao	Technical Assistant Retired on
P Govinda Raju	Technical Assistant Retired on
A Ramesh	Senior Technician
V Srinivas	Technician
S Yadaiah	Technician
R Sathamaiah	Technician
Chander	Skilled Supporting Staff (SSS)
Giyar Shankaraiah	Skilled Supporting Staff (SSS)
M Anthamma	Skilled Supporting Staff (SSS)
B Susheela	Skilled Supporting Staff (SSS)
R Yellaiah	Skilled Supporting Staff (SSS)
Ahmed Ullah Khan	Skilled Supporting Staff (SSS)
V Golu Naik	Skilled Supporting Staff (SSS)
S. Yellaiah	Skilled Supporting Staff (SSS) joined on 21st May, 2018
Z. Shankaraiah	Skilled Supporting Staff (SSS) joined on 21st May 2018

Publications

Papers in research journals

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Publications

Appendix-1

Promising Entries in Varietal Trials, *Kharif* 2018

S. No.	IET No.	Designation	GT	DFF	Yield (kg/ha)	Trial	Promising for
1	26337	CRR 747-12-3-B	LS	65	2107	AVT 1-E DS	Promising in Zone-III for Jharkhand and VII.
2	25856	MTU 1223	MS	131	6041	AVT 1-RSL	Promising in Zone-III for Odisha and Bihar.
3	25713	***LP 1621 (Hybrid)***	LS	85	6516	AVT 1-ETP	Promising for Jharkhand
4	26126	OR 2512-2	LS	98	6736	AVT 2-IME	Promising for Odisha, Chhattisgarh and Maharashtra.
5	26079	JR 206	LB	98	5742	AVT 2-IME	Promising for Odisha and Bihar
6	26125	JGL 21078	LS	91	5831	AVT 2-IME	Promising for Telangana and Gujarat.
7	25749	***NK 20050 (Hybrid)***	LB	99	6730	AVT 2-IME	Promising for Jammu & Kashmir
8	25746	***KPH 471 (Hybrid)***	LS	94	7387	AVT 2-IME	Promising for Telangana
9	25745	***PHI 16101 (Hybrid)***	LB	97	7189	AVT 2-IME	Promising for Chhattisgarh, Maharashtra and Jammu & Kashmir.
10	24931	***RH 9000 Plus (Hybrid)***	LS	96	6958	AVT 2-IME	Promising for Gujarat
11	25764	***MP 3030 (Hybrid)***	LS	96	6869	AVT 2-IME	Promising for Maharashtra & Gujarat
12	25785	***ADV 1603 (Hybrid)***	LB	109	7532	AVT 2-IM	Promising for Zone-II
13	26027	WGL-697	MS	108	7289	AVT 2-IM	Promising in Zone-VII for Andhra Pradesh and Telangana.
14	26024	OR 2573-15	LB	106	7169	AVT 2-IM	Promising in Zone-VII for Andhra Pradesh and Tamil Nadu.
15	25269	***MEPH 126 (Hybrid)***	MS	115	6428	AVT 1-L	Promising in Zone-III for Bihar and Zone-V for Chhattisgarh.
16	25838	HPR 2748	LS	110	4012	AVT 1-M (H)	Promising for Uttarakhand
17	26171	RP 5601-283-14-4-1	SB	85	5432	AVT 2-Aerob	Promising in Zone-III for Bihar
18	25640	RCPR 22-IR 84899-B-183-20-1-1-1	SB	91	5065	AVT 2-Aerob	Promising for Zone-VI for Gujarat.
19	26157	CR 3996-11-240-3-1	SB	85	5293	AVT2-Aerob	Promising in Zone-III for Bihar
20	25653	RP 5943-421-16-1-1-B	SB	80	5793	AVT 2-Aerob	Promising in Zone-III for Bihar
21	26383	RP 5115-111-24-3-1-1	SB	99	5651	AVT 1-Biofort	Promising in Zone-II for Punjab and in Zone-VII for Kerala
22	26227	OR 2560-6	MS	103	6390	AVT 2-MS	Promising for Chhattisgarh & Telangana
23	26263	MTU 1239	MS	108	7398	AVT 2-MS	Promising in Zone-VII for Tamil Nadu and Andhra Pradesh
24	25793	***MEPH-129 (Hybrid)***	MS	96	6577	AVT 2-MS	Promising in Zone-VI for Maharashtra
25	25798	***TMRH-124 (Hybrid)***	MS	85	6497	AVT 2-MS	Promising for Maharashtra
26	26241	RP 6112-SM-M-93-3-2-3-4-3	MS	100	6192	AVT 2-MS	Promising for Chhattisgarh, Telangana and Karnataka.

Appendix-2

Promising hybrids identified in different hybrid rice trials (2018)

Name of the Hybrid	IET No.	DFF	Promising in
IHRT-E			
RNC 7077	27337	92	Overall
SHX 015	27328	92	Zone III
SHX 023	27330	87	Zone VI
IHRT-ME			
RNC 7047	27366	100	Overall
PHI 18107	27362	99	Overall
PHI 18105	27358	100	Overall
IHRT-M			
PHI 18103	27389	103	Overall
Bio 698	27390	98	Zone III
IIRRH 124	27393	97	Zone III
IHRT-MS			
US 301	27397	104	Overall
TMRH 139	27394	94	Zone IV
HRI 200	27395	100	Zone IV

Appendix-3

Variety Wise Breeder Seed Production During *Kharif*, 2018 (As Per Dac Indent)

Quintals

S. No.	Name of variety	Allocation BSP-I	Actual Prod.	Name of the Producing centre
1	Abhishek (IET-17868)	47.00	30.00	CRURRS, Hazaribagh
2	ADT ® -45 (IET-15924)	0.10	0.10	TNAU,Coimbatore
3	ADT-37	12.00	12.00	TNAU,Coimbatore
4	ADT-39	6.00	6.00	TNAU,Coimbatore
5	Ajit	3.50	8.00	RRS, Chnisurah
6	Amara (MTU-1064)	7.60	7.60	ANGRAU, Guntur
7	ANJALI (IET 16430)	2.70	2.70	CRURRS, Hazaribagh
8	Ankit (CR Dhan101)	1.50	0.00	NRRI, Cuttack
9	Annada	10.50	12.00	NRRI, Cuttack
10	Athira (PBT-51)	0.60	2.50	KAU, Pattambi
11	Badshabhog Selection1	4.50	6.00	IGAU, Raipur
12	Bahadur	0.20	0.25	AAU,Jorhat
13	BAMLESHWARI (IET 14444)	20.00	22.50	IGAU, Raipur
14	Bhadra (MO-4)	3.80	2.00	RRS, Monocompu
15	Bharani (NLR 30491)	7.00	0.00	ANGRAU, Guntur
16	Bhavapuri Sannalu	0.30	0.00	ANGRAU, Guntur
17	Bhogavati	4.70	10.80	ARS, Radhanagari
18	Bhuvan(IET-7804)	0.60	0.00	NRRI, Cuttack

S. No.	Name of variety	Allocation BSP-I	Actual Prod.	Name of the Producing centre
19	Binadhan-10	0.30	0.10	ICAR-IIRR, Hyderabad
20	Binadhan-12	90.00	1.40	NRRI, Cuttack, ICAR-IIRR, Hyderabad
21	Binadhan-8	0.40	0.60	ICAR-IIRR, Hyderabad
22	Birsa Vikas Dhan108	1.70	0.00	BAU, Ranchi
23	Birsa Vikas Dhan-109	5.70	1.20	BAU, Ranchi
24	Birsa Vikas Dhan-110	1.70	1.10	BAU, Ranchi
25	Birsamati	1.70	2.30	BAU, Ranchi
26	BNKR-1(Dhiren) (IET 20760)	4.00	3.90	RRS, Chnisurah
27	BPT-3291(Sonamasuri)	8.60	8.60	ANGRAU, Guntur
28	BR-2665	5.00	6.00	UAS, Bangalore
29	CGZR-1	1.00	3.30	IGAU, Raipur
30	Chandra (MTU-1153)	3.30	3.30	ANGRAU, Guntur
31	Chandrahasini (IET -16800)	30.00	30.84	IGAU, Raipur
32	CHANDRAMA (IET 9354, 10419)	38.00	45.80	AAU, Titabar
33	CHENAB (SKAU-23)	1.00	0.00	SKUAT, Khudwani
34	Chinsurah Rice (IET-19140)	1.00	1.50	RRS, Chnisurah
35	Ciherung Sub-1 (Binadhan-11)	28.50	8.18	IIRR, Hyderabad &NRRI, Cuttack
36	CN1272-55-105 (IET 19886)	0.50	1.00	RRS, Chnisurah
37	CO-43 Sub-1 (IET- 25676)	4.00	3.00	TNAU,Coimbatore
38	CO-51	11.80	11.75	TNAU,Coimbatore
39	Cottondora Sannalu (MTU-1010)	330.00	169.72	ANGRAU, Guntur
40	CR 1009-Sub-1	6.10	6.50	NRRI, Cuttack
41	CR Dhan 10 (IET 18312)	6.00	0.00	NRRI, Cuttack
42	CR Dhan 201(AEROBIC)	1.00	20.00	NRRI, Cuttack
43	CR Dhan 203(Sachala)	9.60	12.00	NRRI, Cuttack
44	CR Dhan 209	1.00	1.00	NRRI, Cuttack
45	CR Dhan 300(CR2301-5)	3.80	0.00	NRRI, Cuttack
46	CR Dhan 303(CR2649-7)	10.30	10.00	NRRI, Cuttack
47	CR Dhan 304(IET 22117)	6.00	7.00	NRRI, Cuttack
48	CR Dhan 305 (IET 21287)	1.30	1.00	NRRI, Cuttack
49	CR Dhan 307	5.00	15.00	NRRI, Cuttack
50	CR Dhan 310	7.50	5.30	NRRI, Cuttack
51	CR Dhan 40	2.50	2.50	CRURRS, Hazaribagh
52	CR Dhan 401(Reeta) (IET 19969)	1.30	0.00	NRRI, Cuttack
53	CR Dhan 405	2.00	3.00	NRRI, Cuttack
54	CR Dhan 500(IET 20220)	60.00	36.00	NRRI, Cuttack
55	CR Dhan 505(IET 21719)	3.00	0.00	NRRI, Cuttack
56	CR Dhan 601 (IET 18558)	60.00	0.00	NRRI, Cuttack
57	CR Dhan 800	5.00	2.10	NRRI, Cuttack
58	CR Dhan 910	0.30	0.10	NRRI, Cuttack
59	CR Dhan-501 (IET 19189)	5.00	3.60	NRRI, Cuttack

S. No.	Name of variety	Allocation BSP-I	Actual Prod.	Name of the Producing centre
60	CR sugandh Dhan-3 (IET 18395)	1.00	1.50	NRRI, Cuttack
61	CR-1014	0.30	1.20	NRRI, Cuttack
62	CSR-30	6.00	8.00	CSSRI, Karnal
63	CSR-36 (Naina) (IET17340)	5.50	7.60	CSSRI, Karnal
64	CSR-43 (IET-18259)	17.50	19.60	CSSRI, Karnal
65	Danteshwari (IET 15450)	10.00	11.40	IGAU, Raipur
66	Dharitri (IET 6272)	4.20	7.00	NRRI, Cuttack
67	DRR Dhan 39	6.30	7.00	ICAR-IIRR, Hyderabad
68	DRR Dhan 43	1.50	2.80	ICAR-IIRR, Hyderabad
69	DRR Dhan 45	4.30	0.00	ICAR-IIRR, Hyderabad
70	DRR Dhan 46	6.00	7.00	ICAR-IIRR, Hyderabad
71	DRR Dhan 47 (IET 23356)	4.00	4.00	ICAR-IIRR, Hyderabad
72	DRR Dhan 48 (IET 24555)	4.00	0.00	ICAR-IIRR, Hyderabad
73	DRR Dhan 49 (IET 24557)	2.50	0.00	ICAR-IIRR, Hyderabad
74	DRR Dhan 50 (IET 25671)	9.00	0.00	ICAR-IIRR, Hyderabad
75	DRR Dhan 51 (IET 25484)	4.00	0.00	ICAR-IIRR, Hyderabad
76	Dubraj Selection-1	4.00	6.00	IGAU, Raipur
77	ErraMallelu (WGL-20471)	6.10	6.50	PJTSAU,Rajendranagar
78	GAR-13	0.10	0.15	NRRI, Cuttack
79	Gayatri (IET 8002)	2.00	16.80	NRRI, Cuttack
80	Geetanjali (CRM-2007-1) (IET-17276)	1.00	1.00	Chatha
81	GIZA-14	0.30	0.00	BCKVV, Nadia
82	Gontra Bidhan-1 (IET 17430)	77.00	77.00	BCKVV, Nadia
83	Gontra Bindhan-3 (IET 22752)	20.70	21.00	GBPUAT, Pantnagar
84	GOVIND	0.40	11.09	GAU, Nawagam
85	HAZARIDHAN	2.50	2.50	CRURRS, Hazaribagh
86	HKR-127 (HKR-95-222)	2.60	10.40	RRS, Kaul
87	HKR-47	4.10	10.40	RRS, Kaul
88	HKR-48	1.10	3.20	RRS, Kaul
89	Hmt Sona	1.50	0.00	ZARS, Sindewahi
90	HPR 2143	8.00	1.50	CSKHPKVV, Malan
91	HPR-1068	5.00	8.00	CSKHPKVV, Malan
92	HPR-1156 (IET-16007)	9.90	1.20	CSKHPKVV, Malan
93	HPR-2612 (Palam Basmati-1)	2.00	10.00	CSKHPKVV, Malan
94	HPR-2720	2.00	0.50	CSKHPKVV, Malan
95	HPR-2880	3.00	1.80	CSKHPKVV, Malan
96	HUR-917	16.00	32.40	BHU, Varanasi
97	IGKVR-1 (IET-19569)	90.00	120.00	IGAU, Raipur
98	IGKVR-2 (IET 19795)	52.00	54.90	IGAU, Raipur
99	IGRKVR-1244 (R1244-1246-1-605-1) (IET 19796)	58.00	60.60	IGAU, Raipur
100	IMPROVED LALAT	15.70	0.00	OUAT, Bhubaneshwar

S. No.	Name of variety	Allocation BSP-I	Actual Prod.	Name of the Producing centre
101	Improved Pusa Basmati-1 (IET - 18990)	2.10	2.50	ICAR-IARI, Regional Station, Karnal
102	Improved Samba Mahsuri (RP Bio-226)	27.00	30.00	ICAR-IIRR, Hyderabad
103	Indira Aerobic- 1 (R1570-2649-1-1546-1)	16.00	16.20	IGAU, Raipur
104	INDIRA BARANI DHAN-1 (RF-17-38-70)(IET 21205)	35.00	45.00	IGAU, Raipur
105	Indra(MTU - 1061)	7.00	7.00	ANGRAU, Guntur
106	Indrayani (IET - 12897)	16.00	38.00	Vadagaon
107	INTAN	2.00	3.00	ARS, Mugad
108	IR-36	16.00	27.00	IGAU, Raipur
109	IR-64	58.50	64.50	IGAU, Raipur
110	IR64 Drt 1(IET 22836) (DRR-42)	95.00	64.50	ICAR-IIRR, Hyderabad & NRRI, Cuttack
111	JAJATI (IET - 7284)	0.50	0.00	OUAT, Bhubaneshwar
112	Jaldbi (IET - 17153)	1.00	1.10	IGAU, Raipur
113	JAYA	17.20	4.20	ICAR-IIRR, Hyderabad
114	JGL-1798	4.70	4.70	PJTSAU,Rajendranagar
115	JGL-18047 (Bathukamma)	6.50	6.50	PJTSAU,Rajendranagar
116	JR 767	10.00	124.97	JNKVV, Jabalpur
117	JR-503 (Richa) (IET-16783)	0.50	0.00	JNKVV, Jabalpur
118	Jyothi	12.50	35.00	KAU, Pattambi
119	KALACHAMPA	10.00	10.00	SSTL, BBSR, Govt of Odisha
120	KARJAT-184	1.00	3.59	RARS, Karjat
121	KARJAT-2	1.32	4.80	RARS, Karjat
122	KARJAT-3	5.00	5.44	RARS, Karjat
123	Karjat-5	2.80	4.48	RARS, Karjat
124	KARJAT-6	1.88	5.12	RARS, Karjat
125	Karjat-7	3.00	7.36	RARS, Karjat
126	KARJAT-8	1.00	7.36	RARS, Karjat
127	Karma Mahsuri (IET 19991)	20.00	29.10	IGAU, Raipur
128	KAVYA (WGL-48684)	0.50	0.60	PJTSAU,Rajendranagar
129	KHANDAGIRI	9.70	9.70	OUAT, Bhubaneshwar
130	KHITISH (IET-4094)	8.60	13.00	RRS, Chnisurah & NRRI, Cuttack
131	KMD-2 (ABHILASH)	1.25	4.00	ARS, Mugad
132	KNM-118	16.20	16.20	PJTSAU,Rajendranagar
133	KRANTI (R-2022)	19.10	2872.20	JNKVV, Jabalpur
134	KRISHNA HAMSA	0.05	0.30	ICAR-IIRR, Hyderabad
135	LALAT (IET-9947)	46.00	13.00	OUAT, Bhubaneshwar
136	Lunasampad (IET 19470)	1.60	1.80	NRRI, Cuttack
137	Lunasuwarna (IET 18697)	1.60	1.80	NRRI, Cuttack
138	Lunusree	0.60	0.00	NRRI, Cuttack

S. No.	Name of variety	Allocation BSP-I	Actual Prod.	Name of the Producing centre
139	MAHAMAYA (IET-10749)	26.60	27.00	IGAU, Raipur
140	Manaswini (IET 19005)	5.00	6.00	OUAT, Bhubaneshwar
141	MANDAKINI (OR 2077-4) (IET 17847)	10.30	10.00	OUAT, Bhubaneshwar
142	Maruteru sannalu (MTU-1006, IET-14348)	1.30	1.30	ANGRAU, Guntur
143	MASURI	2.00	2.80	ICAR-IIRR, Hyderabad
144	MRUNALINI (OR 1898-18) IET 18649	5.00	18.00	OUAT, Bhubaneshwar
145	MTU 1075 (IET 18482)	18.00	18.00	ANGRAU, Guntur
146	MTU-1031 (Tholakuri)	0.30	0.30	ANGRAU, Guntur
147	MTU-1032 (Godavari)	0.30	0.30	ANGRAU, Guntur
148	MTU--1038	3.00	0.00	ANGRAU, Guntur
149	MTU-1081	0.10	0.00	ANGRAU, Guntur
150	MTU-1156	0.30	0.30	ANGRAU, Guntur
151	MTU-1210	1.00	0.00	ANGRAU, Guntur
152	MTU-7029	237.20	105.00	ANGRAU, Guntur
153	Narendra Dhan 97	1.10	5.40	NDUAT, Faizabad
154	Narendra Usar Dhan-2008 (NDRK-5088) IET-18699)	1.10	0.00	NDUAT, Faizabad
155	Narendra-8002 (IET-15848)	1.10	34.00	NDUAT, Faizabad
156	NAVEEN (CR-749-20-2) (IET-14461)	50.00	87.20	AAU, Titabar, NRRI Cuttack
157	NDR 2064 (IET 17475)	1.10	58.50	NDUAT, Faizabad
158	NDR 2065 (IET 17476)	1.10	54.65	NDUAT, Faizabad
159	NDR-359	1.10	16.00	NDUAT, Faizabad
160	Nellore Mahsuri (NLR-34449)	34.50	0.00	ANGRAU, Guntur
161	NLR-145	7.00	0.00	ANGRAU, Guntur
162	PANKAJ	0.90	0.00	OUAT, Bhubaneshwar
163	Pant Dhan 18 (IET 17920) (UPRI 99-1)	1.00	13.80	GBPUAT, Pantnagar
164	PANT DHAN-10 (IET - 8616)	0.30	12.42	GBPUAT, Pantnagar
165	PANT DHAN-11 (IET - 9620)	0.30	25.70	GBPUAT, Pantnagar
166	PANT DHAN-12 (IET-10955)	1.10	7.92	GBPUAT, Pantnagar
167	Pant Dhan-19(IET 17544)	0.30	24.30	GBPUAT, Pantnagar
168	PANT DHAN-24	10.00	44.12	GBPUAT, Pantnagar
169	Pardhiva (NLR - 33892)	3.00	3.00	ANGRAU, Guntur
170	PARIJAT (IET-2684)	6.10	4.40	OUAT, Bhubaneshwar
171	PAU-201	2.40	6.00	PAU, Ludhina
172	Phalguni (IET 18720) CRAC 2224-1041)	0.50	1.00	NRRI, Cuttack
173	Phule Samrudhi	6.00	21.50	Vadagaon
174	PKV HMT	79.60	116.89	ADR, Sindewahi
175	Pooja(IET-12241)	44.10	76.20	NRRI, Cuttack
176	Poorna Bhog	0.30	0.10	NRRI, Cuttack

S. No.	Name of variety	Allocation BSP-I	Actual Prod.	Name of the Producing centre
177	POORNIMA (IET-12284, R-281-PP-31-1)	5.50	6.90	IGAU, Raipur
178	PR 121	28.00	30.00	PAU, Ludhina
179	PR-111	8.04	9.00	PAU, Ludhina
180	PR-113	9.10	11.00	PAU, Ludhina
181	PR-114	19.10	28.00	PAU, Ludhina
182	PR-116	2.20	4.30	PAU, Ludhina
183	PR-118	13.60	25.00	PAU, Ludhina
184	PR-122	17.40	20.00	PAU, Ludhina
185	PR-123	4.70	6.00	PAU, Ludhina
186	PR-124	10.70	12.00	PAU, Ludhina
187	PR-126	34.10	40.00	PAU, Ludhina
188	Pratap-1 (RSK-1091-10-1-1)	0.10	0.10	MPUAT, Kota
189	Pratikshya (ORS 201-5) (IET-15191)	60.70	89.00	OUAT, Bhubaneshwar
190	PTB-45 (Matta Triveni)	2.00	5.00	KAU, Pattambi
191	Punjab Basmati - 2	0.10	1.00	PAU, Ludhina
192	Punjab Basmati - 3	1.10	4.00	PAU, Ludhina
193	Punjab Basmati - 4	0.25	1.00	PAU, Ludhina
194	Punjab Basmati - 5	5.70	5.70	PAU, Ludhina
195	PUSA 1592 (IET 22289)	1.20	8.00	IARI, New Delhi
196	Pusa Basmati- 1121	69.00	69.00	BEDF, New Delhi, ICAR-IARI, RS, Karnal
197	Pusa Basmati -1637	20.00	20.00	ICAR-IARI,RS , Karnal
198	Pusa Basmati -1728	10.00	10.00	ICAR-IARI,RS , Karnal
199	PUSA BASMATI-1 (IET-10364)	23.00	24.50	BEDF, New Delhi & I ICAR-IARI, RS, Karnal
200	Pusa Basmati-1509 (IET 21960)	46.00	48.00	BEDF, New Delhi, ICAR-IARI, RS, Karnal
201	PUSA BASMATI-6 (IET 18005)	20.00	20.00	ICAR-IARI, RS, Karnal
202	PUSA SUGANDH-2 (IET-16310, PUSA-204-1-126)	0.40	0.00	ICAR-IARI, RS, Karnal
203	PUSA SUGANDH-3 (IET-16313, PUSA 2504-1-3-1)	0.50	0.00	ICAR-IARI, RS, Karnal
204	Pusa Sugandh-5 (IET-17021)	40.00	80.00	IARI, New Delhi
205	PUSA-44	35.00	35.00	ICAR-IARI, RS, Karnal
206	PUSA-6 (IET 22290) (PUSA 1612-07-6-5)	1.90	8.00	IARI, New Delhi
207	Pushpa (IET 17509)	1.60	1.00	RRS, Chnisurah
208	Rajendra Bagavathi	81.00	90.50	RAU, PUSA
209	Rajendra Kasturi	1.50	2.20	RAU, PUSA
210	Rajendra Mahsuri-1	64.00	63.88	RAU, PUSA
211	Rajendra Suwasini	1.50	2.00	RAU, PUSA
212	Rajendra Sweta	32.60	32.60	RAU, PUSA

S. No.	Name of variety	Allocation BSP-I	Actual Prod.	Name of the Producing centre
213	Rajshree (TCA-80-4) (IET-7970)	0.40	0.40	RAU, PUSA
214	Rani Dhan (IET-19148)	13.20	20.00	OUAT, Bhubaneshwar
215	Ranjit	20.70	22.80	AAU,Jorhat
216	RASHMI(JR-201)	10.00	19.40	JNKVV, Jabalpur
217	RASI (IET- 1444)	0.30	0.50	ICAR-IIRR, Hyderabad
218	RATNAGIRI-1	0.60	60.70	ARS, Ratanagiri
219	RATNAGIRI-2	1.00	1.50	ARS, Ratanagiri
220	RATNAGIRI-24 (RTN-24) (IET-19812)	3.00	11.50	ARS, Ratanagiri
221	RNR-15048	10.30	11.00	PJTSAU,Rajendranagar
222	RTN-5	2.00	17.50	ARS, Ratanagiri
223	SABITA (IET-8970)	4.90	6.00	RRS, Chinsurah
224	SAHBHAGI DHAN (IET 19576)	383.70	231.00	CRURRS, Hazaribagh
225	SAMALEI (IET-3350)	0.10	0.00	NRRI, Cuttack
226	Samba Mahsuri (BPT-5204)	91.60	91.60	ANGRAU, Guntur
227	Sambha Sub - 1 (IET 21248)	23.50	7.80	NRRI, Cuttack
228	Sampada (IET 19424)	43.00	47.80	ICAR-IIRR, Hyderabad
229	SAMPRITI (BNKR-B12) (IET-21987)	2.40	2.40	RRS, Chinsurah
230	SARALA CR-260-77 (IET-10279)	5.60	21.00	NRRI, Cuttack
231	Sarjoo-52	5.90	16.00	NDUAT, Faizabad
232	SATYABHAMA	12.00	3.00	NRRI, Cuttack
233	SAVITRI (IET - 5897) (CR 1009)	4.60	11.40	NRRI, Cuttack
234	SHATABDI (IET-4786)	56.00	50.00	RRS, Chinsurah & NRRI, Cuttack
235	Shusk Samrat (NDR 1045-2) (IET-17458)	0.30	6.80	NDUAT, Faizabad
236	SJR 5	10.00	12.00	SKUAST, Chatha
237	Sri Dhruthi (MTU-1121)	2.30	2.30	ANGRAU, Guntur
238	Srikakulam Sannalu (RGL-2537)	10.00	10.00	ANGRAU, Guntur
239	Sujala (CNR-2) (IET 20235)	10.10	5.00	RRS, Chnisurah
240	SUKHA DHAN-6	0.10	0.00	ICAR-IIRR, Hyderabad
241	SURENDRA (IET-12815)	1.40	2.00	OUAT, Bhubaneshwar
242	SWARANA-SUB 1 (CR 2539-1) IET-20266	314.70	125.10	NRRI, Cuttack
243	Swarna Shreya	10.00	12.50	ICAR-Patna
244	Tarunbhog Selection-1	4.00	4.50	IGAU, Raipur
245	TELLAHAMSA	2.70	2.70	PJTSAU,Rajendranagar
246	Thanu	3.30	4.00	UAS, Bangalore
247	Tunga (IET-13901)	5.10	0.00	UAS, Bangalore
248	UDAYAGIRI (IET-12316)	0.30	2.60	OUAT, Bhubaneshwar
249	Uma	6.80	8.00	RRS, Monocompu
250	Vallabh Basmati-24 (IET 20827) (MAUB-171)	2.00	2.25	SVBAUA&T Meerut

S. No.	Name of variety	Allocation BSP-I	Actual Prod.	Name of the Producing centre
251	VANDANA (RR-167-982)	2.04	2.10	CRURRS, Hazaribagh
252	Varsha (PTB-56)	0.30	0.10	KAU, Pattambi
253	Varshadhan(CRLC-899) (IET-15296)	15.30	16.20	NRRI, Cuttack
254	Vijetha (MTU-1001)	124.00	124.00	ANGRAU, Guntur
255	Vishnubhog Selection-1	1.50	2.30	IGAU, Raipur
256	VL Dhan 157 (VL 31611) (IET 22292)	0.40	0.20	VIHA, Almora
257	VL Dhan 65	0.30	1.00	VIHA, Almora
258	VL Dhan 68 (VL 31611) (IET 22283)	7.30	6.50	VIHA, Almora
259	VL Dhan-86 (VL 97-3861) (IET-16863)	0.30	0.50	VIHA, Almora
260	VL.Dhan 85 (IET-16455) (VL-3613)	0.30	0.90	VIHA, Almora
261	WARANGAL SAMBA (WGL-14)	0.30	4.00	PJTSAU,Rajendranagar
262	Warangal Sannalu (WGL-32100)(IET 18044)	10.00	10.00	PJTSAU,Rajendranagar
	Total	**4323.23**	**7204.33**	

Appendix-4

List of Institute projects (2018-19)

	Project Code	Project Title	PI and Co-PI
CROP IMPROVEMENT DIVISION			
Plant Breeding			
1	*GEY/CI/BR/9*	Enhancing nutritional quality of rice through bio-fortification	**Dr. L. V Subba Rao, Drs.** G Padmavathi, K Surekha, B Sreedevi, CN Neeraja, D Sanjeeva Rao, T Longvah (NIN)
2	*GEY/CI/BR/16*	Traditional and molecular approaches for breeding improved rice varieties with resistance to planthoppers	**Dr.G Padmavathi,** Dr. C. Gireesh, Dr.V. Jhansi Lakshmi, Dr.M. Sheshu Madhav, Dr.P.V.Satyanarayana, PS, Plant breeding, APRRI, Maruteru, Dr.N.Mallikarjuna Rao, SS, Entomology, APRRI, Maruteru.
3	*GEY/CI/BR/22*	Identification and introgression of agronomically important traits from wild species of rice	**Dr.C. Gireesh,** Drs. MS Anantha, Divya B, Suneetha K, G. Padmavathi, Abdul Fiyaz R, Jyothi B, Senguttvel P, KB Kemparaju, RM. Sundaram, Sheshu Madhav, GS Laha, Prakasham V, Sridhar Y, Jhansi Lakshmi V, P Raghuveer Rao
4	*GEY/CI/BR/23*	Breeding high yielding rice lines possessing multiple biotic stress resistance/tolerance through conventional and molecular approaches.	**Dr. R. Abdul Fiyaz Drs** R.M. Sundaram, Sheshumadhav, L.V. Subba Rao, C. Gireesh, M.S. Anantha, M.S. Prasad, G.S. Laha
5	*GEY/CI/BR/25*	Broadening the genetic base of *indica* rice varieties and modify plant type by introgressing traits from Tropical *japonica*	**Dr.Jyothi Badri,** Drs LV Subba Rao, Divya Balakrishnan, Aravind Kumar, P Revathi, P Raghuveer Rao, Dr V Prakasam, CH Padmavathi, B Sreedevi, Ch Suvarna Rani.

	Project Code	Project Title	PI and Co-PI
6	*GEY/CI/BR/24*	Breeding high yielding Rice cultivars for tolerance to low phosphorus and nitrogen	**Dr. M. S. Anantha,** Drs. C Gireesh, R Abdul Fiyaz, P Senguttuvel, R M Sundaram, R Mahender Kumar, K Surekha, Brajendra, Raghuveer Rao, Aarthi Singh, H K Ranganath
HYBRID RICE			
7	*GEY/CI/HY/13*	Development and evaluation of three line hybrids with better grain quality and resistance to major pests and diseases.	**Dr.A.S. Hari Prasad,** Drs P Senguttuvel, P Revathi, KB Kemparaju, K Sruthi, RM Sundaram
8	*GEY/CI/HY/10*	Development of parental lines and Hybrids with tolerance to salinity and suitability to aerobic situations	**Dr.P. Senguttuvel,** Drs. AS HariPrasad, P.Revathi, KB Kemparaju, RM Sundaram, Sheshu Madhav, G.Padmavathi, C Gireesh, MS Anantha, B.Sreedevi, Mahender Kumar, Brajendra, Gopinath and D.Subrahmanyam
9	*GEY/CI/HY/12*	Development of superior restorers and Identification of new restorer(*Rf*) genes for WA-CMS system in rice by conventional and molecular approaches	**Dr.P. Revathi ,** Drs. Jyothi Badri, Satendra Kumar Mangrauthia, Divya balakrishnan, M. Srinivas Prasad, V. Jhansilakshmi
10	*GEY/CI/HY/11*	Development of CMS line with good agronomic base and higher out crossing ability.	**Dr.K.B. Kemparaju,** Drs. A. S Hari Prasad, P Senguttuvel, P Revathi, RM Sundaram, M Sheshu Madhav
11	*GEY/CI/HY/14*	Establishment and validation of heterotic gene pools in hybrid rice	**K. Sruthi,** Drs. A.S. Hari Prasad, P. Senguttuvel, P. Revathi, K.B.Kemparaju and R.M. Sundaram
BIOTECHNOLOGY			
12	*ABR/CI/BT/9*	Improvement of rice against biotic and abiotic stresses through transgenic approach inside	**Dr.SM Balachandran,** Drs. A.P. Padmakumari, Ch. Padmavathi, D. Subrahmanyam, S.K. Mangrauthia
13	*ABR/CI/BT/6*	Identification of genes for grain filling in rice (*Oryza* sativa L.)	**Dr.CN Neeraja, Drs** SR. Voleti, LV Subbarao, M Sheshu Madhav, SM Balachandran, Divya Shyamala Devi D Sanjeeva Rao, Kalyani M. Barbadikar
14	*ABR/CI/BT/10*	Genomic studies on grain yield heterosis and WA-CMS trait in rice	**Dr.R.M. Sundaram,** Drs. S.M. Balachandran, M.S. Madhav, A.S. Hariprasad, Dr. P. Revathi, P. Raghuveer Rao, K. Sruthi
15	*ABR/CI/BT/16*	Exploring the mutant resources for rice improvement	**Dr.M. Sheshu Madhav,** Drs. R. M. Sundaram, Kalyani Kulkarni, D. Sanjeeva Rao, B. Sreedevi, P. Senguttuvel, L.V. Subba Rao, C. Gireesh, A.P. Padma kumari, Jhansi Laxmi, Ch. Padmavathi, Y. Sridhar, G.S. Laha, M.S. Prasad, D. Ladhalakshmi
16	*ABR/CI/BT/13*	Candidate gene identification for manipulating growth related genes in rice through computational and expression studies	**Dr. P.S. Divya,** Dr. S.M. Balachandran Dr. D. Subrahmanyam

	Project Code	Project Title	PI and Co-PI
17	*ABR/CI/BT/14*	Exploring RNAi Technology for Management of Rice Diseases	**Dr.Satendra Kumar Mangrauthia,** Drs. P. Anand Kumar, S.M. Balachandran, G.S. Laha, D. Krishnaveni, P Revathi, V. Prakasam, Kalyani Kulkarni,
18	*ABR/CI/BT/15*	Molecular and functional characterization of useful root traits in rice	**Dr. Kalyani M. Barbadikar,** Dr. M. Seshu Madhav, Dr. D. Subrahmanyam, Dr. P. Senguttuvel, Dr. S. M. Balachandran, Dr. Divya P. S.
NATIONAL PROFESSOR PROJECT			
19	*NP/1*	Development of chromosome segment substitution from elite x wild species crosses for mapping of yield enhancing QTLs/genes in rice"	**Dr.N Sarla,** Dr. Divya Balakrishnan
20	*ABR/ CI/BR/28*	Exploring wild introgression lines and mutants to identify novel genes/ QTLs for yield contributing traits	**Dr.Divya Balakrishnan,** Dr. N Sarla, Dr. D. Subrahmaniyam, Dr. G Padmavathi, Dr. Jyothi B, Dr. P. Revathi, Dr. C.Gireesh, Dr. Ladha Lakshmi, Dr. B.Kalyani, Dr. Suvarna C
CROP PRODUCTION DIVISION			
AGRONOMY			
21	*RUE/CP/AG/ 14*	Strategic research on enhancing water Use efficiency and productivity in irrigated rice system	**Dr.R.Mahender Kumar,** Drs.B.Sreedevi, L.V.Subba Rao, K. Surekha, Ch Padmavthi, P.C. Latha, M.Sreenivas Prasad, N.Somashekhar, P.Muthuraman, P. Raghuveer Rao, S.Ravichandran, B.Nirmala, B.Shailaja, Shaik N Meera, DVK Nageswar Rao, Vidhan Singh, MBB. Prasad Babu, K.Srinivas , PS, CRIDA (For Biochar work), Prof. Saran Sohi, University of Edinburgh, UK.
22	*RUE/CP/AG/ 13*	Improved Agro-techniques for sustainable aerobic rice based cropping systems	**Dr.B. Sreedevi,** Drs. N.Somasekhar, P.C.Latha, P.Senguttuvel, Mangal Deep Tuti, C. Kannan, D.V.K. Nageswararao, R. Mahender Kumar and B. Jhansirani
23	*SSP/CP/AG/15*	Sustainable intensification of rice-maize system through conservation agriculture	**Dr. Mangal Deep Tuti,** Drs. R. Mahender Kumar, B. Sreedevi, Soumya Saha, Aarti Singh, B. Nirmala, T. Vidhan Singh, Bandeppa and M.N. Arun
24	*RUE/CP/ AG/17*	Comparative study of organic and conservation agriculture for enhanced resource use efficiency, yield and quality of rice	**Dr Aarti Singh,** Drs. V. Manasa, M.D. Tuti, Anantha M.S., Sanjeeva Rao, K. Sruthi, Vidhan Singh, Satish Chavan, R.M. Kumar and M.N. Arun
SOIL SCIENCE			
25	*SSP/CP/SS/11*	Assessment of Genotypic variability in nitrogen use efficiency and improving NUE in irrigated rice	**Dr.K. Surekha,** Dr. D. V. K. Nageswara Rao, Dr. C.N. Neeraja, Dr. R.M. Kumar, Dr. S.R. Voleti, Dr. M.S. Anantha.

Appendices

	Project Code	Project Title	PI and Co-PI
26	*CCR/CP/ SS/17*	Studies on emission of green house gases (GHGs) from rice soils and their mitigation	**Dr. M.B.B.Prasad Babu,** Drs. R. Mahender Kumar, Dr. P.C. Latha and Dr. Brajendra
27	*RUE/CP/SS/16*	Study of rice vegetation in terms of crop stress to model the yield using NDVI	**Dr. D.V.K. Nageswara Rao,** Drs. K. Surekha, R. Mahender Kumar, B. Sridevi, Ch. Padmavati and V. Prakasam
28	*SSP/CP/SS/18*	Studies on Soil Organic Carbon Status, Mapping and stocks in Rice Soils of India	**Dr. Brajendra,** Dr. B Sailaja, Dr. MBB Prasad Babu, Dr. P Muthuraman
29	*SSP/CP/SS/13*	Utilization of plant growth promoting micro organisms for improving nitrogen and water use efficiency in rice	**Dr. PC Latha,** Drs. Bandeppa, Dr. MBB Prasad Babu and Dr. B. Sreedevi
30	*SSP/CP/SS/15*	Microbial population dynamics in different rice establishment method in relation to nutritional availability and acquisition.	**Dr. Bandeppa,** Drs. P. C Latha, Dr. K. Surekha, Dr. Mangal Deep Tuti and Kalyani M Barbadikar
31	*RUE/CP/SS/19*	Evaluation of ZnO nanoparticles on performance of rice	**Gobinath, R,** Dr. Surekha, K., Dr. Brajendra, Dr. P.C. Latha and Dr. Manasa, V.
32	*RUE/CP/SS/20*	Efficacy of hydrogel on yield and soil properties of rice	**Dr. V. Manasa,** Drs. K. Surekha, Mr. R. Gobinath, Bandeppa, Aarti Singh, M.M. Azam
PLANT PHYSIOLOGY AND BIOCHEMISTRY			
33	*CCR/CP/PP/11*	Evaluation of genotypic variability in leaf photosynthetic efficiency and its associated factors in rice	**Dr. D Subrahmanyam,** Dr. S.R. Voleti,
34	*GEY/CP/PP/12*	Physiological studies for improving ideotype breeding in rice	**Dr. P Raghuveer Rao,** Dr. A.S. Hariprasad, Dr. Jyoti Badri
35	*GEQ/CI/BR/26*	Investigation into the role of major metabolites on rice grain quality	**Dr. D. Sanjeeva Rao,** Dr. C. N. Neeraja, Dr. D. Subrahmanyam, Dr. M. Seshu Madhav, Dr. P. Senguttuvel and Dr. Jyothi Badri
AGRICULTURAL ENGINEERING AND CHEMICALS			
36	*RUE/CP/ ENG/6*	Selective mechanization in rice cultivation	**Dr.T Vidhan Singh,** Dr. R.Mahender Kumar and Dr. B.Nirmala
COMPUTER APPLICATIONS			
37	*TTI/CP/CA/4*	Wireless Sensor Networks integrating with Rice DSS model for real time advisories	**Dr.B Sailaja,** Dr. Shaik N Meera, Dr. D. Subrahmanyam, Dr. K. Surekha
AGRICULTURAL CHEMICALS			
38	*RUE/CP/AC/1*	Post Harvest Treatment of Rice and Rice By-Products for Health Benefits and on-farm application	**Dr. M.M. Azam,** Drs. PC Latha, R Mahendra Kumar, R Abdul Fiyaz, Surekha Kochi, Amtul Waris, V Manasa, T Vidhan Singh, SR Voleti, D Sanjeeva Rao, GR Katti, MS Prasad, GS Laha, AP Padmakumari,V Prakasam and Aparna Kuna (PJTSAU)

Appendices

Project Code		Project Title	PI and Co-PI
CROP PROTECTION DIVISION			
ENTOMOLOGY			
39	*IPM/ CPT/ ENT/3*	Chemical control of rice insect pests as a component of rice	**Dr.Gururaj Katti,** Drs. V. Jhansilakshmi, A.P. Padmakumari and Chitra Shanker
40	*IPM/CPT/ ENT/21*	Botanicals for sustainable management of major pests of rice	**Dr.B Jhansi Rani,** Dr. Chitra Shankar, Dr. M.M. Azam, Dr. M. Srinivas Prasad
41	*HRI/CPT/ ENT/11*	Assessment of host plant resistance to rice planthoppers viz., brown planthopper *Nilaparvata lugens* and whitebacked Planthopper *Sogatella furcifera* and their management	**Dr.V Jhansi Lakshmi,** Dr. D. Sanjeeva Rao, Dr. Y Sreedhar
42	*IPM/ CPT/ ENT/22*	Investigations on Nematodes of Importance to Rice Cultivation	**Dr.N. Soma Sekhar,** Drs. S.N. Chavan, P.C. Latha and M. Sheshu Madhav
43	*HRI/ CPT/ ENT/23*	Insect-plant interactions with special reference to rice pests – yellow stem borer and gall midge	**Dr.A.P.Padmakumari,** Dr Y. Sreedhar, Dr S.R Voleti
44	*IPM/ CPT/ ENT/26*	Biointensive pest management with emphasis on biological control of rice pests	**Dr.Chitra Shanker,** Drs. Gururaj Katti, B. Jhansi Rani, N. Somasekhar and C. Kannan
45	*HRI/CPT/ ENT/27*	HPR and Semiochemical approaches for the management of insect pests of rice	**Dr.Ch Padmavathi,** Drs. Y Sridhar, Divya Balakrishnan, G Katti
47	*IPM/CPT/ ENT/24*	Bioecology and Management of Emerging Insect and Mite pests of rice	**Dr. Y. Sridhar,** Drs. Jhansi Rani, M. Sheshumadhav, C. Gireesh, Sanjeeva Rao, S. Chawan
48	*IPM/CPT/ ENT/25*	Development of Entomopathogenic Nematodes (EPN) for Biointensive Integrated Pest Management in Rice	**Mr. Satish N. Chavan,** Drs. N. Somasekhar, Gururaj Katti, A.P. Padmakumari, C. Kannan.
PLANT PATHOLOGY			
49	*HRP/CPT/ PATH/15*	Assessment of host plant resistance to rice blast disease and its management	**Dr.M.S. Prasad,** Drs. Seshumadhav M, Balachandran SM, V. Prakasam, Divya Blalakrishnan
50	*HRP/CPT/ PATH/13*	Assessment of resistant sources and monitoring of pathogen virulence in bacterial leaf blight of rice	**Dr.G.S. Laha,** Dr. D. Krishnaveni, D. Ladha Lakshmi, R. M. Sundaram and Dr. S. K. Mangrautia

	Project Code	Project Title	PI and Co-PI
51	*HRP/CPT/ PATH/14*	Assessment of host plant resistance and development of diagnostic tools for rice tungro virus disease	**Dr.D. Krishnaveni,** Drs G.S. Laha, C. N. Neeraja, Chitra Shanker, S.K Mangrauthia, and Dr. D. Ladhalakshmi
52	*HRP/CPT/ PATH/20*	A consortia approach to the biological management of diseases in rice	**Dr.C. Kannan,** Drs. M.Srinivas Prasad, D.Krishnaveni, G.S.Laha, V.Prakasam, D.Ladhalakshmi, Chitra Shanker, P.C.Latha and B. Sridevi
53	*HRP/CPT/ PATH/19*	Epidemiology and management of False smut disease	**Dr.D. Ladhalakshmi,** Drs. G.S. Laha, M. S. Prasad, D. Krishnaveni, K. Suneetha
54	*HRP/CPT/ PATH/22*	Population dynamics of *Rhizoctonia solani* and sustainable management of rice sheath blight disease	**Dr.V. Prakasam,** Drs M S Prasad, G S Laha, D Ladha lakshmi, Jyothi badri
TRANSFER OF TECHNOLOGY & TRAINING			
55	*TTT/EXT/15*	Climate change and rice farming: Farmers perception and adaptation strategies	**Dr.P. Muthuraman,** Drs. Shaik N. Meera, S. Arun Kumar, P. Jeyakumar, Brajendra, Ranganath
56	*TTT/EXT/12*	Dissemination of climate resilient rice production technologies to farmers in selected Districts of Telangana State	**Dr.Amtul Waris,** Drs. Mahender Kumar, S. N. Meera, Arun Kumar, K. Surekha, B. Sreedevi, V Jhansi lakshmi, T. Vidhan Singh, B. Nirmala and Brajendra
57	*TTT/EXT/11*	Maximizing the impact of rice technologies through ICT applications	**Dr. S.N. Meera, Drs** Arun Kumar S, P. Muthuraman, Amtul Waris, Chitra Shanker, D. Krishnaveni, B. Sailaja, Brajendra, and P. Senguttuvel and S.R. Voleti
58	*TTI/TTT/ ECON/3*	IPR - Competition interaction in rice seed sector – Emerging scenario- implications for enhancing quality seed use.	**Dr. P.A. Lakshmi Prasanna,** Drs. L.V. Subba Rao, A.S. Hari Prasad, Amtul Waris, S. N. Meera, B. Nirmala, S. Arun Kumar and Divya P. Symaladevi
59	*TTT/ECON/2*	Socio-economic impact assessment of rice production technologies	**Dr. B. Nirmala,** Drs. P.Muthuraman, Amtul Waris, R.Mahender Kumar,A.S.Hari Prasad and T.Vidhan Singh
60	*TTI/TTT/ EXT/14*	Innovations in group based extension approaches: Accelerating rice technology transfer through farmer based organisations	**Dr. S. Arun Kumar,** Drs. Shaik N. Meera, Amtul Waris, P Jeya Kumar, P. Muthuraman

Appendix-5

Externally funded projects sanctioned during 2018-19

S. No.	Title of the Project / Schemes	Name of the PI & Co-PI	Funding Agency	Duration	Budget (lakh Rs.)
1	Biofortification of rice (Harvest Plus)	G. Padmavathi – PI LV Subba Rao - Co-PI	CIAT, Columbia & IFPRI, USA under HPlus program	2018-20	80.00
2	Exploring Chromosome Segment Substitution Lines from inter-specific crosses to decipher the genetics of grain weight and earliness	Divya Balakrishnan (PI)	DBT BioCARE	2019-2022	43.10
3	From QTL to Variety: Genomics-Assisted Introgression and Field evaluation of Rice Varieties with Genes/QTLs for yield under Drought, Flood and Salt Stress.	G. Padmavathi - PI	DBT	2018-20	72.00
4	Evaluation of Bio efficiency of Thiobencarb in wet direct sown rice	**Dr. B. Sreedevi**	ICAR-IIRR and IPL	2018- 19	5.81 lakhs
					~200 Lakhs

Appendix-6

Ongoing Externally funded projects during 2018-19

S. No.	Title of the Project / Schemes	Name of the PI & Co-PI	Funding Agency	Duration	Budget (lakh Rs.)
1	ICAR-Consortia Research Platform on Molecular Breeding in Crops.	R M Sundaram (PI) LV Subba Rao R Abdul Fiyaz C Gireesh MS Anantha P Senguttuvel S M Balachandran MS Madhav MS Prasad GS Laha AP Padmakumari V Jhansi Lakshmi	ICAR	2017-2020	38.125
2	ICAR-Plan Scheme: "Incentivizing Research in Agriculture"Project: Genetic modifications to improve biological nitrogen fixation for augmenting nitrogen needs of cereals.	R M Sundaram (PI) PC Latha Bandeppa KalyaniMBarbadikar MBB Prasad Babu	ICAR	2017-2020	104.00
3	ICAR-Plant Scheme: "Incentivizing Research in Agriculture". Project: Molecular genetic analysis of resistance/ tolerance to different stresses in rice, wheat, chickpea and mustard including sheath blight complex genomics.	R MSundaram (PI) GS Laha V Prakasam D Ladha Lakshmi JyothiBadri	ICAR	2017-2020	48.01

S. No.	Title of the Project / Schemes	Name of the PI & Co-PI	Funding Agency	Duration	Budget (lakh Rs.)
4	CRP on Agro-biodiversity.	L V Subba Rao (PI) C Gireesh M S Anantha	ICAR	2014-2020	4.0 / year
5	CRP- Biofortification in selected crops for nutritional security-Rice- IIRR.	C N Neeraja (PI) K Surekha Kalyani Kulkarni D Sanjeeva Rao L V Subba Rao R M Sundaram AmtulWaris U Chaitanya	ICAR	2017-2020	159.85
6	Mega Seed Project.	L V Subba Rao (PI) R Abdul Fiyaz M S Anantha ChSuvarna Rani U. Chaitanya	ICAR	2006- Long term	8.0/year
7	National Seed Project.	L V Subba Rao (PI) R Abdul Fiyaz M S Ananatha G Padmavathi U. Chaitanya	ICAR	1992 – Long term	3.5/year
8	Pre-breeding to broaden the genetic base of rice for yield enhancing traits, heterotic yield QTLs, brown plant hopper and stem borer resistance by utilizing wild species and land races.	G Padmavathi (PI) Gireesh C P Revathi	ICAR	2016-2019	44.71
9	CRP on Hybrid Technology (Hybrid Rice).	A S Hari Prasad (PI) P Senguttuvel P Revarhi K B Kemparaju	ICAR	2015-2020	112.89
10	National Innovations in Climate Resilient Agriculture (NICRA): Phase III.	P Raghuveer Rao (PI) S R Voleti N Sarla D Subrahmanyam C N Neeraja V Jhansi Lakshmi B Sailaja P Senguttuvel SK Mangrauthia DivyaBalakrishnan	ICAR	2017-2020	55.00
11	ICAR-National Professor Project on “Development of Chromosome segment substitution lines of rice from elite x wild crosses to map QTLs/genes for yield traits”.	N Sarla (PI) Divya Balakrishnan	ICAR	2013-2020	250.00

S. No.	Title of the Project / Schemes	Name of the PI & Co-PI	Funding Agency	Duration	Budget (lakh Rs.)
12	ICAR-NPTC Project: Functional Genomics of Rice Micronutrients -Iron & Zinc.	N Sarla (PI) S K Mangrauthia	ICAR	2017-2020	3.60
13	Lal Bahadur Shastri Challenge Award: Enhancing the Farmers' Learning and Skill Development in Rice Sector: Creating Impact through Video and Mobile Extension Approaches.	Shaik N Meera (PI)	ICAR	2015-2018	35.00
14	ICAR-NPTC-network Project on Transgenics in Crops –FG iron and zinc changed as NPFGGM Network Project on Functional Genomics and Genetic Modification in Crops	N Sarla (PI)	ICAR	2017-2020	16.00
15	Transgenic over expression of phosphite dehydrogenase: A comprehensive strategy to enhance phosphorus use efficiency with integrated weed and disease management for sustainable agriculture.	M. Srinivas Prasad (PI)	ICAR	2017-2019	53.78
16	Enhancing the Farmers' Learning and Skill Development in Rice Sector: Creating Impact through Video and Mobile Extension Approaches	S. N. Meera (PI)	ICAR	2015-2018	35.00
17	ICAR-Emeritus Scientist Project -Molecular responses of rice under aerobic conditions	P. Ananda Kumar (PI)	ICAR	2019-2020	20.0
18	Identification and introgression of yield enhancing heterotic QTLs from wild species *Oryza rufipogon* into parental lines of hybrid rice	G. Padmavathi (PI) P. Revathi	ICAR extramural research grant	2016-2020	44.71
19	Molecular cross talk between defence pathways in rice: antagonism to synergism.	M Srinivas Prasad(CC PI)	ICAR-NASF	2015-2018	36.09
20	Genetic improvement of rice for yield, NUE, WUE, abiotic and biotic stress tolerance through RNA Guided Genome Editing (CRISPR/Cas9/Cpf1).	**S K Mangrauthia (PI)** M SheshuMadhav G S Laha R M Sundaram P Senguttuvel	ICAR-NASF	2018-2021	83.85
21	AICRIP – Biocontrol	C. Shanker(PI)	ICAR		
22	DUS Tests in Rice	L V Subba Rao (PI) J Aravind Kumar JyothiBadri	PPV&FRA	2008 – Long term	13.0

S. No.	Title of the Project / Schemes	Name of the PI & Co-PI	Funding Agency	Duration	Budget (lakh Rs.)
23	DBT Programme Support on "Development of sheath blight disease resistant transgenic rice: Resistance tests in PR-protein- expressing transgenic rice and discovery of new RNA silencing strategies.	S M Balachandran (Co-Leader & PI-1) S K Mangrauthia ((PI-2) M Srinivas Prasad G S Laha	DBT	2014-2019	153.53
24	DBT sponsored Project on "Marker-assisted introgression of yield enhancing genes to increase yield potential of Indian rice varieties.	RM Sundaram (PI) MS Madhav SM Balachandran P Senguttuvel JyothiBadri	DBT	2016-2021	82.504
25	Development of high yielding, non lodging and biotic stress resistant varieties of black scented rice of Manipur and Assam through biotechnological interventions.	M SheshuMadhav (PI) MS. Prasad	DBT	2016-2019	30.0
26	Exploiting amiR technology to target viral genes for curtailing the tungro virus infection in rice.	S K Mangrauthia (PI) S M Balachandran D Krishnaveni M SheshuMadhav	DBT	2015-2018	31.40
27	Maintenance, characteri-zation and use of EMS Mutants of Upland Variety Nagina 22 for functional genomics in rice-Phase-II.	S K Mangrauthia (PI) S R Voleti Divya Balakrishnan	DBT	2015-2020	93.03
28	Marker assisted introgression of different traits for development of new generation varieties.	JyothiBadri (PI) M S Prasad G S Laha AP Padmakumari B Sreedevi	DBT	2013-2019	88.18
29	Newton-Bhabha Virtual Centre on Nitrogen Efficiency of Whole Cropping Systems for improved performance and resilience in agriculture (NEWS India-UK).	D Subrahmanyam (PI) S R Voleti R Mahendra Kumar K Surekha C N Neeraja	DBT	2016-2019	90.78
30	Mass Production and field release techniques of *Tetrastichusschoenobii* Ferriere an egg parasitoid of rice stem borer	ChitraShanker (PI) M Sampath Kumar Gururaj Katti	DBT	2015-2018	44.00
31	DBT project on Maintenance, characterization and use of EMS mutants of upland variety Nagina 22 for functional genomics in rice – phase II, IIRR component- mutants for tolerance to low phosphorus.	N Sarla (PI) S K Mangrauthia	DBT	2015-20	

S. No.	Title of the Project / Schemes	Name of the PI & Co-PI	Funding Agency	Duration	Budget (lakh Rs.)
32	Mass production of stemborer and its egg parasitoid	C.Shanker(PI)	DBT	2015-2018	44.00
33	Mapping and introgression of weed competitiveness in hill rice genotypes in NEH regions of India under DBT program for NE.	**Gireesh C (PI)** M S Anantha P Senguttuvel R Abdul Fiyaz Mangal Deep Tuti	DBT-BCIL	2017-2019	14.00
34	Characterization of strong culm Sambha Mahsuri mutants and identification of candidate genes associated with strong culm	M Sheshu Madhav (PI) Kalyani Sunil Kulkarni R M Sundaram	DST	2018-2021	27.7
35	DST-ICRISAT Center of Excellence on Climate Change Research for Plant Protection (CoE-CCRPP): Pest and disease management for climate change adaptation (5 years)	**V Prakasam (PI)** M S Prasad G S Laha G R Katti ChPadmavathi ChitraShanker S K Mangrauthia M S Madhav D Subrahmanyam P Muthuraman	DST	2018-2023	87.96
36	Technological empowerment of tribal farm women through good agricultural practices and eco-entrepreneurship development in rice based cropping systems in Deverkonda mandal of Telangana	Amtul Waris (PI)	DST-SEED	2017-2020	51.97
37	Enhancing growth in rice through re-engineering genes in rice.	Divya P Syamaladevi (PI)	DST-SERB	2016-2019	29.85
38	RNA-seq based mapping of robust root system architecture for identification of candidate genes	Kalyani M Barbadikar (PI)	DST-SERB	2018-2021	44.18
39	Identification of novel alleles of wild rice derived bacterial blight resistance genes and their functional analysis.	**RM Sundaram (PI)** GS Laha Gireesh C	DST-SERB	2018-2021	18.28
40	Identification of heterotic yield QTLs in Swarna X *Oryza* rufipogon introgression lines (ILs) and transferring into parental lines of hybrid rice to enhance the magnitude of heterosis	P. Revathi(PI)	SERB	2018-2021	33.59
41	Characterization and understanding the genetics of resistance of *Ustilaginoideavirens* and Identification of false smut disease tolerant sources in rice	D. Ladhalakshmi (PI)	SERB	2019-2022	33.30

S. No.	Title of the Project / Schemes	Name of the PI & Co-PI	Funding Agency	Duration	Budget (lakh Rs.)
42	Upscaling of high yielding/elite Sambha Mahsuri mutant line SM93 for product translation	M Sheshu Madhav (PI)	CSIR	2018-2020	145.0
43	Towards product development in rice using mutants that have traits of agronomic importance	M SheshuMadhav (PI)	CSIR	2018-2020	143.3
44	CSIR 800 (Blight Out).	L V Subba Rao (PI) R M Sundaram P Muthuraman G S Laha U Chaitanya	CSIR-CCMB	2012-2019	25.0 /year
45	STRASA-Drought Breeding Network.	Jyothi Badri (PI) G Padmavathi Jhansi Lakshmi G S Laha	IRRI	2014-2019	USD4000 (INR 2.733)
46	Accelerating Impact & Equity: Adoption & impact Assessment under ICAR-IRRI Collaborative project #3.	Shaik N Meera (PI) S Arun Kumar	IRRI	2016-2019	14.10
47	Green Super Rice (GSR) for the Resource-Poor of Africa and Asia Phase III.	Shaik N Meera (PI) K B Kempa Raju Abdul Fiyaz R	IRRI	2017-2020	70.00
48	Increasing production and Productivity of ODISHA farmers	C. Shanker(PI)	IRRI -ODISHA		14.12
49	Stress Tolerant Rice for Africa and South Asia (STRASA)"	G Padmavathi (PI) B JyotiBadri G S Laha MS Prasad S N Meera B Sreedevi	IRRI/Bill & Melinda Gates Foundation.	2014 -2019	9.36
50	Genetic Improvement of Hybrid Rice Parental Lines for enhancing yield heterosis	A S Hari Prasad (PI)	ASEAN INDIA COOPERATION FUND, Jakarta, Indonesia	2017-2020	38.00
51	Evaluation of BAS 750 02 F 400g/l SC (Mefentrifluconazole 400g/l SC against sheath blight and Metiram 70% against blast of rice).	V. Prakasam (PI) M. Srinivas Prasad	BASF India	2016-2018	10.04
52	Evaluation of BAS 750-02-F400 g/l SC (Mefentrifluconazole 400 g/l SC) against sheath blight and grain discoloration of rice"	V. Prakasam (PI) M. S. Prasad	BASF India	2018-2020	17.00

S. No.	Title of the Project / Schemes	Name of the PI & Co-PI	Funding Agency	Duration	Budget (lakh Rs.)
53	Evaluation of Bioefficacy of BCS CL 73507SC 200 against eggs and larvae of yellow stem borer, *Scirpophagaincertulas*(Walker)"	G. Katti (PI) A P Padmakumari	Bayer Crop Science India ltd	2017-19	21.01
54	Efficacy evaluation of council Prime (Triafamone 200 SC) in puddled direct sown and transplanted rice	**Dr. B. Sreedevi**	Bayer Crop Sciences	2017-19	7.20 lakhs
55	Studies on performance of Wonder Paddy.	**R Mahender Kumar (PI)**	Dhana Crops Pvt. Ltd., Sec'bad	2017-2019	4.85
56	Strategy for sustainable crop production in direct seeded rice in India.	R Mahender Kumar (PI)	IIRR-BASF Project	2015-2017	16.08
57	Evaluation of Iron Coated seed for Direct Seeded Rice (DSR)	**Dr. R. Mahender Kumar**	JFE Steel Corporation Pvt. Ltd., Haryana.	2017-19	15 lakhs/ year
58	Evaluating the effect of Sea6 Biostimulant on the grain yield of rice under puddle conditions.	**R Mahender Kumar (PI)**	Sea6 Energy Pvt. Ltd., Bangalore	2017-2019	3.89

Appendices

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