PLANT PHYSIOLOGY

6. PLANT PHYSIOLOGY

CONTENTS

6. Plant Physiology

Summary

Physiological studies under All India C0-Ordinated Rice Improvement Program were conducted at six funded centres, (Coimbatore, Maruteru, Pantnagar, Pattambi, Rewa and Titabar), three ICAR institutions (DRR, Hyderabad, CRRI, Cuttack and IARI, New Delhi) and five voluntary centers (BHU Varanasi, NDUAT Faizabad, PJNAR, Karaikal, Zonal drought paddy station, Hathwara and RARS Karjat). The trials conducted during 2013 are given in a small table:

Star Chart of Plant Physiology Co-ordinated studies for the year 2013

Trial	***Locations selected/allotted trials***	***Allotted***	***Received***	*(%)*
PTI	*BHU, CBT, DRR, FZB, HAT, KRK, MTU, PNR, PTB, PUSA, SRI, TTB, UMM,*	*13*	*9*	*70*
SILICON	*CBT, CTK, DRR, HAT, KJT, KRK, MTU, PNR, PTB, PUSA, SRI, REWA, TTB, UMM,*	*14*	*11*	*79*
RFU (Drought)	*BHU, CTK, DRR, FZB, HAT, PTB, REWA,*	*7*	*7*	*100*
Heat Tolerance	*CTK, DRR, FZB, MTU, PNR, PTB, PUSA, REWA, TTB*	*9*	*8*	*92*
Multi Abiotic Stress	*CBT, CTK, DRR, HAT, KJT, KRK, MTU, PNR, PTB, PUSA, SRI, REWA, TTB, UMM,*	*14*	*9*	*64*

Salient findings of the experimental results, in brief, are presented below.

6.1. a) PHOTOTHERMIC INDEXING and RADIATION USE EFFICIENCY OF GENOTYPES :

The experiment was conducted at 9 locations across the country. The experiment was laid in split plot mode with three replications and under normal cultural practices with two dates of planting viz., early (15 days) and normal sown sets. About 20 rice cultures were selected for this study. The composition included top yielding 6 IET rice cultures, DRRH-3 and RP-4918-16630, susceptible cultures, US-312, and PR-113, varieties MTU 1010, IR-64 (all from previous year) and 8 new entries, Viz., IVT 2-IME (IET 22568, IET 22580 and IET 22592), NS-5, Shanthi, Sampada, and Akshayadhan. Consistently tested for four years and reported as promising entry under this program, i.e.., IET 20924 served as control against other test entries for validation. The variation in mean CDD and CNP with reference to the positive or negative was largely dependent on genotypes could be realized based on the phenology during the early and normal planting dates. The mean CNP at PI was differed by 8 cumulative days which increased to nearly 50 cumulative days by 50% flowering stage. It was significant that, the CDD though within the range of critical limits 1300-1500, slightly towards lower side under normal planting situation. Among the genotypes, comparable to

IET 20924, are DRRH-3 IET 22580, IET 22569, IET 22218 and NS-5 (NS-5 out of 8 locations CDD and CNP at 5 locations only) which are within the critical regimes of CNP at both PI, 50% flowering stage and also CDD at maturity stage. It is of interest to note that, the out of 8 cultures (6 IET and DRRH_3, RP -4918-16630) three IET cultures and DRRH-3 (except NS-5) are on the basis of previous study of Photothermic indexing.

In conclusion, genotypes with lower photo sensitivity and superior to IET 20924 as control revealed that, DRRH-3, IET 22580, IET 22569 and IET 22218 and new culture NS-5 at 5 locations met the critical limits of both CDD and CNP from PI to maturity stage. Leaving the other genotypes which were superior at 7 locations NS-5 at four locations fulfilled the PTI critical limits. The performance of this genotype at 4 of the locations in terms of grain yield supports the concept of PTI at field level. Selection of these genotypes for genetic improvement of rice breeding at molecular level might provide insights into flowering response in relation to environment.

RUE is the ratio of gross photosynthesis without respiration and photorespiration and root growth over a period which crops complete their life time. The above ground mass is generally converted to RUE i.e., the efficiency of capture of radiation that is intercepted by the crop. From the available PAR, the radiation that is intercepted in to the lower canopy due to larger LAI would be often <1% and therefore related to the indirect assessment of plant architecture. This study was conducted at six of the locations viz., BHU, CBT, MTU, DRR, TTB and PNR. Genotypes such as IET 20924, IET 22218, IET 22580, Akshayadhan, have higher RUE at PI stage while NS-5 had significantly lower RUE. The genotypes which had lower RUE had PI stage had higher RUE by maturity indicated that, the dry matter accumulation is not yet completed by the time of grain filling. The average RUE values reported for rice are 2.2 g/Mj at maturity stage. Under AICRIP, database for RUE stage wise are being collected for the past two years at limited locations indicate that RUE at PI to maturity stage is more important and determining factor for yield.

6.2. Influence of silicon solubilizers on induced stress tolerance in rice genotypes

Silicon accumulated rice genotypes were found to exhibit tolerance to biotic and abiotic stresses and also maintain nutrient balance. The ability of the silicon accumulation depends on roots accumulate as high as 10% on dry weight basis The solubility also depends upon the pH, acidity and alkalinity. The efficiency of Silicon solubility and availability can be enhanced by addition of carrier molecules or by direct means of application such as sodium, potassium silicates.

From the observations recorded, carrier molecule and Na, K silicate improved the partition of dry matter towards the tiller growth in both varieties and hybrids. Silicon application improved leaf photosynthetic rates at DRR and CBT. Also, it is correlated with silicilic acid contents in the leaf tissues. Locations wise, during the second consecutive year eastern region particularly CTK, TTB, (sandy or silty clay soils), PTB (sandy loam soil) and CBT (clay soil) silicon application was found to improve general crop health in terms of diverting the biomass with marginal influence on grain yield. Hybrids might need higher dose of silicon as compared to the varieties is evident from the internal leaf silicilic acid content**.**

6.3 Screening for high temperature tolerance in rice genotypes

This trail was conducted at 8 AICRIP centres (DRR, FZB, MTU, PNR, PTB, REWA, IARI and TTB) located across India. Heat stress was imposed by enclosing the crop with transparent polyethylene sheet supported by metal or bamboo frame. Enclosing the field crop during reproductive phase with polythene sheet had resulted in significant increase in temperature. In this trial, 26 rice cultures consisting of 19 IET(AVT-1-ME) cultures and 7 popular varieties including N-22 a known heat tolerant variety were included. The crop was allowed to grow inside the enclosure from anthesis until harvest. Based on the grain yield, DMHSI, GWHSI and spikelet sterility Sasyasree, IET 22116 and IET 21404 could be identified as relatively heat tolerant. However, the check variety N-22 performed exceptionally better at all the 8 locations where the trial was conducted during kharif-2013. Amongst the centers PTB centre the stress effect was more severe as revealed by highest GWHSI due to the fact that the crop was exposed to >7°C at this centre.

6. 4 Screening of elite rice cultures for drought tolerance (rainfed upland)

The drought tolerance traits of rice cultures with respect to yield and other attributes under dry spells investigated at 6 locations. In this trial 17 rice cultures consisting of 6 AVT-VE-DS and 10 IVT-VE-DS cultures and Anjali as check variety were included. At PTB, RWA and CRRI the rice cultures were grown under rain fed and irrigated conditions which facilitated computing yield based stress tolerance indices. During kharif-2013, the crop was exposed to brief dry spells during vegetative stage at Faizabad and CRRI location, and during reproductive growth crop was exposed to brief dry spells at BHU(Varanasi) centre. Based on the TDM and grain yield produced IET 22743, IET 22743. IET24061, IET 24064 and IET 24067 performed better at BHU, FZB and HAT centers. At PTB, CRRI and REWA centres the trial included an irrigation treatment which facilitated computation of drought susceptibility in.dices (DSI, DMSI, YS and GWSI). Based on these indices IET 24063, IET 23383, IET24064, IET 23383 and IET 22744 are relatively tolerant to water stress. Due to better rainfall distribution at most of the centres, the differences observed amongst the entries with respect to important drought indices were not significant

6.5 Physiological characterization of selected genotypes for multiple abiotic stress tolerance.

This trial was conducted at 8 locations in the laboratory and one location at a field. There were total 10 cultures, viz., 4 IET cultures selected from 2012-13 AICRIP physiology program, 4 promising lines from DRR biotechnology, AK Dhan variety and AC 39416-A from CRRI. During this year, water stress, NaCl stress, anaerobic stress and cold stress and the studies were restricted to germination %, root and shoot lengths and seedling vigour.

Though with reference to the of 25 d stress imposed, genotypic response appears to be maintained equally well except for the intensity. Among the various stresses, anaerobic stress signals seems to be stronger followed by NaCl and water stress. The strength of the seed to germinate under the anaerobic situation was drastically reduced to that of either water stress or NaCl Stress. Under the anaerobic situation, severe inhibition of root emergence irrespective of genotypes was observed at all locations. NS-1, IET 22116, IET 22218 had better shoot length after 25 d stress treatment. Rice cultures, NS-1, NS-3, NS-4, AC 39416 A were having relative superiority with reference to multiple abiotic stress tolerance and yield at field level except IET 22117, but could not confirm the multiple abiotic stress tolerance at any of the locations.

6.1.1. Photothermic Indexing and radiation use efficiency

Locations: BHU, CBT, DRR, FZB, KRK, MTU, PNR, PTB and TTB

Plant pheno-typing is a prerequisite to identify suitable donors to develop genotypes with wider climatic adaptability. India's natural geographical and weather variable situation are the best experimental sites for field pheno-typing. In this context, rice crop, being one of the major food cereal crops of Asia, may become susceptible, to future climate change situation wherein water scarcity in combination with increased temperature may result in poor crop productivity and yield. About 26% rice production comes from India, with a geographical cultivable area of 150 million he with 132 billion metric tonnes production. The most climatically adoptable rice crop cultivation is extended from banks of Amur River at 50^0 N to 40^0S to Central Argentina. Also it can be grown, as high as 2000m above sea level, Himalayas to hot deserts of Egypt. The wide adaptability of rice crop is not limited to its geographical regions but also its survival in a wide range of ecosystems such as semi deep, deep, irrigated, upland, and rainfed systems. AICRIP trails explores geographical advantage to its stride as the most inexpensive way for field level screening and selections of rice crop and offers strength for developing wider genetic diversity in rice breeding program. Further, the huge numbers of rice cultures developed in different geographical zones can be simultaneously experimented for their suitability to narrow down selections, so as to handle with ease in a shortened time frame more economically. In this regard, some of the physiological processes such as heading dates, flowering and grain filling phenomena are the most important ones whose regulation is associated with climate. Photothermic indexing trial under AICRIP is focused with the objective of identifying suitable donor lines for purpose of utilization in developing rice breeding lines. At 9 of the wider geographical locations the trials were conducted and the input data for modelling were received for analysis. The experiment was laid in split plot mode with three replications and under 15 day early and normal sown sets. About 20 rice cultures were selected for this study. The composition included top performed 6 IET rice cultures, DRRH-3 and RP-4918-16630, susceptible cultures, US-312, and PR-113, varieties MTU 1010, IR-64 (all from previous year) and 8 new entries, Viz., 2-IME (IET 22568, IET 22580 and IET 22592), NS-5, Shanthi, Sampada, and AK Dhan. Consistently tested for four years and reported as promising entry under this program, i.e.., IET 20924 served as control against other test entries for validation.

Quantification of the thermal and nyctoperiods was carried out using the phenology and weather parameters as described earlier (www.drr. nicra/8000; developed by Sailaja et al 2010 and Annual Progress Report Vol 3: 2004/05).

Phenology: The average time taken for PI, 50% flowering and maturity across the locations under early and normal sets of sowing dates were 78, 99 130 days and 71,94, 123 days respectively. Thus, a total of 7 days crop life cycle is compensated and also extended to the same extent in the early sown set of planting. In other words the crop duration is extended by 7 days over all by sowing in advance for 15 days and resulted in favourable periods during grain filling. Location and genotypic variation with respect to the stages was found to be significant. For instance, at PTB, CBT, KRK, MTU and PNR locations the crop reached PI stage (54 -70 days) while BHU, DRR, FZB, it was moderate (85 days) and as high as 101 days at TTB. Compensation of duration for 50% flowering and maturity was seen with respect to CBT, KRK, and PNR locations, but not MTU and PTB. On the other, the normal planting dates, as low as 49 days at PTB, to as high as 99 days at TTB for PI occurred. BHU, DRR, FZB, were moderate with reference to the duration for arriving PI stage. The trend remained similar with 50% flowering and maturity of the crop stage under normal set of sowing (Table 1).

Among the test entries, the duration of PI for NS-5, MTU 1010, IET 22568 had a duration of 70 days under both sets of planting dates. DRRH-3, RP-4918-16630 and Sampada took 82 days and 72 days under early and normal planting sets. The trend remained more or less similar with reference to the 50% flowering and maturity stages. Location wise, the crop duration was significantly higher at TTB, DRR and lower at PTB, MTU,KRK and CBT.

TDM (g/m2): The average TDM at tillering, flowering and maturity under early set of sowing date was 244, 875 and 1252 respectively. Except at 50% flowering stage, the mean TDM was more at normal set i.e TDM at tillering and maturity. The 7 days advanced planting of early sown set appears to induce dry matter accumulation by 50% flowering stage. Location wise, CBT, MTU at tillering stage, MTU, DRR, KRK, PNR at 50% flowering stage, and BHU, PNR and CBT at maturity had superior TDM under early set. Differences with TDM recorded at tillering stage under normal set were evident. For instance, at tillering stage, DRR, MTU and CBT the crop biomass was around 400g/m2 against an average of 300 g/m2 at these locations. FZB the TDM at tillering was lowest (88g/m2). At 50% flowering time, a clear spurge in crop growth in terms of TDM was evident. DRR, KRK, MTU, the TDM was >900g/m2 while it was lower at PTB, FZB,CBT and TTB. Due to the grain filling the TDM at maturity was lower at DRR, KRK while it was relatively poor at PTB, CBT and BHU. At other locations it was moderate (Table 2 to 4).

Amongst the genotypes, under early sown set Shanti and IR 64 had lower TDM and IET 22569, IET 22218, DRRH-3, IET 22580 had higher TDM and is about 1300g/m2. The same genotypes under normal set of conditions had TDM in the range of 1400g/m2 indicating that, the efficiency had been continued irrespective of sowing dates in these test entries. Some of the other entries which had lower TDM at early sown conditions did accumulate superior TDM under normal planting situation but inferior in their grain filling characteristic.

Grain yield: The mean grain yields under early and normal set of planting were 586 g/m2 and 511 g/m2 respectively. Thus, TDM accumulated in 7 days (advantage) under early sown condition resulted in better partitioning (75 g/m2) of metabolites into grain. Location wise, the grain yields were superior at BHU (711), CBT (781) and PNR (797) under early sown conditions. Lowest grain yields were recorded at MTU and TTB while at rest of the locations it was moderate. Under normal sown conditions, apart from BHU< CBT and PNR, additional two locations, i.e. TTB and FZB had superior grain yields than mean of the test entries. The grain yields were lower at MTU and PTB under normal set of conditions (Table 5).

Variation with reference to the locations : Between the two sets of plantings grain yields of early set except at TTB was superior. The advantage in grain yields varied from as lower as 11 g/m2 at CBT to as higher as 204 g/m2 at PNR. PNR, PTB, it was above 150g/m2, while at BHU, DRR, FZB, KRK and MTU and it was around 75 g/m2 under early sown situation as a result of 7 days extension in the 50% flowering time. Thus, it appears TDM at flowering time is one such determining factor in to grain yield.

Variation with reference to the Genotypes: Irrespective of locations, the mean grain yield difference between two sets of planting situations was 74 g/m2. Amongst the genotypes, the yield advantage was on the positive side ranged from 23-to 160g/m2.10 genotypes had more than mean advantage of sowing dates. Among these, IET 22569, DRRH-3, IET 22580, IET 22218, had grain yields more than the IET 20924, the one which was found to be superior in earlier trials. Based on the observations made earlier with reference to the other characteristic` features this new Entry IET 20924 was taken as control as its performance across the locations was consistent and stable for four consecutive seasons. This approach is adopted to narrow down identification of newer genotypes which is already available for the photosensitive traits such as critical thermal photoperiod (CDD) and cumulative nyctoperiod (CNP). Both these characteristics features were calculated for each of the location and genotype analyzed and discussed as below.

Cumulative Degree days and Cumulative nyctoperiods

Locations: Earlier, under this study, requirement of nycto period during the PI and flowering stage and its critical limits were reported. Also, reported were, the photoperiod and its significance with reference to grain filling stage. Accordingly, at PI stage and flowering stage, the critical nycto periods determined under the Indian geographical situation were 850-1000 and 1000-1200 for rice crop. The mean CNP across the locations in the present study under early and normal planting dates in the current year were well within the critical limits. A similar situation with reference to the mean CDD at maturity was also noticed. From the means of location, it could be realized that the critical limits varied in both positive, negative directions and also very few within the limits. The extreme being TTB on negative side, PNR on positive side and other locations it was moderate. Thus, influence of environment is superior at some of these locations is evident. At the locations which are well within the ranges the grain yields were undoubtedly superior supporting the concept of photothermic indexing and genotypes performed well irrespective of planting dates (Tables 6).

Genotypes: The variation in mean CDD and CNP with reference to the positive or negative was largely dependent on genotypes could be realized based on the phenology during the early and normal planting dates. The mean CNP at PI was differed by 8 cumulative days which increased to nearly 50 cumulative days by 50% flowering stage. It was significant that, the CDD though within the range of critical limits 1300-1500, slightly towards lower side under normal planting situation. Among the genotypes, comparable to IET 20924, DRRH-3

IET 22580, IET 22569, IET 22218 and NS-5 (NS-5 out of 8 locations CDD and CNP at 5 locations only) were falling largely within the critical limits of CNP at both PI, 50% flowering stage and also CDD at maturity stage. It is of interest to note that, the out of 8 cultures (6 IET and DRRH_3, RP -4918-16630) three IET cultures and DRRH-3 (except NS-5) were on the basis of previous study of Photothermic indexing and comparable with IET 20924. Genotypic variation is relatively higher and leading to lower stability under different planting situations particularly PI to maturity stages (Table 7).

In conclusion, genotypes with lower photo sensitivity and superior to IET 20924 as control revealed that, DRRH-3, IET 22580, IET 22569 and IET 22218 and new culture NS-5 at 5 locations met the critical limits of both CDD and CNP from PI to maturity stage. Leaving the other genotypes which were superior at 7 locations NS-5 at four locations fulfilled the PTI critical limits. The performance of this genotype at 4 of the locations in terms of grain yield supports the concept of PTI at field level. Selection of these genotypes for genetic improvement of rice breeding at molecular level might provide insights into flowering response in relation to environment.

Radiation Use efficiency (RUE): RUE is the ratio of gross photosynthesis without respiration and photorespiration and root a period of crops complete life time. The above ground mass is generally converted to RUE i.e., the efficiency of capture of radiation that is intercepted by the crop. From the available PAR, the radiation that is intercepted in to the lower canopy due to larger LAI would be often <1% and therefore related to the indirect assessment of plant architecture. This study was conducted at six of the locations viz., BHU, CBT, MTU, DRR,TTB and PNR. At other locations, the data provided was insufficient to analyze the radiation use efficiency of the genotypes. A model program was developed at DRR for analyzing the RUE of the genotypes, validated against the data generated using AICRIP plant physiology trials conducted at different locations for its applicability and the results reported previously in 2012 (for details please see AICRIP Report 2012: Vol 3 and www.drr. nicra/8000; developed by Sailaja et al 2012). The RUE analyzed across the locations and also genotype wise are presented in (Table 8 to 10).

Locations: The means of RUE of the six locations data, stage wise under early sowing was higher than the normal sowing. Among the six locations, RUE was significantly higher at TTB and DRR under both planting dates followed by PNR, MTU, PTB and CBT (Table). The RUE at PI stage under early planting date was higher and reduced very significantly by the time of maturity. Early or late planting dates the RUE was almost similar. RUE calculated between the two stages though a variation of 7 days in terms of phenology existed did not differ significantly. Thus, it would be only the genotypes as a result of leaf area and TDM accumulated and the grain filling resulting in variation in RUE.

Genotypes: The genotypic means of RUE across the locations at PI and maturity stage under early (1.66 and 1.02) and normal planting dates (0.53 and 0.56). Between the two stages of PI to maturity the RUE was 0.49 (early 0.47 and normal 0.51). Genotypes differed significantly in their RUE where in almost 3 fold decrease from PI to maturity stage was recorded under both early and planting dates. The genotypes which had >1.5 RUE at PI stage had produced larger TDM with few exceptions of higher leaf area. However, the genotypes accumulated with higher Leaf area did not have

Genotypes	RUE at Pi	RUE at PI to Mat	RUE at Mat
IET 20924	1.645	0.493	0.561
IET 22212	1.294	0.430	0.551
IET 22084	1.258	0.198	0.483
IET 22218	1.535	0.676	0.624
IET 22568	1.393	0.378	0.463
IET 22569	1.424	0.595	0.564
IET 22580	1.610	0.363	0.481
IET 22592	1.537	0.508	0.539
DRRH-3	1.226	0.355	0.469
LALAT	1.172	0.498	0.659
MTU-1010	1.165	0.774	0.599
PR-113	1.317	0.385	0.508
RP-4918-16630	1.340	0.367	0.569
Sasyasree	1.209	0.504	0.577
US-312	1.256	0.333	0.468
AK. Dhan	1.536	0.450	0.564
IR-64	1.343	0.661	0.602
Shanti	1.225	1.033	0.657
Sampada	1.410	0.513	0.607
NS-5 (SM-219)	0.984	0.294	0.417
Mean	**1.344**	**0.490**	**0.548**

RUE at later stages could be due to the oversized canopy. Genotypes such as IET 20924, IET 22218, IET 22580, Akshayadhan, have higher RUE at PI stage while NS-5 had significantly lower RUE. The genotypes which had lower RUE had PI stage had higher RUE by maturity indicating that, the Dry matter accumulation is not yet completed by the time of grain filling. The average RUE values reported for rice are 2.2 g/Mj at maturity stage. However, the RUE interception values stage wise were not received much attention. Under AICRIP, database for RUE stage wise are being collected for the past two years at limited locations indicate that RUE at PI to maturity stage is more important and determining factor for yield predictions. In this context, the values at PI stage are comparable to that of values generated and reported for rice crop while the values between PI to maturity indicate possibilities of enhancing the RUE further exists in rice crop. Thus, the above genotypes could be still photo synthetically active and continue to be assimilating and may have a characteristic feature of forming ready for next ratoon crop is to be verified.

Table. 6.1.1 PTI Study crop phenology at different locations Kh 2013

	Location	DOS	Tr.Date	Date of Pi		Days to 50% flow		Date of Mat	
	Early								
1	BHU	June,13	Jul,12	Sept,6	85	Sept,19	97	Oct,18	127
2	CBT	June,15	July,5	Aug,19	65	Sept,20	97	Oct,19	126
3	DRR	June,10	July,6	Sept,7	89	Sept,23	105	Oct,25	137
4	FZB	June,26	July,25	Sept,19	85	Oct,7	103	Nov,01	128
5	KRK	Aug,13	Oct,1	Oct,31	66	Nov,28	94	Jan,8	135
6	MTU	July,4	Aug,1	Sept,7	65	Sep,27	85	Oct,27	115
7	PNR	June,11	July,2	Aug,21	70	Oct,14	106	Nov,9	132
8	PTB	june,14	July,5	Aug,6	53	Sept,10	84	Oct,8	132
9	TTB	June,5	July,2	Sep,13	101	Sept,28	115	Oct,22	139
	Normal								
1	BHU	June,29	July,20	Sep,15	78	Sept,26	89	Oct,25	118
2	CBT	June,29	July,19	Sep,2	65	Sept,29	92	Oct,26	119
3	DRR	June,26	July,23	Sept,17	83	Oct,4	100	Nov,5	132
4	FZB	July,14	Aug,14	Oct,31	81	Oct,20	98	Nov,15	124
5	KRK	Sep,12	Oct,08	Nov,6	55	Dec,4	83	Jan,10	120
6	MTU	July,18	Aug,24	Sep,21	64	Oct,11	84	Nov,9	114
7	PNR	June,26	July,17	Aug,31	64	Sep,22	98	Nov,8	124
8	PTB	June,29	July,23	Aug,17	49	Sep,28	91	Oct,25	118
9	TTB	June,25	July,21	Oct,1	99	Oct,18	115	Nov,14	142

Table. 6.1.2 PTI Study TDM (g/m2) tillering stage at different locations Kh 2013

S.No.	Entries	CBT Early	DRR Early	FZB Early	MTU Early	PNR Early	PTB Early	TTB Early	Mean Early	CBT Normal	DRR Normal	FZB Normal	MTU Normal	PNR Normal	PTB Normal	TTB Normal	Mean Normal
1	IET 20924	398	81	122	324	197	316	352	256	338	314	78	368	208	288	305	271
2	IET 22212	450	140	106	357	214	248	245	251	394	409	76	368	219	225	180	267
3	IET 22084	339	132	87	416	222	395	192	255	283	473	64	406	228	359	177	284
4	IET 22218	294	103	66	365	242	275	222	224	238	355	76	384	219	250	209	247
5	IET 22568	459	112	111	393	203	279	200	251	403	323	70	420	214	254	163	264
6	IET 22569	394	101	88	375	225	344	195	246	338	334	78	384	231	313	171	264
7	IET 22580	322	83	113	323	217	205	282	221	266	454	99	453	222	187	158	263
8	IET 22592	311	121	95	293	233	270	250	225	255	373	88	415	228	245	134	248
9	DRRH-3	427	211	86	379	219	234	367	275	371	462	95	426	231	212	176	282
10	LALAT	379	168	116	368	233	287	297	264	425	461	111	423	231	261	158	296
11	MTU-1010	385	162	131	400	214	273	247	259	329	498	104	372	214	248	134	271
12	PR-113	424	155	82	359	236	241	251	250	368	314	64	405	228	219	129	247
13	RP-4918-16630	308	151	65	374	222	194	189	215	252	758	94	439	219	176	188	304
14	Sasyasree	312	174	120	371	233	210	237	237	300	433	114	436	219	191	143	262
15	US-312	370	165	130	403	205	224	188	241	306	558	92	404	230	203	161	279
16	AK. Dhan	207	123	131	382	222	209	213	212	226	346	105	480	214	190	184	249
17	IR-64	438	129	116	402	194	247	273	257	382	354	97	480	219	224	141	271
18	Shanti	326	146	137	396	219	301	210	248	306	551	87	409	233	274	181	292
19	Sampada	299	128	106	358	222	230	262	229	293	312	76	396	244	210	179	244
20	NS-5 (SM-219)	379	184	117	381	253	276	241	261	409	483	89	432	225	251	180	296
	Mean	**361**	**138**	**106**	**371**	**221**	**263**	**246**	**244**	**324**	**428**	**88**	**415**	**224**	**239**	**173**	**270**
	Ex. Mean	**342.51**	**283**	**97.12**	**393**	**223**	**251**	**209**	**257**								
	M and T	ns	ns	5.48	ns	ns	ns	72.07	38.78								
	T and M	ns	ns	5.9	ns	ns	ns	72.91	39.41								
	CD(0.05)	37.87	ns	3.87	47.27	ns	79.52	50.96	43.90								
	CV(%)	9.67	45.29	3.49	10.52	9.46	27.72	21.32	18.21								

Table. 6.1.3 PTI Study TDM (g/m2) flowering stage at different locations Kh 2013

S.No.	Entries	CBT	DRR	FZB	KRK	MTU	PNR	PTB	TTB	Mean	CBT	DRR	FZB	KRK	MTU	PNR	PTB	TTB	Mean
		Early	Early	Early	Early	Early	Early	Early	Early	Early	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
1	IET 20924	770	906	913	1363	1152	797	514	927	271	676	855	767	913	953	938	467	928	812
2	IET 22212	730	845	937	1142	1154	921	554	806	267	690	1080	746	1233	962	915	504	877	876
3	IET 22084	728	1063	922	900	1134	847	534	748	284	688	912	442	1346	1001	826	485	630	791
4	IET 22218	662	813	919	688	1162	869	439	568	247	622	951	604	1338	973	881	399	847	827
5	IET 22568	759	984	866	1325	1198	982	363	794	264	719	898	504	1133	969	878	330	884	789
6	IET 22569	828	897	787	1163	1189	969	697	859	264	788	887	925	1250	1031	876	633	576	871
7	IET 22580	719	1055	892	1163	1276	918	405	791	263	679	1079	637	1275	1038	864	369	669	826
8	IET 22592	661	843	940	1138	1242	864	479	778	248	621	920	750	1513	891	844	436	781	844
9	DRRH-3	665	1118	959	1163	1221	892	863	948	282	625	1178	791	2096	947	849	785	887	1020
10	LALAT	644	773	876	650	1135	851	547	667	296	1019	955	696	1117	835	895	497	758	846
11	MTU-1010	730	825	626	550	1103	893	564	872	271	690	1193	525	1250	965	897	513	574	826
12	PR-113	766	805	620	1292	1187	889	459	836	247	726	905	750	1175	940	908	418	561	798
13	RP-4918-16630	716	704	777	1100	1136	981	399	717	304	676	1076	808	1275	924	839	363	607	821
14	Sasyasree	713	813	875	1183	1179	936	464	813	262	727	906	567	1292	970	929	422	587	800
15	US-312	727	940	836	1075	1158	894	608	823	279	642	778	712	1183	898	899	553	586	781
16	AK. Dhan	812	910	809	988	1143	917	532	846	249	839	845	829	1075	971	862	484	721	828
17	IR-64	628	1042	833	1300	1139	956	396	828	271	588	904	442	1250	992	907	360	575	752
18	Shanti	734	1083	621	1763	1193	851	473	710	292	759	1053	858	883	932	839	430	755	814
19	Sampada	800	1030	813	1558	1161	999	595	888	244	811	1393	766	850	1007	947	541	760	884
20	NS-5 (SM-219)	850	654	821	1208	1073	920	732	608	296	845	842	508	783	1019	883	666	564	764
	Mean	**732**	**905**	**832**	**1135**	**1167**	**907**	**531**	**791**		**721**	**980**	**681**	**1211**	**961**	**884**	**483**	**706**	**829**
	Ex. Mean	**727**	**943**	**757**	**1173**	**1064**	**896**	**507**	**749**										
	M and T	ns	ns	55.83	262.6	91.6	ns	ns	148.0										
	T and M	ns	ns	71.3	432	106.5	ns	ns	156.8										
	CD(0.05)	130.6	238.2	39.5	185.7	64.7	69.1	138.3	104.7										
	CV(%)	15.7	22.1	4.6	13.8	5.32	6.75	23.9	12.22										

Table. 6.1.4 PTI Study TDM (g/m2) maturity stage at different locations Kh 2013

S.No.	Entries	BHU	CBT	DRR	KRK	MTU	PNR	TTB	Mean	BHU	CBT	DRR	KRK	MTU	PNR	PTB	TTB	Mean
		Early	Early	Early	Early	Early	Early	Early	Early	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
1	IET 20924	1740	1592	984	1650	1433	1938	1479	1545	1720	1512	914	1375	1204	1854	721	1534	1354
2	IET 22212	1740	1915	1002	1208	1435	1847	1013	1451	1680	2063	990	750	1213	1817	716	1471	1338
3	IET 22084	1740	1694	1092	1108	1415	1950	1540	1506	1670	1747	857	1775	1276	1900	1074	1477	1472
4	IET 22218	1740	1591	931	1192	1431	1921	1495	1471	1610	1889	1028	1533	1222	1840	514	1415	1382
5	IET 22568	1740	1928	1031	1225	1467	1696	1553	1520	1600	2111	1715	1567	1218	1800	648	1470	1516
6	IET 22569	1740	1631	950	1442	1416	1844	1730	1536	1630	1815	1005	1533	1279	1917	802	1589	1446
7	IET 22580	1740	1820	1093	1075	1503	1914	1520	1523	1570	1720	1086	1375	1286	1910	948	1428	1415
8	IET 22592	1740	1838	1102	1375	1468	1804	1207	1505	1670	1882	918	1550	1139	1857	585	1565	1396
9	DRRH-3	1740	1991	1492	1867	1448	1967	1563	1724	1930	2039	1274	1367	1170	1810	913	1648	1519
10	LALAT	1740	1461	1102	1458	1361	1878	1548	1507	1950	1038	895	1525	1078	1831	721	1566	1325
11	MTU-1010	1740	1628	1101	1042	1360	1799	1577	1464	1880	2114	1165	1200	1229	1908	564	1416	1435
12	PR-113	1740	1291	1014	1050	1444	1803	1443	1398	1790	2019	996	983	1204	1825	1050	1588	1432
13	RP-4918-16630	1740	1730	823	2633	1394	1749	1177	1606	1830	1983	985	1617	1188	1819	673	1662	1470
14	Sasyasree	1740	1638	1030	950	1437	1911	1542	1464	1680	1539	929	867	1234	1901	700	1434	1285
15	US-312	1740	1742	1147	1250	1405	1925	1549	1537	1810	1805	1175	1308	1162	1903	833	1690	1461
16	AK. Dhan	1740	1366	1435	1492	1367	2067	1243	1530	1700	1261	969	1008	1248	1878	700	1247	1251
17	IR-64	1740	1764	1213	950	1363	1904	1133	1438	1710	1922	1163	925	1268	1853	444	1205	1311
18	Shanti	1740	1011	1356	1192	1448	1810	1375	1419	1730	1094	1302	1183	1208	1792	284	1302	1237
19	Sampada	1740	1215	960	1833	1416	2047	1167	1483	1810	1262	870	1017	1283	1900	839	1647	1328
20	NS-5 (SM-219)	1740	1671	997	792	1328	1892	1240	1380	1760	1811	1460	867	1295	1914	882	1159	1393
	Mean	**1740**	**1626**	**1093**	**1339**	**1417**	**1883**	**1405**	**1500**	**1740**	**1731**	**1085**	**1266**	**1220**	**1861**	**731**	**1476**	**1389**
	Ex. Mean	**1740**	**1678**	**1089**	**1303**	**1319**	**1872**	**1440**	**1492**									
	M and T	0.21	266.31	ns	283.9	ns	ns	265.32	203.94									
	T and M	0.22	288.21	ns	277.35	ns	ns	316.09	220.47									
	CD(0.05)	0.15	188.31	301.3	200.75	70.72	123.6	187.61	153.21									
	CV(%)	7.03	9.81	24.21	13.48	4.69	5.77	11.4	10.91									

Table. 6.1.5 PTI Study Grain yield (g/m2) at different locations Kh 2013

S.No.	Entry	BHU		CBT		DRR		FZB		KRK		MTU		PNR		PTB		TTB		Overall Mean	
		Early	Normal	Early	Normal	Early	Normal	Early	Normal	Early	Normal	Early	Normal	Early	Normal	Early	Normal	Early	Normal	Early	Normal
1	IET20924	760	720	728	658	432	428	642	612	437	469	406	224	815	484	371	268	708	697	589	507
2	IET22212	788	708	886	866	553	300	575	560	229	250	274	282	690	661	419	157	623	467	560	472
3	IET22084	808	713	892	787	514	445	553	517	333	448	353	243	987	622	569	597	343	528	595	545
4	IET22218	812	770	813	768	499	406	702	666	417	500	339	329	911	580	450	134	628	507	619	518
5	IET22568	843	787	859	832	536	359	419	382	271	458	449	375	842	632	349	436	633	621	578	543
6	IET22569	812	670	835	817	405	373	530	502	563	198	560	375	864	618	698	391	697	607	663	506
7	IET22580	805	712	856	855	540	533	574	514	479	333	323	256	870	513	619	224	450	525	613	496
8	IET22592	790	643	875	866	461	353	619	564	511	427	426	422	900	598	496	124	257	495	593	499
9	DRRH3	767	620	865	817	776	600	573	538	562	562	418	289	863	528	743	324	623	654	688	548
10	Lalat	830	793	617	552	596	353	665	617	448	354	259	220	753	571	475	329	455	540	566	481
11	MTU1010	810	775	813	775	558	590	560	507	167	209	291	307	686	648	518	282	485	512	543	512
12	PR113	833	627	756	733	537	508	504	430	417	313	235	299	800	551	545	369	502	590	570	491
13	RP-4918-166-30	853	708	802	765	421	465	554	501	417	479	426	313	639	686	518	179	335	514	552	512
14	Sasyasree	783	730	755	724	430	387	611	548	271	260	329	271	831	694	461	336	663	570	570	502
15	US312	793	675	754	764	573	596	613	603	438	354	399	275	946	576	394	448	493	635	600	547
16	Akshayadhan	813	600	578	650	731	461	557	511	438	219	553	520	803	497	405	344	290	433	574	471
17	IR64	843	833	868	874	591	541	709	703	500	198	267	299	669	655	664	302	219	407	592	535
18	Shanti	847	707	654	720	685	664	437	407	385	365	314	290	805	513	392	526	372	460	543	517
19	Sampada	812	733	681	731	447	358	530	478	500	406	355	398	878	638	581	347	385	550	574	516
20	NS-5 (SM-219)	817	803	741	850	521	664	541	460	521	219	229	188	402	593	687	492	329	371	532	516
	Mean	**811**	**716**	**781**	**770**	**540**	**469**	**573**	**531**	**415**	**351**	**360**	**309**	**798**	**593**	**518**	**330**	**475**	**534**	**586**	**512**
	Grand Mean	**764**		**776**		**505**		**552**		**383**		**334**		**695**		**424**		**504**		**549**	
	LSD(Treat)			11.76																	
	LSD(Variety)			NS																	
	LSD (Treat x Variety)			NS																	
	CV(%)			15.88																	

Table. 6.1.6 PTI Study Photoperiod and nyctoperiod for PI, Flowering and Maturity stage at different locations Kh 2013

level	Loc	CDD PI	CDD FL	CDD Mat	CNP PI	CNP FL	CNP Mat
1	BHU	943	1098	1476	1089	1238	1572
1	CBT	756	1131	1490	813	1189	1530
1	DRR	1026	1220	1618	1121	1306	1667
1	FZB	945	1141	1167	1102	1293	1312
1	KRK	759	1100	1607	813	1156	1638
1	MTU	741	975	1339	829	1066	1414
1	PNR	766	1200	1528	932	1355	1632
1	PTB	604	1007	1342	654	1064	1389
1	TTB	1139	1316	1636	1284	1442	1710
	Early Means	**853**	**1132**	**1467**	**960**	**1234**	**1541**
2	BHU	861	993	1361	1005	1137	1474
2	CBT	748	1071	1407	805	1129	1453
2	DRR	942	1157	1552	1039	1248	1609
2	FZB	894	1091	1107	1050	1242	1256
2	KRK	635	961	1421	686	1019	1465
2	MTU	730	962	1325	817	1054	1402
2	PNR	686	1088	1433	848	1252	1553
2	PTB	568	1062	1392	617	1120	1438
2	TTB	1112	1322	1666	1258	1447	1748
	Normal Means	**797**	**1079**	**1407**	**903**	**1183**	**1489**

Table. 6.1.7 PTI Study Photoperiod and nyctoperiod for PI, Flowering and Maturity stage at different locations Kh 2013

S.No.	Entries	CDD_PI		CDD_FL		CDD_MAT		CNP_PI		CNP_FL		CNP_MAT	
		Early	Normal	Early	Normal	Early	Normal	Early	Normal	Early	Normal	Early	Normal
1	IET 20924	838	796	1099	1062	1407	1389	942	901	1195	1168	1472	1471
2	IET 22212	841	848	1080	1109	1386	1422	945	956	1177	1212	1455	1500
3	IET 22084	790	756	1032	1069	1347	1387	893	861	1132	1173	1421	1470
4	IET 22218	837	872	1120	1143	1397	1472	939	979	1227	1244	1464	1543
5	IET 22568	793	762	1050	1058	1360	1387	897	863	1149	1163	1432	1468
6	IET 22569	783	814	1013	1102	1357	1445	887	922	1110	1205	1430	1520
7	IET 22580	759	767	996	1049	1273	1389	860	873	1094	1155	1348	1471
8	IET 22592	796	827	1035	1094	1328	1406	898	933	1131	1200	1396	1487
9	DRRH-3	846	857	1093	1136	1392	1464	947	964	1184	1238	1451	1536
10	LALAT	798	754	1039	1066	1339	1400	899	859	1133	1171	1405	1480
11	MTU-1010	721	741	953	1055	1261	1398	822	845	1053	1160	1337	1482
12	PR-113	763	809	1025	1092	1305	1429	865	915	1121	1196	1375	1507
13	RP-4918-16630	858	850	1095	1125	1387	1448	959	957	1185	1228	1446	1521
14	Sasyasree	781	807	1013	1095	1332	1424	882	912	1107	1198	1396	1501
15	US-312	773	790	1008	1021	1295	1358	875	895	1105	1127	1367	1442
16	AK. Dhan	807	835	1049	1099	1348	1411	909	940	1143	1204	1411	1493
17	IR-64	732	742	964	1033	1270	1374	834	848	1063	1140	1345	1470
18	Shanti	797	769	1010	1043	1324	1367	898	875	1104	1150	1391	1452
19	Sampada	848	833	1087	1150	1372	1469	948	937	1176	1250	1434	1564
20	NS-5 (SM-219)	707	716	878	971	1186	1299	799	821	981	1080	1271	1391
	Mean	793	797	1032	1079	1333	1407	895	903	1128	1183	1402	1489

Table. 6.1.8 Radiation Use Efficiency at PI stage early and normal sowing dates at different locations Kh 2013

S.No.	Entries	CBT	DRR	MTU	PNR	PTB	TTB	Mean	CBT	DRR	MTU	PNR	PTB	TTB	Mean
		Early	Early	Early	Early	Early	Early	Early	Normal	Normal	Normal	Normal	Normal	Normal	Normal
1	IET 20924	0.54	10.49	0.57	1.18	0.44	0.88	2.35	0.64	2.37	0.49	0.75	0.39	1.02	0.94
2	IET 22212	0.49	5.57	0.50	1.10	0.57	1.28	1.58	0.45	1.69	0.49	1.10	0.56	1.75	1.01
3	IET 22084	0.47	6.08	0.42	0.97	0.24	1.60	1.63	0.50	1.45	0.42	0.92	0.29	1.74	0.88
4	IET 22218	0.77	7.61	0.50	0.83	0.38	1.47	1.92	0.94	2.14	0.49	1.17	0.50	1.63	1.15
5	IET 22568	0.32	6.64	0.46	1.10	0.16	1.61	1.71	0.35	2.38	0.42	0.64	0.48	2.17	1.07
6	IET 22569	0.45	6.45	0.49	1.01	0.36	1.61	1.73	0.52	2.27	0.48	1.04	0.40	1.99	1.12
7	IET 22580	0.52	9.35	0.58	0.97	0.56	1.15	2.19	0.61	1.66	0.39	0.88	0.66	1.99	1.03
8	IET 22592	0.61	7.42	0.65	1.02	0.51	1.26	1.91	0.77	1.91	0.46	0.90	0.55	2.37	1.16
9	DRRH-3	0.53	4.86	0.51	1.12	0.59	0.96	1.43	0.58	1.64	0.45	0.95	0.49	2.04	1.02
10	LALAT	0.43	4.57	0.53	1.05	0.40	1.39	1.40	0.36	1.53	0.46	0.87	0.34	2.13	0.95
11	MTU-1010	0.42	4.48	0.48	0.93	0.40	1.33	1.34	0.47	1.36	0.51	0.92	0.37	2.30	0.99
12	PR-113	0.39	4.81	0.52	1.04	0.52	1.27	1.43	0.55	2.41	0.46	0.86	0.50	2.46	1.21
13	RP-4918-16630	0.60	5.53	0.53	1.17	0.62	1.80	1.71	0.83	1.40	0.44	0.88	0.64	1.64	0.97
14	Sasyasree	0.54	4.25	0.48	1.07	0.50	1.36	1.37	0.53	1.59	0.39	1.11	0.47	2.22	1.05
15	US-312	0.45	5.32	0.44	0.99	0.52	1.72	1.57	0.54	1.37	0.45	0.79	0.56	1.92	0.94
16	AK. Dhan	0.89	7.17	0.47	1.09	0.56	1.53	1.95	0.87	2.20	0.38	0.80	0.68	1.78	1.12
17	IR-64	0.37	6.32	0.48	1.09	0.51	1.12	1.65	0.41	2.03	0.38	0.95	0.39	2.05	1.04
18	Shanti	0.51	5.59	0.47	1.03	0.44	1.59	1.61	0.54	1.18	0.45	0.85	0.35	1.71	0.85
19	Sampada	0.61	5.18	0.54	1.28	0.66	1.32	1.60	0.70	2.81	0.47	0.80	0.41	2.13	1.22
20	NS-5 (SM-219)	0.38	3.88	0.48	0.44	0.28	1.42	1.15	0.33	1.32	0.41	0.91	0.38	1.57	0.82
	Mean	**0.51**	**6.08**	**0.51**	**1.02**	**0.46**	**1.38**	**1.66**	**0.57**	**1.84**	**0.45**	**0.90**	**0.47**	**1.93**	**1.03**
	Grand Mean														
	LSD(Treat)														
	LSD(Variety)														
	LSD (Treat x Variety)														
	CV(%)														

Table. 6.1.9 Radiation Use Efficiency at PI to maturity stage early and normal sowing dates at different locations Kh 2013

S.No.	Entries	CBT Early	DRR Early	MTU Early	PNR Early	PTB Early	TTB Early	Mean Early	CBT Normal	DRR Normal	MTU Normal	PNR Normal	PTB Normal	TTB Normal	Mean Normal
1	IET 20924	0.162	0.338	0.103	0.094	2.506	0.088	0.548	0.147	0.537	0.143	0.117	1.601	0.085	0.438
2	IET 22212	0.121	0.344	0.110	0.098	1.720	0.115	0.418	0.119	0.596	0.140	0.096	1.633	0.071	0.442
3	IET 22084	0.147	0.263	0.119	0.099	3.628	0.066	0.720	0.131	0.900	0.143	0.102	-3.299	0.075	-0.325
4	IET 22218	0.138	0.420	0.110	0.105	2.487	0.067	0.554	0.102	0.475	0.136	0.095	3.902	0.072	0.797
5	IET 22568	0.142	0.389	0.112	0.116	0.749	0.065	0.262	0.101	0.413	0.149	0.149	2.082	0.070	0.494
6	IET 22569	0.170	0.512	0.118	0.101	3.422	0.057	0.730	0.140	0.593	0.136	0.091	1.732	0.066	0.460
7	IET 22580	0.134	0.295	0.100	0.100	1.533	0.063	0.371	0.139	0.637	0.148	0.102	1.032	0.076	0.356
8	IET 22592	0.135	0.289	0.101	0.098	0.943	0.090	0.276	0.118	0.716	0.171	0.105	3.260	0.066	0.739
9	DRRH-3	0.121	0.253	0.112	0.085	1.704	0.069	0.391	0.106	0.442	0.163	0.103	1.031	0.067	0.319
10	LALAT	0.249	0.381	0.114	0.088	1.779	0.069	0.446	0.146	0.868	0.177	0.109	1.931	0.071	0.550
11	MTU-1010	0.171	0.318	0.129	0.115	3.364	0.075	0.695	0.104	0.617	0.143	0.101	4.076	0.077	0.853
12	PR-113	0.241	0.429	0.111	0.089	1.701	0.083	0.442	0.115	0.594	0.145	0.107	0.942	0.066	0.328
13	RP-4918-16630	0.142	0.491	0.116	0.095	1.317	0.092	0.375	0.105	0.138	0.158	0.110	1.569	0.073	0.359
14	Sasyasree	0.156	0.414	0.111	0.093	1.727	0.070	0.429	0.147	0.761	0.154	0.091	2.253	0.071	0.580
15	US-312	0.158	0.298	0.120	0.102	1.227	0.069	0.329	0.066	0.505	0.155	0.106	1.121	0.067	0.337
16	AK. Dhan	0.175	0.272	0.122	0.086	1.596	0.095	0.391	0.179	0.532	0.152	0.110	1.989	0.091	0.509
17	IR-64	0.158	0.339	0.122	0.099	1.761	0.116	0.432	0.119	0.466	0.149	0.088	4.403	0.119	0.891
18	Shanti	0.304	0.259	0.113	0.106	3.935	0.079	0.799	0.244	0.502	0.150	0.110	6.503	0.096	1.268
19	Sampada	0.220	0.433	0.113	0.073	2.442	0.094	0.563	0.189	0.650	0.136	0.107	1.642	0.051	0.463
20	NS-5 (SM-219)	0.168	0.395	0.123	0.146	0.916	0.036	0.297	0.132	0.323	0.138	0.098	0.947	0.103	0.290
	Mean	0.171	0.357	0.114	0.099	2.023	0.078	0.474	0.132	0.563	0.149	0.105	2.017	0.077	0.507
	Grand Mean														
	LSD(Treat)														
	LSD(Variety)														
	LSD (Treat x Variety)														
	CV(%)														

Table. 6.1.10 Radiation Use Efficiency at maturity stage early and normal sowing dates at different locations Kh 2013

S.No.	Entries	CBT	DRR	MTU	PNR	PTB	TTB	Mean	CBT	DRR	MTU	PNR	PTB	TTB	Mean
		Early	Early	Early	Early	Early	Early	Early	Normal	Normal	Normal	Normal	Normal	Normal	Normal
1	IET 20924	0.257	1.118	0.207	0.205	1.439	0.275	0.583	0.255	1.162	0.246	0.187	1.108	0.271	0.538
2	IET 22212	0.207	1.068	0.206	0.211	1.292	0.394	0.563	0.181	1.040	0.243	0.217	1.274	0.276	0.538
3	IET 22084	0.210	0.951	0.208	0.197	0.818	0.258	0.440	0.189	1.179	0.229	0.199	1.081	0.272	0.525
4	IET 22218	0.255	1.229	0.208	0.196	1.373	0.274	0.589	0.206	1.037	0.249	0.221	1.946	0.299	0.659
5	IET 22568	0.183	1.036	0.203	0.233	0.460	0.256	0.395	0.148	0.860	0.244	0.206	1.446	0.282	0.531
6	IET 22569	0.238	1.124	0.216	0.211	1.596	0.228	0.602	0.210	1.053	0.238	0.205	1.183	0.263	0.525
7	IET 22580	0.202	0.975	0.202	0.198	1.097	0.257	0.488	0.210	0.987	0.232	0.193	0.940	0.285	0.475
8	IET 22592	0.215	0.978	0.211	0.216	0.807	0.331	0.460	0.206	1.137	0.266	0.200	1.638	0.258	0.618
9	DRRH-3	0.209	0.750	0.214	0.200	1.339	0.267	0.497	0.191	0.844	0.264	0.210	0.889	0.255	0.442
10	LALAT	0.285	0.993	0.227	0.207	1.138	0.270	0.520	1.521	1.175	0.284	0.206	1.343	0.264	0.799
11	MTU-1010	0.231	0.923	0.231	0.211	1.645	0.254	0.582	0.162	0.859	0.251	0.192	1.936	0.287	0.615
12	PR-113	0.288	1.087	0.212	0.211	1.253	0.281	0.556	0.194	1.037	0.250	0.200	0.823	0.260	0.461
13	RP-4918-16630	0.222	1.348	0.225	0.232	1.116	0.355	0.583	0.196	1.116	0.260	0.203	1.303	0.250	0.555
14	Sasyasree	0.228	1.076	0.205	0.213	1.253	0.268	0.541	0.221	1.120	0.237	0.208	1.613	0.286	0.614
15	US-312	0.221	0.977	0.212	0.196	1.030	0.257	0.482	0.145	0.906	0.254	0.189	0.983	0.244	0.454
16	AK. Dhan	0.283	0.772	0.221	0.193	1.279	0.356	0.517	0.302	1.127	0.238	0.189	1.460	0.345	0.610
17	IR-64	0.211	0.939	0.227	0.200	1.297	0.358	0.539	0.177	0.935	0.238	0.190	2.099	0.349	0.665
18	Shanti	0.369	0.773	0.210	0.216	1.623	0.312	0.584	0.327	0.786	0.251	0.207	2.496	0.320	0.731
19	Sampada	0.317	1.028	0.220	0.204	1.676	0.370	0.636	0.308	1.167	0.240	0.196	1.299	0.259	0.578
20	NS-5 (SM-219)	0.217	1.017	0.225	0.187	0.693	0.296	0.439	0.178	0.655	0.229	0.193	0.775	0.338	0.395
	Mean	**0.242**	**1.008**	**0.214**	**0.207**	**1.211**	**0.296**	**0.530**	**0.276**	**1.009**	**0.247**	**0.201**	**1.382**	**0.283**	**0.566**
	Grand Mean														
	LSD(Treat)														
	LSD(Variety)														
	LSD (Treat x Variety)														
	CV(%)														

6.1.2. INFLUENCE OF SILICON SOLUBILIZERS ON STRESS TOLERANCE RICE GENOTYPES

Locations: CBT,CTK, DRR, HAT, KJT, KRK, MTU, PNR, PTB, RWA and TTB

Elemental form of silicon is one of the most abundant on earth's crust, but essentiality of silicon has not been proven though large quantities of accumulation were reported in several crops, particularly rice. Silicon accumulated rice genotypes were found to exhibit tolerance to biotic and abiotic stresses and also maintain nutrient balance. The ability of the silicon accumulation depends on roots to take up and rice accumulates as high as 10% on dry weight basis. For sustainable rice production silica requirement is relatively larger than other major elements such as N,P and K. However, lower solubility and detection are two major constraints in understanding the role of silicon played in the plants. The solubility also depends upon the pH, acidity and alkalinity. The efficiency of Silicon solubility and availability can be enhanced by addition of carrier molecules or by direct means of application such as sodium, potassium silicates. Both soil application and spray were advised for several of the monocot species. In this context, efficacy of carrier application and the Na, K silicate as soil application under varied soil characteristic conditions for their suitability on rice crop is examined consecutively for the second year under AICRIP program. The experiment was laid in a split plot design with three replications at 11 locations on five each of hybrids and varieties. Apart from control, two treatments were imposed as soil application i.e. direct form of silicilic acid (Na, K Silicate @ 15 and 35ml at vegetative and Panicle initiation (PI) stage: T1) and 20gm carrier molecule T2 dissolved and applied in equal splits dose.

Observations: Phenological observations, portioning of leaf stem and panicle dry matter at different growth stages of crop were recorded. Grain yield and its components were also recorded. The leaf sap was extracted for silicilic acid estimation from five locations analyzed at DRR according to Kimio saito method (2005). At 2 locations where facilities were available for photosynthesis and its components, viz., CBT and DRR were recorded. Location wise and pooled analysis for TDM, Grain yield, HI and silicon contents were analysed for statistical significance. Information on soil ecosphere gathered during monitoring, characteristics used for identifying the utility of silicon application in relation to requirement of soil as amendment.

Phenology: Replicated data recorded at 8 locations on phenology is analyzed. At flowering stage, among the 8 locations only at 3 locations viz., MTU, HAT, DRR silicon influence was observed. However, when the crop reached maturity stage, the trend with reference to the locations was altered, where in viz., KJT,TTB and CBT treatment and at CBT varietal variation with reference to phenology was not significant. Excepting CTK and DRR for the crop to reach 50% flowering and maturity were within a range of 88- 98 days and 113-128 days respectively. Genotypic variation was found to be higher at MTU location.

Growth parameters: Leaf weight, Leaf area index (LAI) and culm weights at different growth stages:

In the previous year AICRIP trial with silicon application, we reported enhanced plant dry matter and total grain yields. In the current year partitioning of total dry matter into culm, leaf and leaf area index at different growth stages was monitored under the influence of silicon treatment. However this year also there was no stress imposition. Leaf weights (g/m2) recorded at individual growth stages did not vary significantly in all the three stage viz., tillering, PI and flowering except PNR. At this location, the leaf weights were relatively higher at all the three growth stages relative to the other locations (Table 1). Silicon treatment resulted in significant increase of biomass at MTU and PNR. However, the total biomass of the culms was 2-3 fold higher from tillering to flowering stage at PNR and DRR. Biomass of culm at CBT did not vary with respect to growth stage. The average minimum and maximum LAI recorded at tillering 1.80 (DRR: carrier) and 5.41 (CTK: carrier) shows the wide variability for this trait as influenced by treatment. Of the four locations where LAI is reported, three (except CBT) of the locations silicon influence was significant. However, it is surprising that, the total leaf weight did not increase significantly but for the culm weight. Thus, it appears that, silicon influence dry weight increase of the tillers as was reported data significant with reference to treatment are presented.

Leaf Photosynthesis (Pn): Leaf photosynthesis was measured using LICOR 6400 at CBT and DRR. The mean Pn at both the locations were comparable ranged between 20- 24. At both the locations silicon application improved Pn rate. At DRR the Pn rate was associated with variety, while at CBT treatment application was also significant. Similar trend with reference to other parameters i.e., stomatal conductance and transpirations were recorded were found to be at these locations. Additional parameters studied at DRR, such as internal carbon concentration and also intrinsic water use efficiencies were influenced by silicon treatment. It was interesting to note that carrier molecule application has relative advantage on leaf photosynthetic characteristics compared to the Na, K silicate and improving the general crop health (Table 2).

Leaf Silicilic acid content: The mean silicon content was 0.334 µmol (control). Both the treatments resulted in increased silicilic acid content in the leaf tissues confirmed uptake irrespective of treatment. However, application of Na, K silicate had superior silicilic acid content compared to the carrier molecule in the leaf tissues (0.434 and 0.398 respectively). Among the five locations, at PTB internal Silicilic acid content was significantly lower (0.099) while it was highest at DRR (0.841). The mean silicilic acid uptake was 100 µmol and 64 µmol per 100 ml cell sap by Na, K silicate and carrier molecules respectively (Table 3).

Genotypic variation with reference to the silicilic acid in the leaf tissues was apparent in the present study. Treatment resulted in superior tissue level silicilic acid content recorded in Hybrids, PA 6444, KRH-2 and varieties Nagarjuna, and Sampada. On the contrary, hybrids, PA 6201, PHB-71 and varieties AK Dhan and Varadhan did not respond to external silicon treatment. In general, hybrids had lower silicilic acid content and may require higher doses of external application.

Yield components:

TDM: Significant influence of silicon treatment and interactive influence of varieties was observed on TDM at harvest. Mean Total dry matter produced at the end of crop growth in control was 1557 g/m2.Silicon influenced an increase of 50g/m2 and 110 g/m2 under direct and carrier treatments respectively. The data however analyzed location wise yielded interesting results. Among the 10 locations at four locations, Viz., CBT, CTK, MTU and PNR TDM was found to be positively influenced and moderate but not significant at KRK,PTB,RWA and TTB and negatively at DRR and HAT (Table 4).

Grain yield: The influence of Na,K silicate was found to have significant influence on grain yield compared to the application of carrier molecule. Similar to TDM, there was an overall influence of treatment. At 5 of the locations, Viz., CBT,CTK, PTB,RWA and TTB an improvement in grain yield was noticed while at MTU and PNR it was moderate and DRR,HAT, KRK negative influence on grain yield was recorded (Table 5).

Genotypic variation: Silicon acts as only a beneficial element and till date the biochemical mechanisms have not been fully understood. Therefore, the application of silicon can has to be attributed as a preventive remedy rather than an accelerator. Since silicon role is attributed to the aboitic stress and biotic stress in the present experiment that was no stress treatment imposed. Hence the result with reference grain yield and other character may not be found significant at the applied silicon doses. The marginal increase in grain yield and silicilic acid in the leaf tissues was lower in hybrids except PHB 71. Varieties responded to the silicon treatment moderately with 25 g/m2 grain yield improvement. However there was no significant correlation between treatment and grain yield (Table 5).

HI : The mean HI of the genotypes was 37.5% in control situation. HI was improved by 1%. Unlike in the previous year where better partitioning was reported, in the current year, no such influence was noticed. The increase in the TDM and grain yield resulted in improving partitioning capability during the current year (Table 4).

In conclusion, carrier molecule and Na, K silicate did improve the partition of dry matter towards the tiller growth in both varieties and hybrids. Silicon application improved leaf photosynthetic rates at DRR and CBT. Also, it is correlated with silicilic acid contents in the leaf tissues. Locations wise, during the second consecutive year eastern region particularly CTK, TTB, (sandy or silty clay soils), PTB (sandy loam soil) and CBT (clay soil) silicon application was found to improve general crop health in terms of diverting the biomass with marginal influence on grain yield. Hybrids might need higher dose of silicon as compared to the varieties is evident from the internal leaf silicilic acid content**.**

Table 6.2.1 Summary table of means for Leaf area index, total dry matter, leaf and stem wt under silicon treatment Kh 2013

Silicon		LAI till	LAI-PI	LAI flow				TDM_till sq.mt	TDM PI	TDM/ m2_flow
MTU	Control	3.17	5.88	7.9		MTU	Control	316	508	857
	Na,K Si	2.6	6.32	8.4			Na,K Si	323	532	894
	Carrier	4.12	6.08	8.21			Carrier	337	535	901
T		NS	NS	NS		T		NS	NS	26.68
V		0.6	0.56	0.76		V		NS	NS	37.94
TxV		1.4	NS	NS		TxV		NS	NS	NS
CBT	Control	2.34	3.70	5.32		CBT	Control	243	542	874
	Na,K Si	2.72	4.46	6.15			Na,K Si	259	558	900
	Carrier	2.95	4.76	6.38			Carrier	271	571	917
T						T				5.01
V						V				5.31
TxV						TxV				NS
PNR	Control	3.00	5.69	6.42		PNR	Control	334	756	1255
	Na,K Si	3.69	6.14	6.90			Na,K Si	378	837	1347
	Carrier	3.75	6.32	7.06			Carrier	413	851	1391
T		0.57	0.23	0.44		T		13.7	72.8	NS
V		0.33	0.43	0.41		V		33.7	74.6	95.4
TxV		NS	NS	NS		TxV		NS	NS	NS
DRR	Control	2.07		4.31		DRR	Control	266		1187
	Na,K Si	2.01		4.44			Na,K Si	232		1184
	Carrier	1.80		4.75			Carrier	267		1197
T		0.21		NS		T		NS		NS
V		NS		NS		V		NS		NS
TxV		NS		NS		TxV		NS		NS
CRRI	Control	4.02	4.59			CRRI	Control	362		563
	Na,K Si	4.92	4.69				Na,K Si	381		591
	Carrier	5.41	4.82				Carrier	398		614
T		0.52	NS			T		NS		26.53
V		0.66	NS			V		81.27		NS
TxV		NS	NS			TxV		NS		NS
TTB	Control	2.65		5.20		TTB	Control	571		1173
	Na,K Si	2.63		5.00			Na,K Si	572		1165
	Carrier	2.68		4.90			Carrier	587		1146
T		NS		0.2		T		NS	NS	NS
V		0.2		NS		V		3.9	3.7	NS
TxV		NS		NS		TxV		NS	NS	NS
PTB	Control		3.07	4.54		PTB	Control			673
	Na,K Si		3.19	4.89			Na,K Si			758
	Carrier		2.98	4.59			Carrier			643
T			NS	NS		KRK	Control			1290
V			0.53	NS			Na,K Si			1371
TxV			NS	NS			Carrier			1411
						KJT	Control			1509
							Na,K Si			1635
							Carrier			1774
						HAT	Control			806
							Na,K Si			820
							Carrier			763
						T				NS
						V				113
						TxV				NS

Contd...Table 6.2.1 Leaf area index, total dry matter, leaf and stem wt under silicon treatment Kh 2013

		Leaf wt. till	Leaf Wt_PI	Leaf Wt flow				Culm Wt_till	Culm wt PI	Culm Wt_Flr
MTU	Control	109	266	356		MTU	Control	207	242	393
	Na,K Si	111	276	363			Na,K Si	212	256	415
	Carrier	116	277	367			Carrier	221	259	418
T		NS	NS	NS		T		6.7	11.63	NS
V		NS	23.1	NS		V		NS	20.41	27.14
TxV		NS	NS	NS		TxV		NS	NS	NS
CBT	Control	83	128	186		CBT	Control	161	413	536
	Na,K Si	91	137	196			Na,K Si	168	422	537
	Carrier	97	143	202			Carrier	174	428	543
T						T				
V						V				
TxV						TxV				
PNR	Control	154	269	406		PNR	Control	180	502	651
	Na,K Si	174	267	430			Na,K Si	204	556	689
	Carrier	190	303	442			Carrier	223	566	708
T		6.3	25.9	17.8		T		7.4	48.4	NS
V		15.5	26.5	18.2		V		18.2	49.6	29.2
TxV		NS	NS	NS		TxV		NS	NS	NS
DRR	Control	100		240		DRR	Control	167		777
	Na,K Si	89		239			Na,K Si	143		767
	Carrier	98		255			Carrier	169		765
T		5.97		NS		T		NS		NS
V		NS		NS		V		NS		NS
TxV		NS		NS		TxV		NS		NS
CRRI	Control					CRRI	Control			
	Na,K Si						Na,K Si			
	Carrier						Carrier			
T						T				
V						V				
TxV						TxV				
TTB	Control					TTB	Control			
	Na,K Si						Na,K Si			
	Carrier						Carrier			
T						T				
V						V				
TxV						TxV				

Table 6.2.2 .Silicilic acid content (Mmols/100Mmol sap) and photosynthetic characters under silicon treatment Kh 2013

	Means	Fv/fm	Pn (Mmols .m-2S-1	TRANS (mmol m-2S-1	Conductance (gs) mol.m-2S-1			
	Control	0.70	20.07	10.02	0.53			
CBT	Na,K Si	0.74	22.19	10.85	0.70			
	Carrier	0.76	23.87	11.14	0.72			
	T (0.5%)		20.2	11.91	0.501			
	V (0.5%)		21.13	12.53	0.473			
	T x V		20.46	11.28	0.427	Efficiencies		
						Transpiration	IWUE	Carboxylation
	Control		20.2	11.91	0.501	1.7	40.48	0.072
DRR	Na,K Si		21.13	12.53	0.473	1.69	45.46	0.078
	Carrier		20.46	11.28	0.427	1.84	48.58	0.075
	T (0.5%)		NS	0.73	0.04	0.11	4.6	NS
	V (0.5%)		2.08	1.19	NS	0.18	6.3	0.01
	T x V		3.6	2.07	0.098	0.31	10.91	0.015

Table 6.2.3 Influence of Silica application Study Silica content µmols per 1000 µl cellsap at AICRIP locations Kh 2013

Treat	S.No.	Varieties	DRR	KJT	PTB	TTB	PNR	Mean
Control	1	Akshaya Dhan	0.783	0.671	0.088	0.162	0.149	0.371
	2	KRH-2	0.609	0.400	0.098	0.222	0.134	0.292
	3	Nagarjuna	0.729	0.480	0.085	0.182	0.140	0.323
	4	PA-6129	0.725	0.475	0.110	0.198	0.107	0.323
	5	PA-6201	0.654	0.611	0.084	0.235	0.208	0.358
	6	PA-6444	0.743	0.420	0.110	0.217	0.123	0.323
	7	PHB-71	0.839	0.495	0.055	0.226	0.159	0.355
	8	Sampada	0.629	0.644	0.094	0.226	0.099	0.339
	9	Shanthi	0.418	0.448	0.106	0.220	0.141	0.266
	10	Varadhan	1.016	0.547	0.029	0.230	0.149	0.394
		Mean	***0.714***	***0.519***	***0.086***	***0.212***	***0.141***	***0.334***
T1	1	Akshaya Dhan	1.143	0.469	0.127	0.194	0.317	0.450
	2	KRH-2	0.891	0.384	0.215	0.344	0.594	0.486
	3	Nagarjuna	1.060	0.601	0.138	0.341	0.251	0.478
	4	PA-6129	0.838	0.404	0.080	0.311	0.259	0.378
	5	PA-6201	0.903	0.473	0.091	0.273	0.227	0.394
	6	PA-6444	1.027	0.497	0.055	0.291	0.299	0.434
	7	PHB-71	0.759	0.666	0.102	0.243	0.189	0.392
	8	Sampada	0.951	0.628	0.084	0.263	0.435	0.472
	9	Shanthi	0.740	0.481	0.047	0.254	0.262	0.357
	10	Varadhan	1.077	0.640	0.088	0.311	0.370	0.497
		Mean	***0.939***	***0.524***	***0.103***	***0.282***	***0.320***	***0.434***
T2	1	Akshaya Dhan	1.103	0.397	0.109	0.222	0.321	0.430
	2	KRH-2	0.878	0.557	0.111	0.265	0.229	0.408
	3	Nagarjuna	1.005	0.397	0.103	0.257	0.206	0.394
	4	PA-6129	0.965	0.577	0.058	0.286	0.146	0.407
	5	PA-6201	0.768	0.491	0.127	0.298	0.123	0.362
	6	PA-6444	0.970	0.529	0.184	0.344	0.141	0.434
	7	PHB-71	0.794	0.557	0.036	0.240	0.226	0.371
	8	Sampada	0.582	0.666	0.088	0.266	0.176	0.356
	9	Shanthi	0.579	0.467	0.162	0.251	0.266	0.345
	10	Varadhan	1.052	0.628	0.106	0.230	0.159	0.435
		Mean	**0.870**	**0.527**	**0.108**	**0.266**	**0.220**	**0.398**
		Grand Mean	0.841	0.523	0.099	0.253	0.189	0.381
		LSD (Treatment)	*NS*					
		LSD (Variety)	*NS*					
		LSD (Treat x Variety)	*NS*					
		LSD(Centre X Variety)	*0.086*	*(P<0.01)*				
		LSD(Centre x Treatment)	*0.085*	*(P<0.01)*				
		LSD (Centre x Treatment x Variety)	*0.149*	*(P<0.01)*				
		CV(residueal) %	*16.393*					

Table 6.2.4 Summary table of means for Grain yield components, TDM (g/m2), Grain yield (g/m2) and HI (%) under silicon treatment Kh 2013

		PNO/M2 havst	SPK PAN	Grain /pan	1000 gr Wt.g				TDM mat	Yield g/m2	HI (%)
MTU	Control	300	120	98	23.2		MTU	Control	1243	351	28.3
	Na,K Si	317	127	104	23.2			Na,K Si	1301	398	30.6
	Carrier	318	127	104	23.3			Carrier	1303	392	30.1
CBT	Control	319	210	180	23.7		TTB	Control	1310	491	37.82
	Na,K Si	354	221	191	24.4			Na,K Si	1310	461	35.23
	Carrier	372	232	200	24.9			Carrier	1347	500	37.01
TTB	Control	217	193	168	23.1		RWA	Control	1911	737	37.80
	Na,K Si	211	202	182	23.5			Na,K Si	1931	728	37.10
	Carrier	212	205	180	22.7			Carrier	1950	701	35.43
RWA	Control	270	180	164	23.8		PNR	Control	2039	755	37.03
	Na,K Si	283	193	171	23.9			Na,K Si	2409	817	33.92
	Carrier	275	181	166	23.8			Carrier	2523	798	31.64
PTB	Control	255	87	61	18.7		KRK	Control	656	477	41.57
	Na,K Si	272	81	50	20.5			Na,K Si	641	416	39.27
	Carrier	264	94	64	17.1			Carrier	758	494	39.63
PNR	Control	302	165	130	22.7		KJT	Control	420	541	49.66
	Na,K Si	338	165	136	23.8			Na,K Si	410	507	48.78
	Carrier	350	167	138	23.9			Carrier	400	535	50.24
DRR	Control	310	161	116	23.7		HAT	Control	942	530	5.78
	Na,K Si	302	164	118	23.5			Na,K Si	916	440	4.98
	Carrier	303	161	116	23.8			Carrier	846	460	5.46
KJT	Control	202	180	166	24.6		DRR	Control	1716	834	48.30
	Na,K Si	197	180	161	24.8			Na,K Si	1668	813	48.97
	Carrier	211	194	178	25.1			Carrier	1670	818	49.11
HAT	Control	212	143	115			CBT	Control	1242	674	54.2
	Na,K Si	219	145	114				Na,K Si	1396	770	55.2
	Carrier	219	138	110				Carrier	1346	728	54.1
CRRI	Control	272			21.77		CRRI	Control	864	365	42.01
	Na,K Si	253			21.67			Na,K Si	907	385	42.30
	Carrier	268			21.70			Carrier	948	384	40.41
							PTB	Control	1328	457	34.44
MTU		40.35*	4.37	4.02	0.39*			Na,K Si	1371	500	36.47
PNR		30.3/56*	23*	22*	0.6/1.6*			Carrier	1489	590	39.61
PTB		98.9*	29.6*	10.3/23.7*			T		30	NS	NS
RWA		6.55/54*	4.1/36.1*	3.85/33.8*	0.13/2.0*		V		NS	32	NS
CBT		7.6/7.9*	1.7/2.2*	0.12/0.21*	0.5/1.6*		T x V		NS	NS	NS
CTK		32.1*			2.8*		C X V		266	106	6.19
DRR		49*	35.1*	26*	3.1*		C x T		132	69	3.58
HAT	NS						C x T x V		NS	NS	8.15
KJT		43.3*	10.6/18.7*	10.6/10.8*	0.39/0.36*		CV (%)		13.9	15.4	13.4
TTB		26.5*	29.4*	26*							
* Variety sig											

Table 6.2.5 Influence of Silica application Study Grain yield (g/m2) at AICRIP locations Kh 2013

Treat	S.No.	Varieties	CBT	CRRI	DRR	HAT	KJT	KRK
Control	1	Akshaya Dhan	611	939	762	156	480	417
	2	KRH-2	718	787	857	39	562	521
	3	Nagarjuna	573	894	919	41	516	469
	4	PA-6129	730	918	1010	43	594	490
	5	PA-6201	778	824	838	44	581	542
	6	PA-6444	742	845	704	50	641	688
	7	PHB-71	754	924	888	39	608	396
	8	Sampada	601	830	768	39	601	469
	9	Shanthi	578	889	890	30	360	417
	10	Varadhan	659	790	705	46	462	365
		Mean	**674**	**864**	**834**	**53**	**541**	**477**
T1	1	Akshaya Dhan	725	978	816	44	463	490
	2	KRH-2	873	897	897	42	530	438
	3	Nagarjuna	587	939	929	50	476	354
	4	PA-6129	866	939	878	48	565	417
	5	PA-6201	820	871	784	46	424	438
	6	PA-6444	873	850	785	44	653	469
	7	PHB-71	825	932	822	48	557	438
	8	Sampada	754	883	743	41	623	458
	9	Shanthi	611	904	868	43	331	333
	10	Varadhan	761	871	609	39	448	323
		Mean	**770**	**907**	**813**	**44**	**507**	**416**
T2	1	Akshaya Dhan	658	1072	667	49	431	396
	2	KRH-2	837	893	860	45	559	510
	3	Nagarjuna	635	934	867	47	424	448
	4	PA-6129	873	930	865	45	633	521
	5	PA-6201	773	855	982	49	518	594
	6	PA-6444	840	980	701	46	730	469
	7	PHB-71	811	965	975	46	635	531
	8	Sampada	635	982	734	43	610	531
	9	Shanthi	622	914	839	48	321	479
	10	Varadhan	730	956	689	37	491	458
		Mean	**741**	**948**	**818**	**46**	**535**	**494**
		Grand Mean	728	906	822	48	528	462
		LSD(Treat)	68					
		LSD(Variety)	115					
		LSD (Treat x Variety)	NS					
		CV(%)	16					

Contd.. Table 6.2.5 Influence of Silica application Study Grain yield (g/m2) at AICRIP locations Kh 2013

Treat	S.No.	Varieties	MTU	PNR	PTB	REWA	TTB	Grand Mean
Control	1	Akshaya Dhan	334	712	370	575	385	522
	2	KRH-2	313	988	449	875	545	605
	3	Nagarjuna	395	198	356	675	553	508
	4	PA-6129	296	788	634	750	484	612
	5	PA-6201	288	797	588	925	592	618
	6	PA-6444	402	823	481	708	420	591
	7	PHB-71	419	1021	417	792	552	619
	8	Sampada	365	719	463	750	449	550
	9	Shanthi	373	687	361	700	451	522
	10	Varadhan	328	818	454	617	480	520
		Mean	**351**	**755**	**457**	**737**	**491**	**567**
T1	1	Akshaya Dhan	382	789	454	467	366	543
	2	KRH-2	364	1074	528	858	486	635
	3	Nagarjuna	433	397	352	650	539	519
	4	PA-6129	337	946	685	775	464	629
	5	PA-6201	328	886	449	892	553	590
	6	PA-6444	454	635	565	692	434	587
	7	PHB-71	503	1110	565	808	412	638
	8	Sampada	404	782	505	775	458	584
	9	Shanthi	407	658	384	725	427	517
	10	Varadhan	369	894	514	642	473	540
		Mean	**398**	**817**	**500**	**728**	**461**	**578**
T2	1	Akshaya Dhan	359	760	512	458	397	524
	2	KRH-2	339	968	782	842	570	655
	3	Nagarjuna	395	209	403	600	557	502
	4	PA-6129	344	911	546	767	498	630
	5	PA-6201	348	915	588	938	580	649
	6	PA-6444	437	916	727	692	433	634
	7	PHB-71	478	1048	611	750	554	673
	8	Sampada	401	715	699	733	477	597
	9	Shanthi	437	680	358	683	452	530
	10	Varadhan	381	860	671	550	484	574
		Mean	**392**	**798**	**590**	**701**	**500**	**597**
		Grand Mean	380	790	516	722	484	581
		LSD(Treat)						
		LSD(Variety)						
		LSD (Treat x Variety)						
		CV(%)						

6.3. Screening for high temperature tolerance in rice genotypes

Locations DRR, FZB, MTU, PNR, PTB, REWA, IARI and TTB

Climate change induced temperature and precipitation changes would affect crop production of countries. Data based on average across several species under unstressed conditions, revealed that, compared to current atmospheric CO_2 concentrations, crop yields increase at 550 ppm CO_2 in the range of 10-20% for C_3 crops and 0-10% for C_4. However, recent modeling studies suggest crops yield reduced with minimal warming in the tropics. Mid- to high-latitude crops may benefit from a small amount of warming (about +2°C) but plant health declines with additional warming. Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1 to 3°C depending on the crop, and then decrease beyond that in some regions (medium confidence). At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1 to 2°C), which would increase the risk of hunger. It was estimated that for every one degree rise in temperature the decline in rice yield would be about 6%. Decrease in yield of crops as temperature increases in different parts of India - For example a 2°C increase in mean air temperature, rice yields could decrease by about 0.75 ton/hectare in the high yield areas and by about 0.06 ton/hectare in the low yield coastal regions. Major impacts of climate change will be on rain fed crops which account for nearly 60% of cropland area. In India poorest farmers practice rain fed agriculture. The loss in farm-level net revenue will range between 9 and 25% for a temperature rise of 2-3.5°C.

The objectives of this work is to screen rice cultivars for high temperature tolerance and to understand the impact of high temperature stress on rice. This trail was conducted at 8 AICRIP centres located across India. Heat stress was imposed by enclosing the crop with transparent polyethylene sheet supported by metal or bamboo frame. Enclosing the field crop during reproductive phase with polythene sheet had resulted in significant increase in temperature. In this trial, 26 rice cultures consisting of 19 IET cultures (AVT 1 ME), and 7 popular varieties including N-22 a known heat tolerant variety were included. The crop was allowed to grow inside the enclosure from anthesis until harvest. The trial was conducted in Split-Plot design with treatments (Control and Heat stress) as main plot treatments and genotypes as sub-plot treatment with 3 replications.

Enclosing the field grown crop with polythene had significantly increased the temperature inside the tunnel. At DRR the average maximum temperature recorded from flowering to maturity was >4.1°C higher than ambient maximum temperature. The mean minimum temperature inside the tunnel was 3.1°C higher (Fig. 1). At REWA centre the mean maximum temperature inside the tunnel during the reproductive stage is 34.9° which is 2.5°C higher than the ambient maximum temperature. Similarly, the mean minimum temperature during the reproductive period is 2.1°C higher inside the tunnel (Fig.2). The mean maximum temperature inside the poly-tunnel at TTB centre was 34.17°C which is 4.17°C higher than the ambient mean maximum temperature recorded during the reproductive stage. Similarly, the mean minimum temperature recorded inside the tunnel was 1.6°C higher than the mean ambient minimum temperature (Fig.3). At PNR centre the mean maximum temperature recorded inside the poly-tunnel was 39.5°C which is >8.0°C higher than the average ambient maximum temperature recorded at this centre. The mean minimum temperature inside the tunnel was also 1.5°C higher than the ambient mean minimum temperatures. At PTB

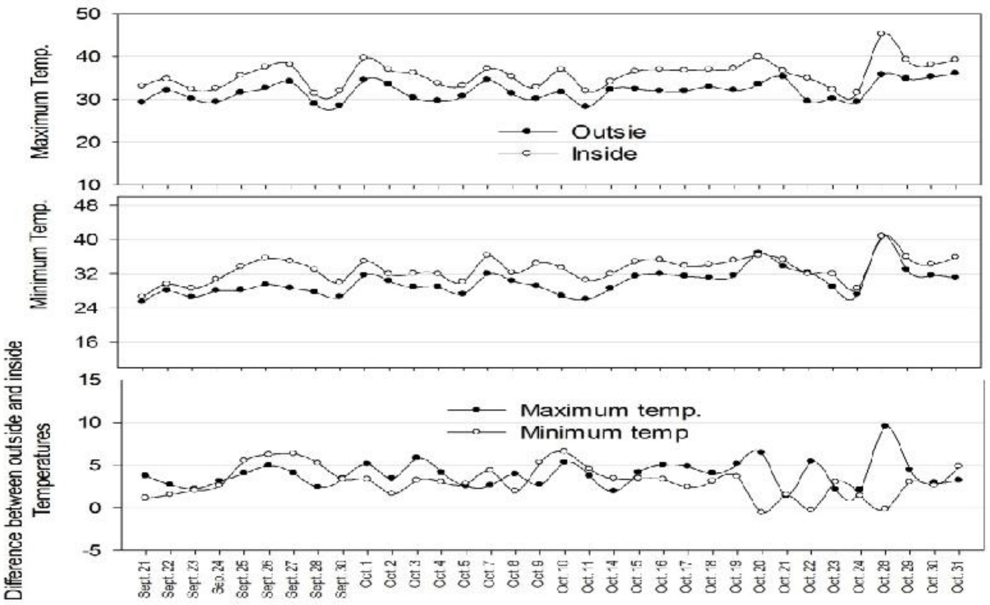


Fig. 1 Changes in maximum and minimum temperatures recorded inside and out side the polythene tunnel at DRR during reproductive phase (Sept.21 to Oct 31).

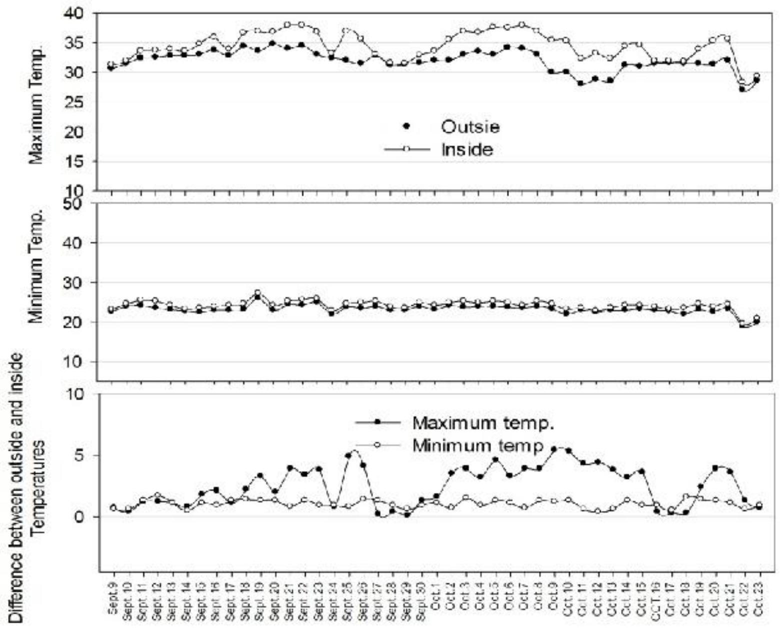


Fig. 2 Changes in maximum and minimum temperatures recorded inside and out side the polythene tunnel at REWA during reproductive phase (Sept.9 to Oct.23).

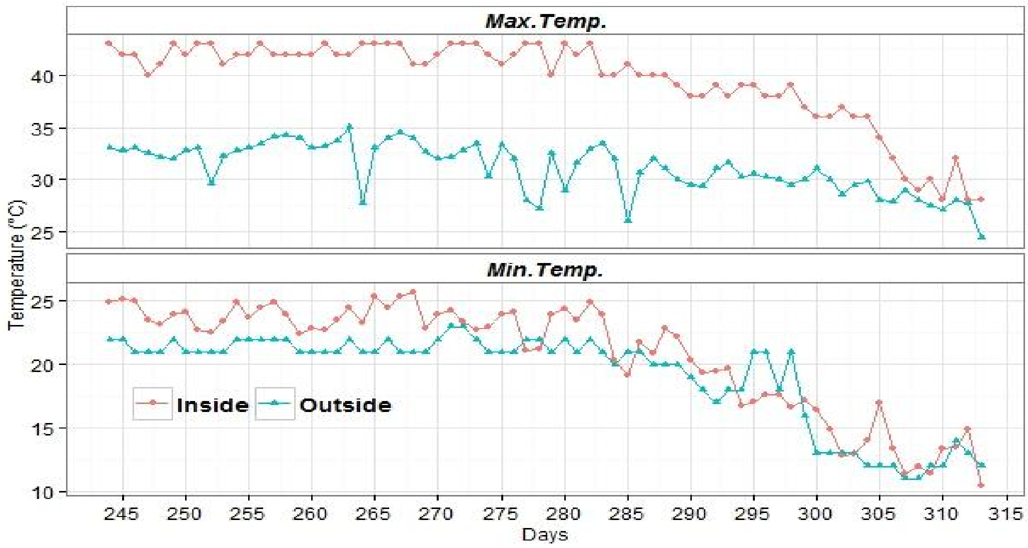


Fig. 3 Changes in maximum and minimum temperatures recorded inside and out side the polythene tunnel at Pantnagar (PNR) during reproductive phase (Sept.1 to Nov. 9,2013).

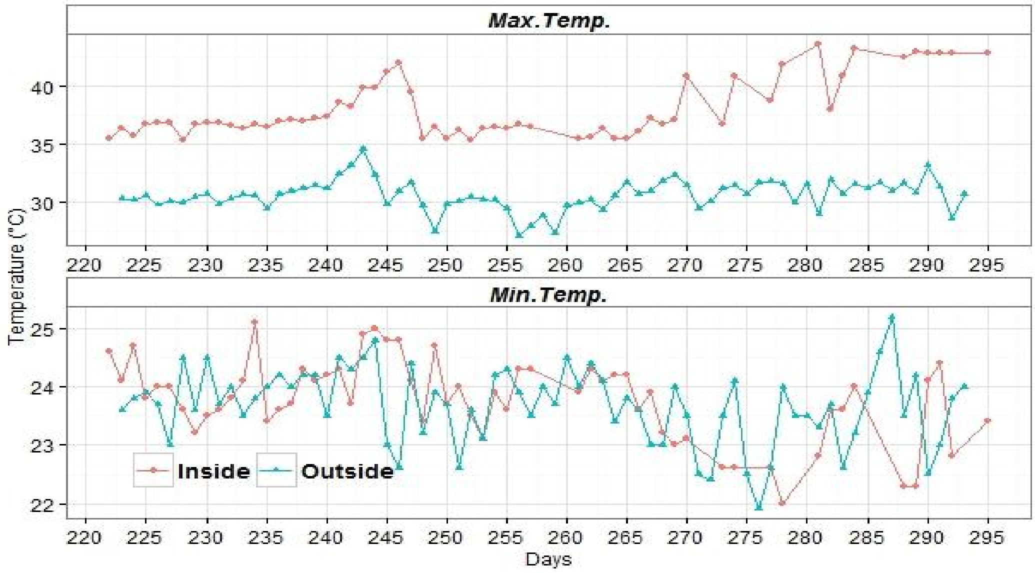


Fig. 3 Changes in maximum and minimum temperatures recorded inside and out side the polythene tunnel at Pattambi (PTB) during reproductive phase (Aug.8 to Oct.22 2013).

centre also enclosing the field grown crop had significantly increased the mean maximum temperature by >7 °C than the ambient maximum temperature. Whereas the mean minimum temperature recorded <0.5°C increase over ambient mean minimum temperature recorded during the reproductive phase of the crop.

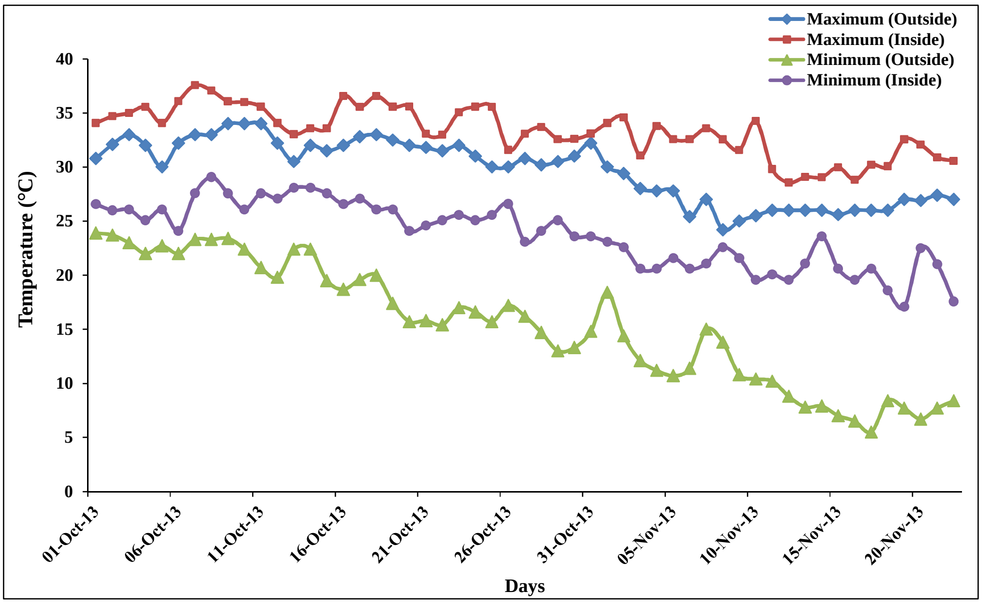


Fig.2. Maximum and minimum temperatures recorded outside and inside polychambers at IARI, New Delhi during high temperature exposure period (panicle emergence to maturity)

Significant differences were noticed in the days taken for 50% flowering amongst the genotypes across the locations. The mean days to flowering varied from 102 days at TTB to 84 days at MTU centre under ambient condition. Similarly, The days taken to reach physiological maturity also varied significantly across the locations. The mean days to maturity varied between 116 days(PTB) to 133 days(DRR). Significant differences were observed amongst the genotypes at all the centres. However, the differences amongst the treatments was found to be non-significant for all the centres except PNR and DRR where the differences were found to be significant and the crop matured 6 and 7 days late under heat stress conditions at DRR and PNR centres, respectively.

Perusal of the data TDM (g m^{-2}) revealed that a significant reduction in mean TDM for all the genotypes was discernible across the locations where the experiment was conducted. The interaction between treatments and locations was also found to be highly significant ($P<0.01$). Similarly, the differences amongst the genotypes across the locations was also found to be significant ($P<0.01$). The data on mean TDM of all locations for different genotypes revealed that the *Dry Matter Heat Susceptibility Index* varied between a minimum of 0.01 (IET 22896) to a maximum reduction of 22% (IET 22038). The DMSI for the check variety N-22 was 0.55 only. In case of IET 22894 TDM was not affected by heat stress with DMHSI of -2.0. IET 23279, IET 22219, IET 23300, IET 21411, IET 22116, Sayasree, IET 23297 and IET 22905 are the other entries with DMHSI value <10 indicating relative tolerance to heat stress (Fig.). Significant variation in DMHI amongst the varieties was noticed at IARI centre. IET23299, IET 22894 IET22116 and IET 23275 performed better than N-22 as the DMHSI of these entries were < N22 in these advanced entries (Fig.). The mean DMHSI for all centres and all varieties was >10%. At REWA, MTU and PTB centers the DHMSI was >20. No reduction in total dry mater was recorded at PTB centres and the mean DMHSI for all the varieties was negative indicating that the TDM under HT was higher at this centre (Fig.3)

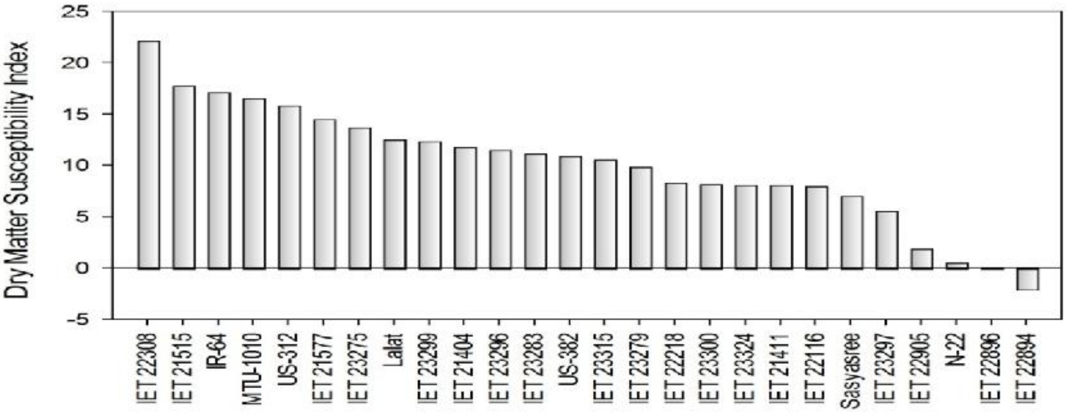


Fig. Mean Dry Matter Heat Susceptibility Index (DMHSI) of different rice genotypes estimated across 7 AICRIP locations during Kharif-2013

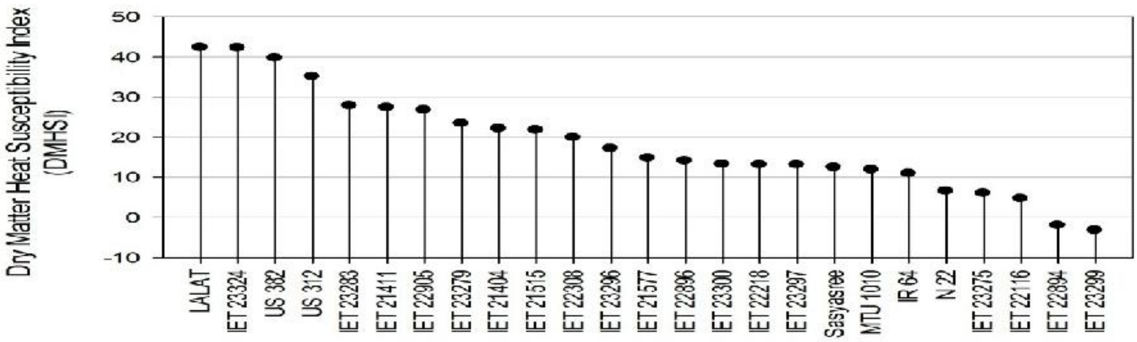


Fig. Mean Dry Matter Heat Susceptibility Index (DMHSI) of different rice genotypes estimated at IARI, New Delhi during Kharif-2013

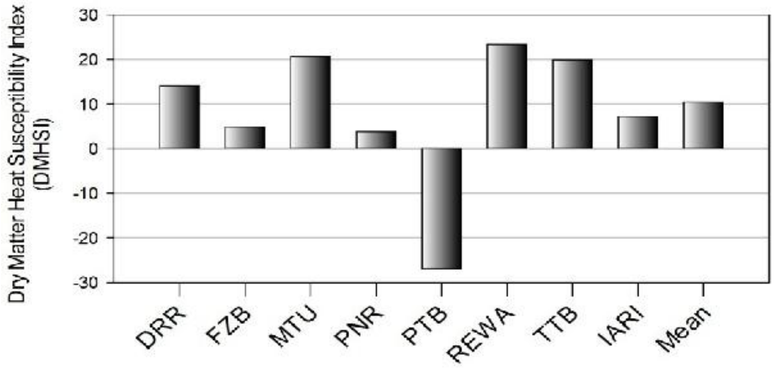


Fig. 3: Dry Matter Heat Susceptibility Index (DMHSI) for all the varieties across different AICRIP centres.

Exposure to high temperature caused marked reduction in 1000 grain weight of rice genotypes. The interaction between Location and Genotype, Genotype x Treatment and Location x Genotype x Treatment were also found to be highly significant (Table.). The reduction in mean 1000 grain weight for all varieties was maximum (20.5% reduction) at PTB centre and is only marginal in case of FZB and MTU centres(Fig.) The mean 1000 g weight for all locations revealed that the reduction in test weight varied from >26% over ambient control in Sasyasree and IET 23299 and a the reduction was lowest in N-22(15%) which is a known heat tolerant variety. In all other entries the reduction in test weight was >20% with respect to ambient control (Fig. 4).

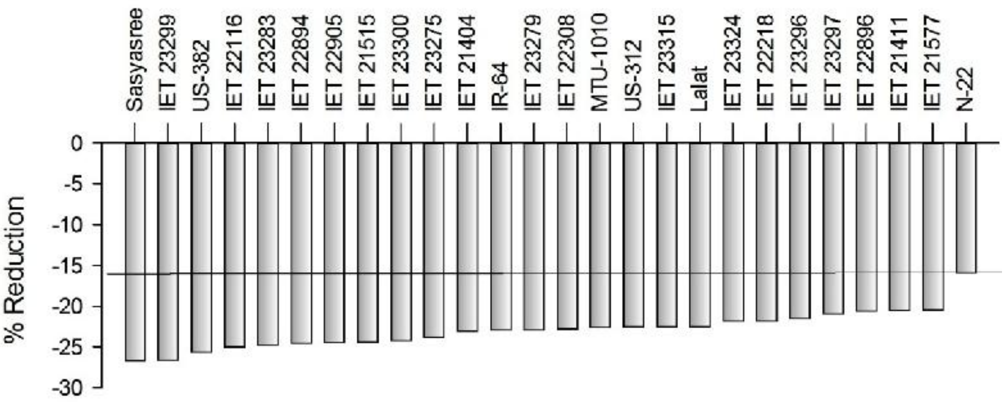


Fig. 4 Influence of high temperature during reproductive period on 1000 grain weight (mean of 8 AICRIP centres). Data was expressed as % reduction over ambient control.

The number of filled grains per panicle is an important yield determining character which was significantly (P<0.01) affected by high temperature stress (Table). The interaction between Location and Genotype, Genotype x Treatment and Location x Genotype x Treatment were also found to be highly significant (Table.). At PTB centre highest reduction in mean filled grains for all the varieties was observed (66% reduction over control) and minimum reduction was recorded at FZB (10% reduction) (Fig.5). The mean number of filled grains for all the locations revealed that the reduction was highest for IET 22894 (51% reduction) and lowest reduction was observed for Sasyasree (20%) which is less than the check variety N-22 (25% reduction).

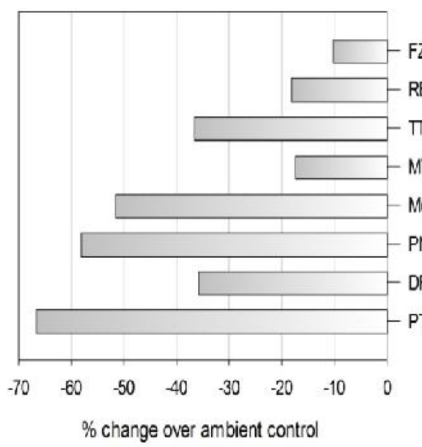


Fig.5: Influence of heat stress on mean No. of filled grains for all varieties across AICRP centres

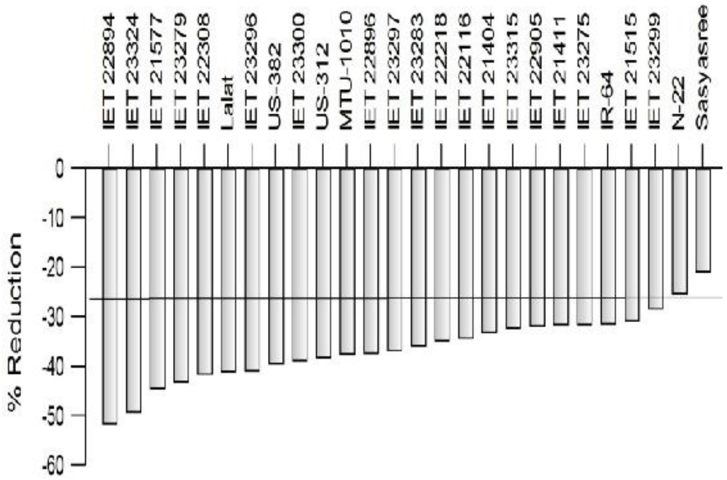


Fig.6 : Influence of heat stress on No. of filled grains of different rice varieties. Each value represents the mean of different AICRIP centres.

High temperature during post-anthesis period had significantly (P<0.01) increased the spikelet sterility represented by the number of unfilled grains in the panicle. Exposure to high temperature had resulted in 87% increase in average number of unfilled grains per panicle for all genotypes and locations. Highest increase was observed PNR (167% increase) centre followed by PTB centres. TTB and FZB recorded lowest increase in number of unfilled grains (Fig. 6). The average values across the locations for each genotype indicated that the increase in number of unfilled grains was highest for IET 23324 followed by IET 23296, IET 22304, IET 22905 and IET 23283 The genotypes with <50% increase in unfilled grains are US 382, N-22 and IET 21515 (Fig.7).

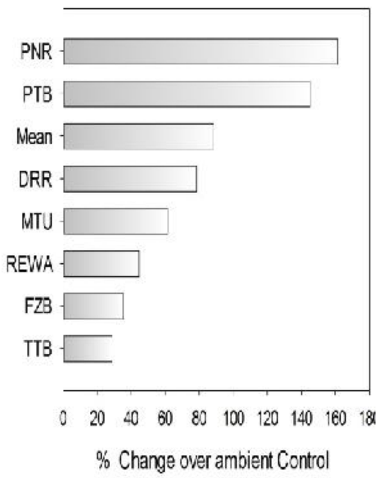


Fig. 6: Influence of high temperature on No. of unfilled grains. Each value represents mean of all tested varieties

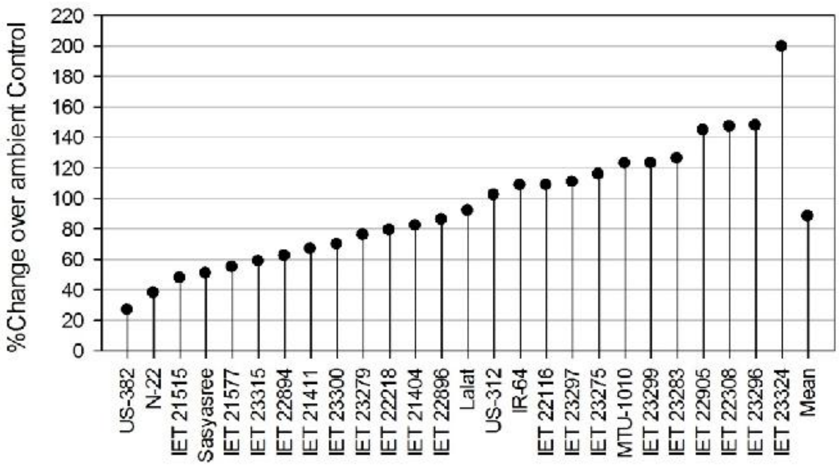


Fig.7: Influence of high temperature on No. of unfilled grains in different rice varieties. Each all locations. represents the mean of

a perusal of the data on grain yield (g m-^{2}) revealed that high temperature during post-anthesis period significantly reduced the grain yield. The mean grain yield for all genotypes was significantly reduced (P<0.01) across the locations. The interaction between location and treatment was also found to be significant (Table 5.4). Significant differences were noticed amongst rice genotypes for grain yield across locations. The mean grain yield for all the varieties and locations was significantly reduced (34%) reduction under high temperature stress. Significant variation was noticed among the varieties in their response to high temperature stress. The reduction in mean grain yield (g m^{-2}) was highest (>40%) in IET 23324, US-312, IET 23296, US-382, IET 23315 and IET 2379. The reduction in grain yield was >25% in N-22, IET 22116, Sasyasree and IET 21404. At IARI centre heat stress caused significant reduction in yield (20% reduction over ambient control). The Grain Weight Heat Susceptibility Index(GWHSI) was computed from the grain yield (g m^{-2}) recorded at both ambient temperatures and elevated temperature. The data revealed that the mean GWHSI for all entries across the locations was highest at Pattambi (PTB) centre followed by Titabar (TTB) and Pantnagar(PNR). Minimum reduction in grain weight was observed at Faizabad centre(FZB) Fig. 8. Significant variation was observed amongst the varieties in their response to the elevated temperature during reproductive phase. The data on mean GWHSI for all the locations show that highest GWHSI was observed in IET 23324, US-312, IET 23296, US-382, IET 23315 and IET 2379. The GWHSI was lowest (<5) in N-22 which is a known heat tolerant variety. None of the tested varieties recorded GWHSI values ≤ GWHSI of N-22 indicating susceptibility of these varieties to high temperature during reproductive growth. However, amongst the remaining varieties IET 22116, Sasyasree and IET

21404 performed relatively better with <25% GWHSI across the 8 locations where the trial was conducted during kharif-2013.

Based on the grain yield, DMHSI, GWHSI and spikelet sterility Sasyasree, IET 22116 and IET 21404 could be identified as relatively heat tolerant. However, the check variety N-22 performed exceptionally better at all the 8 locations where the trial was conducted during kharif-2013. Amongst the centers PTB centre the stress effect was more severe as revealed by highest GWHSI due to the fact that the crop was exposed to >7°C at this centre throughout reproductive phase.

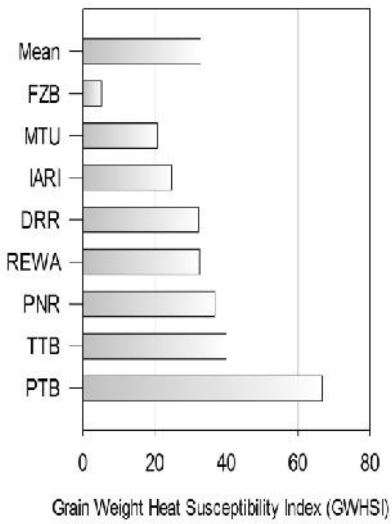


Fig.8 Influence of heat stress on Grain Weight Heat Susceptibility Index (GWHSI) at different AICRP locations. Each value represents the mean of all varieties.

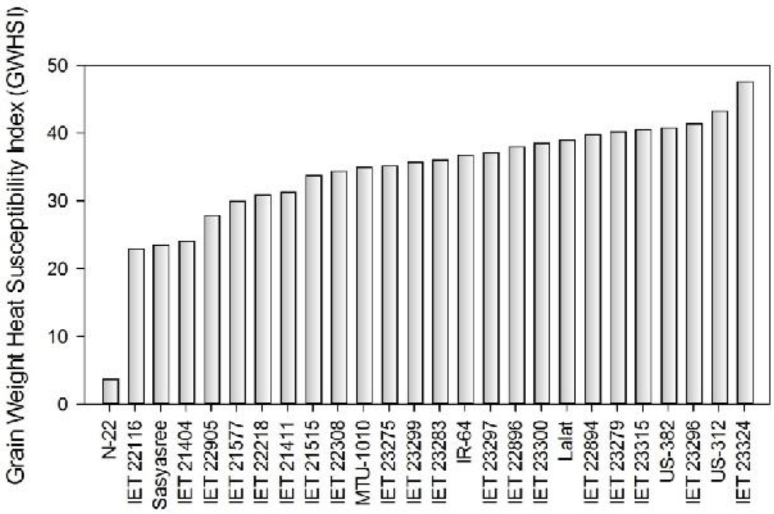


Fig. 9 High temperature effect on GWHSI of different rice varieties. Each bar represents the mean of all the 8 locations where the trial was conducted.

Table 6.3.1 Influence of Heat stress on Days to flowering at different AICRP Centres Kharif-2013

Treatment	S.No.	Genotype	DRR	FZB	MTU	PNR	PTB	REWA	TTB	Mean
Control	1	IET 21404	97	100	76	94	90	88	104	93
	2	IET 21411	97	100	76	93	77	87	104	91
	3	IET 21515	102	102	88	91	99	94	108	98
	4	IET 21577	98	101	87	90	90	87	104	94
	5	IET 22116	108	111	89	100	98	96	111	102
	6	IET 22218	107	107	93	97	104	96	112	102
	7	IET 22308	107	100	79	99	98	90	108	97
	8	IET 22894	97	94	77	86	88	87	95	89
	9	IET 22896	103	104	88	90	95	88	95	95
	10	IET 22905	103	93	87	88	96	87	107	95
	11	IET 23275	105	102	91	97	91	92	104	97
	12	IET 23279	99	94	85	65	84	94	95	88
	13	IET 23283	103	103	81	95	96	94	99	96
	14	IET 23296	103	103	93	92	89	92	106	97
	15	IET 23297	99	88	79	86	85	87	95	88
	16	IET 23299	98	99	87	92	91	95	104	95
	17	IET 23300	98	94	77	89	90	93	94	91
	18	IET 23315	106	109	87	107	99	93	106	101
	19	IET 23324	106	93	75	83	93	91	105	92
	20	IR-64	99	94	87	86	89	83	94	90
	21	Lalat	101	108	88	100	89	89	104	97
	22	MTU-1010	96	88	85	89	84	86	96	89
	23	N-22	87	87	79	78	59	86	85	80
	24	Sasyasree	102	103	95	106	82	94	106	98
	25	US-312	102	94	77	93	96	91	99	93
	26	US-382	102	99	79	101	93	91	106	96
		Control Mean	**101**	**99**	**84**	**92**	**90**	**90**	**102**	**94**
Heat Stress	1	IET 21404	103	100	77	90	79	88	101	91
	2	IET 21411	105	99	76	90	79	87	102	91
	3	IET 21515	108	101	88	90	88	94	104	96
	4	IET 21577	101	101	88	90	88	87	101	94
	5	IET 22116	110	111	89	108	99	96	109	103
	6	IET 22218	110	106	94	95	104	96	111	102
	7	IET 22308	110	99	79	97	97	90	105	97
	8	IET 22894	102	93	78	85	86	87	94	89
	9	IET 22896	108	97	88	90	94	88	95	94
	10	IET 22905	107	93	87	88	91	87	103	94
	11	IET 23275	109	101	91	96	97	92	102	98
	12	IET 23279	105	93	85	84	82	94	92	91
	13	IET 23283	107	104	80	93	91	94	100	95
	14	IET 23296	107	102	93	91	88	92	107	97
	15	IET 23297	103	89	79	89	89	87	96	90
	16	IET 23299	103	98	88	92	90	95	104	96
	17	IET 23300	104	95	77	88	87	93	95	91
	18	IET 23315	107	107	87	104	97	93	106	100
	19	IET 23324	108	122	75	89	90	91	105	97
	20	IR-64	102	94	87	85	85	83	92	90
	21	Lalat	105	108	88	98	83	89	104	96
	22	MTU-1010	99	87	85	86	83	86	93	89
	23	N-22	99	86	79	78	59	86	83	81
	24	Sasyasree	107	103	94	108	81	94	106	99
	25	US-312	107	94	78	92	98	91	100	94
	26	US-382	107	99	79	98	88	91	104	95
		Stress Mean	**106**	**99**	**84**	**92**	**88**	**90**	**101**	**94**
		Grand Mean	103	99	84	92	89	90	101	94
		Treatment			NS					
		LSD(Location x Treatment)			0.97		(p<0.01)			
		LSD(Genotype)			0.93		(p<0.01)			
		LSD(Location x Genotype)			2.46		(p<0.01)			
		Treatment x Genotype			1.32		(p<0.01)			
		location x Treatment x Genotype			3.49		(p<0.01)			
		CV(Residual) %			2.17					

Table 6.3.2 Influence of high temperature on Days to maturity at different AICRP centres

Treatment		Genotype	DRR	FZB	MTU	PNR	PTB	REWA	TTB	Mean
Control	1	IET 21404	129.3	126.3	105.0	126.0	114.0	116.7	128.3	120.8
	2	IET 21411	129.7	126.3	105.3	118.0	106.0	116.3	129.0	118.7
	3	IET 21515	134.0	127.3	116.7	128.0	126.0	123.7	134.7	127.2
	4	IET 21577	129.3	126.7	116.3	123.0	115.0	117.0	128.0	122.2
	5	IET 22116	139.0	137.7	117.7	149.0	123.0	125.3	138.7	132.9
	6	IET 22218	137.7	131.3	122.0	128.0	128.0	125.0	136.3	129.8
	7	IET 22308	138.3	124.7	108.0	125.0	123.0	123.3	134.0	125.2
	8	IET 22894	131.0	118.7	107.0	124.0	116.0	116.3	123.7	119.5
	9	IET 22896	135.0	122.7	116.3	123.0	120.0	116.0	124.0	122.4
	10	IET 22905	134.3	118.7	115.7	120.0	123.0	116.7	130.3	122.7
	11	IET 23275	138.3	127.7	119.7	127.0	118.0	124.7	132.7	126.9
	12	IET 23279	131.0	120.0	115.0	126.0	110.0	123.0	121.3	120.9
	13	IET 23283	134.0	128.3	110.7	127.0	123.0	123.3	126.3	124.7
	14	IET 23296	135.0	129.3	122.0	124.0	113.0	122.0	130.7	125.1
	15	IET 23297	131.0	112.3	108.0	121.0	111.0	116.3	120.7	117.2
	16	IET 23299	129.3	125.3	116.0	124.0	114.0	125.3	128.0	123.1
	17	IET 23300	129.3	119.7	106.0	123.0	116.0	123.3	118.7	119.4
	18	IET 23315	135.0	135.3	115.7	150.0	126.0	122.3	129.7	130.6
	19	IET 23324	137.0	147.7	104.7	111.0	120.0	119.0	130.0	124.2
	20	IR-64	129.0	148.7	116.3	112.0	116.0	115.7	120.0	122.5
	21	Lalat	134.3	135.7	116.7	151.0	114.0	118.3	127.7	128.2
	22	MTU-1010	127.0	113.7	114.0	122.0	112.0	116.3	121.0	118.0
	23	N-22	121.0	113.7	108.3	107.0	86.0	116.0	108.7	108.7
	24	Sasyasree	135.0	129.3	123.7	152.0	111.0	123.3	131.7	129.4
	25	US-312	135.0	122.0	107.0	128.0	123.0	120.0	126.7	123.1
	26	US-382	133.7	123.3	108.7	142.0	120.0	119.7	132.3	125.7
		Control Mean	**132.8**	**126.6**	**113.2**	**127.3**	**116.4**	**120.2**	**127.4**	**123.4**
Heat Stress	1	IET 21404	140.7	126.3	105.7	125.0	108.0	115.0	126.3	121.0
	2	IET 21411	141.0	125.7	106.0	128.0	108.0	114.0	126.3	121.3
	3	IET 21515	141.0	126.3	116.3	127.0	114.0	123.0	130.3	125.4
	4	IET 21577	137.0	126.7	116.7	128.0	114.0	114.0	125.3	123.1
	5	IET 22116	141.0	137.0	118.0	131.0	126.0	124.0	136.3	130.5
	6	IET 22218	142.0	131.7	122.0	126.0	128.0	124.0	136.0	130.0
	7	IET 22308	141.3	124.7	108.0	124.0	123.0	122.0	131.0	124.9
	8	IET 22894	138.7	118.3	107.0	130.0	113.0	115.0	120.0	120.3
	9	IET 22896	141.0	123.7	117.0	128.0	122.0	116.0	121.3	124.1
	10	IET 22905	141.3	119.7	116.0	127.0	118.0	115.0	129.0	123.7
	11	IET 23275	142.7	128.7	120.0	139.0	123.0	124.0	130.7	129.7
	12	IET 23279	137.0	120.3	115.0	141.0	110.0	123.0	120.7	123.9
	13	IET 23283	141.0	129.3	109.3	143.0	118.0	122.0	124.7	126.8
	14	IET 23296	140.7	129.7	122.0	140.0	118.0	122.0	129.0	128.8
	15	IET 23297	134.3	112.7	108.3	144.0	116.0	115.0	123.0	121.9
	16	IET 23299	135.0	126.3	116.7	146.0	116.0	123.0	125.3	126.9
	17	IET 23300	134.7	120.7	106.7	145.0	113.0	121.0	118.7	122.8
	18	IET 23315	136.3	136.3	116.0	146.0	123.0	121.0	128.3	129.6
	19	IET 23324	142.0	147.0	104.7	135.0	118.0	118.0	134.0	128.4
	20	IR-64	133.7	147.3	115.7	136.0	113.0	114.0	117.7	125.3
	21	Lalat	139.0	135.7	117.0	134.0	110.0	117.0	136.0	127.0
	22	MTU-1010	130.3	113.3	114.7	135.0	110.0	116.0	120.7	120.0
	23	N-22	126.7	113.7	108.7	110.0	113.0	115.0	105.3	113.2
	24	Sasyasree	139.0	128.0	123.0	144.0	111.0	122.0	130.0	128.1
	25	US-312	139.3	120.7	107.0	146.0	124.0	119.0	125.0	125.9
	26	US-382	140.7	125.7	108.3	143.0	113.0	119.0	130.3	125.7
		Stress Mean	**138.4**	**126.7**	**113.3**	**134.7**	**116.3**	**119.0**	**126.2**	**124.9**
		Grand Mean	**135.6**	**126.7**	**113.2**	**131.0**	**116.3**	**119.6**	**126.8**	**124.2**
		Treatment			0.38		(p<0.01)			
		LSD(Location x Treatment)			1.01		(p<0.01)			
		LSD(Genotype)			0.79		(p<0.01)			
		LSD(Location x Genotype)			2.10		(p<0.01)			
		Treatment x Genotype			1.12		(p<0.01)			
		Location x Treatment x Genotype			2.97		(p<0.01)			
		CV(Residual) %			1.13					

Table 6.3.3 Influence of Heat stress on TDM(g/m2) at different AICRP Centres Kharif-2013

Treatment		Genotype	DRR	FZB	MTU	PNR	PTB	REWA	TTB	Mean
Control	1	IET 21404	1930.7	1516.7	1086.2	1765.0	667.7	1416.7	1387.7	1395.8
	2	IET 21411	1767.0	1498.3	1246.4	1725.3	406.4	1250.0	1681.3	1367.8
	3	IET 21515	1943.7	1590.0	1259.4	1956.0	536.4	1316.7	1576.3	1454.1
	4	IET 21577	1589.0	1370.0	1243.1	2109.0	424.5	1166.7	1175.3	1296.8
	5	IET 22116	1709.3	1243.3	1246.4	2007.0	319.8	1250.0	1463.0	1319.8
	6	IET 22218	1362.3	1401.7	1240.3	1420.7	368.7	1316.7	1446.0	1222.3
	7	IET 22308	2180.7	1245.0	1274.2	1820.7	746.1	1783.3	1527.0	1511.0
	8	IET 22894	1762.3	1263.3	1158.1	1355.3	256.3	1200.0	1183.7	1168.4
	9	IET 22896	2040.0	1171.7	1092.0	1559.7	478.1	1366.7	1811.7	1360.0
	10	IET 22905	1603.7	1313.3	1055.2	1547.3	327.9	1266.7	1317.7	1204.5
	11	IET 23275	1764.7	1265.0	1194.7	1781.7	438.2	1933.3	1649.7	1432.5
	12	IET 23279	1751.3	1445.0	1030.7	1412.0	460.8	1733.3	1516.7	1335.7
	13	IET 23283	1345.7	1151.7	1138.2	1692.7	471.1	1683.3	1372.7	1265.0
	14	IET 23296	1779.3	1378.3	1182.3	1298.7	279.0	1383.3	1452.7	1250.5
	15	IET 23297	1362.3	1423.3	1119.7	1463.0	532.1	1183.3	1542.7	1232.4
	16	IET 23299	1651.7	1310.0	1166.3	1731.7	458.6	2075.0	1411.7	1400.7
	17	IET 23300	1696.7	1150.0	1230.0	1542.7	471.3	1250.0	1244.0	1226.4
	18	IET 23315	1917.7	1391.7	1362.3	2022.3	427.4	1266.7	1596.0	1426.3
	19	IET 23324	1763.0	1093.3	1247.8	1787.3	323.8	1241.7	1416.7	1267.7
	20	IR-64	1973.3	1359.0	1276.7	1778.0	210.9	1541.7	1436.3	1368.0
	21	Lalat	1841.0	1386.7	1197.7	1695.0	413.5	1383.3	1301.3	1316.9
	22	MTU-1010	1744.3	1171.7	1401.1	1532.0	318.2	1333.3	1351.0	1264.5
	23	N-22	1039.7	1326.7	1325.3	1326.7	268.4	1166.7	1454.7	1129.7
	24	Sasyasree	1239.3	1378.3	1374.0	1899.3	273.8	1291.7	1349.3	1258.0
	25	US-312	1756.0	1343.3	1368.9	1808.3	603.6	1733.3	1219.7	1404.7
	26	US-382	1521.3	1283.3	1337.1	1732.7	511.8	1766.7	1589.3	1391.7
		Control Mean	**1693.7**	**1325.8**	**1225.2**	**1683.5**	**422.9**	**1434.6**	**1441.3**	**1318.1**
Heat Stress	1	IET 21404	1465.0	1436.0	983.7	1859.0	621.7	1116.7	1135.7	1231.1
	2	IET 21411	1681.3	1423.7	1081.2	1839.3	303.6	1083.3	1386.7	1257.0
	3	IET 21515	1271.0	1508.3	974.7	1517.0	805.0	1091.7	1202.0	1195.7
	4	IET 21577	1447.0	1316.7	1016.5	1500.7	601.8	1041.7	834.0	1108.3
	5	IET 22116	1507.0	1180.0	928.4	1872.3	970.6	1058.3	983.3	1214.3
	6	IET 22218	1184.3	1347.3	924.3	1348.7	695.0	1083.3	1258.7	1120.2
	7	IET 22308	1391.0	1164.3	1099.0	1501.0	735.3	1158.3	1185.0	1176.3
	8	IET 22894	1667.3	1160.0	1072.8	1601.0	751.5	1050.0	1043.3	1192.3
	9	IET 22896	2125.3	1061.7	832.7	2003.7	937.5	1133.3	1424.7	1359.8
	10	IET 22905	1303.0	1258.3	858.5	1742.7	892.5	1125.0	1090.0	1181.4
	11	IET 23275	1543.3	1195.0	933.7	1523.7	821.8	1150.0	1485.3	1236.1
	12	IET 23279	1888.3	1395.0	815.2	1362.0	765.8	1091.7	1108.0	1203.7
	13	IET 23283	1434.0	1065.3	986.9	1374.7	992.7	1058.3	952.3	1123.5
	14	IET 23296	1192.0	1350.0	882.9	1551.7	605.2	1075.0	1085.0	1106.0
	15	IET 23297	1233.0	1378.3	1038.4	1555.7	620.1	1050.0	1266.3	1163.1
	16	IET 23299	1303.3	1256.7	859.2	1730.7	1132.2	1166.7	1142.3	1227.3
	17	IET 23300	1308.7	1129.3	1061.2	1540.0	753.5	1158.3	929.7	1125.8
	18	IET 23315	1553.3	1339.7	940.4	1937.3	619.5	1116.7	1418.7	1275.1
	19	IET 23324	1846.0	1029.3	1100.4	1332.0	546.2	1033.3	1267.3	1164.9
	20	IR-64	1172.0	1259.3	944.3	1471.0	780.1	1125.0	1180.0	1133.1
	21	Lalat	1373.7	1310.0	853.4	1857.3	529.5	1066.7	1072.0	1151.8
	22	MTU-1010	1355.0	1119.3	1014.0	1267.7	404.3	1166.7	1058.3	1055.0
	23	N-22	1558.3	1296.3	1006.0	1454.3	306.7	1000.0	1242.7	1123.5
	24	Sasyasree	1145.0	1300.3	855.5	1923.7	726.7	1133.3	1099.0	1169.1
	25	US-312	1320.0	1296.0	1173.4	1684.0	602.5	1208.3	990.7	1182.1
	26	US-382	1547.7	1235.7	1050.0	1756.0	865.7	1033.3	1187.3	1239.4
		Stress Mean	**1454.5**	**1262.0**	**972.6**	**1619.5**	**707.2**	**1099.0**	**1154.9**	**1181.4**
		Grand Mean	**1574.1**	**1293.9**	**1098.9**	**1651.5**	**565.0**	**1266.8**	**1298.1**	**1249.8**
		Treatment				15.59	($p<0.01$)			
		LSD(Location x Treatment)				41.25	($p<0.01$)			
		LSD(Genotype)				96.61	($p<0.01$)			
		LSD(Location x Genotype)				255.61	($p<0.01$)			
		Treatment x Genotype				136.63	($p<0.01$)			
		Location x Treatment x Genotype				361.49	($p<0.01$)			
		CV(Residual) %				13.7				

Table 6.3.4 Influence of high temperature on grain yield (g/m2) recorded at different AICRP centres

Treatment		Genotype	DRR	FZB	MTU	PNR	PTB	REWA	TTB	Mean
Control	1	IET 21404	719	683	345	534	312	475	467	505
	2	IET 21411	796	615	352	575	514	350	587	541
	3	IET 21515	884	775	372	791	664	475	433	628
	4	IET 21577	686	727	369	733	766	275	484	577
	5	IET 22116	801	623	403	492	371	400	468	508
	6	IET 22218	612	790	419	552	647	333	536	555
	7	IET 22308	647	618	353	640	727	605	508	585
	8	IET 22894	887	560	409	536	1511	287	401	656
	9	IET 22896	804	585	325	634	1370	450	472	663
	10	IET 22905	818	683	367	734	577	375	489	578
	11	IET 23275	823	605	475	699	523	675	554	622
	12	IET 23279	862	805	332	721	1080	575	466	692
	13	IET 23283	564	602	402	632	830	550	428	573
	14	IET 23296	805	693	364	592	754	300	488	571
	15	IET 23297	705	742	377	674	605	250	517	553
	16	IET 23299	919	598	410	680	469	697	448	603
	17	IET 23300	845	515	300	548	801	413	444	552
	18	IET 23315	875	565	369	665	847	400	436	594
	19	IET 23324	939	643	381	866	685	375	552	635
	20	IR-64	877	775	342	695	528	600	434	607
	21	Lalat	795	725	345	627	480	475	480	561
	22	MTU-1010	914	578	374	512	633	458	469	563
	23	N-22	493	767	351	399	472	208	473	452
	24	Sasyasree	553	617	381	773	356	400	510	513
	25	US-312	805	560	391	567	743	525	384	568
	26	US-382	575	560	377	631	710	550	492	556
		Control Mean	**769**	**654**	**373**	**635**	**691**	**441**	**478**	**577**
Heat Stress	1	IET 21404	459	633	284	537	191	325	259	384
	2	IET 21411	632	592	284	370	175	258	299	373
	3	IET 21515	513	732	302	609	182	317	262	417
	4	IET 21577	574	701	314	614	203	175	251	405
	5	IET 22116	554	577	284	567	241	275	248	392
	6	IET 22218	484	747	286	449	146	267	313	385
	7	IET 22308	362	565	267	584	230	425	261	385
	8	IET 22894	691	520	324	418	255	275	288	396
	9	IET 22896	648	537	256	579	198	375	290	412
	10	IET 22905	492	647	305	544	353	325	257	417
	11	IET 23275	565	577	378	366	162	425	356	404
	12	IET 23279	779	789	270	256	229	300	277	414
	13	IET 23283	576	553	317	323	264	233	301	367
	14	IET 23296	386	675	314	353	122	242	257	335
	15	IET 23297	414	728	300	332	205	133	328	349
	16	IET 23299	598	568	305	317	219	442	270	388
	17	IET 23300	471	501	241	290	151	417	311	340
	18	IET 23315	569	533	297	360	176	250	292	354
	19	IET 23324	321	606	301	364	196	258	286	333
	20	IR-64	390	723	290	344	371	267	308	385
	21	Lalat	412	680	285	255	216	250	301	343
	22	MTU-1010	499	553	309	275	231	433	267	367
	23	N-22	811	750	313	403	565	142	292	468
	24	Sasyasree	617	579	290	354	232	375	305	393
	25	US-312	328	534	302	296	237	317	249	323
	26	US-382	413	536	252	282	238	250	339	330
		Heat Stress Mean	**521**	**621**	**295**	**402**	**230**	**298**	**287**	**379**
		Grand Mean	**645**	**637**	**334**	**518**	**461**	**370**	**382**	**478**
		Treatment				11.03				
		LSD(Location x Treatment)				29.19				
		LSD(Genotype)				54.23				
		LSD(Location x Genotype)				143.49				
		Treatment x Genotype				76.70				
		Location x Treatment x Genotype				202.93				
		CV(Residual) %				20.12				

Table 6.3.5 Influence of high temperature stress on 1000 grain weight recorded at different AICRIP centres

Treatment		Genotype	DRR	FZB	MTU	PNR	PTB	REWA	TTB	Mean
Control	1	IET 21404	23.1	27.3	24.1	22.3	24.3	25.1	25.5	24.5
	2	IET 21411	21.8	25.2	22.8	25.2	19.9	23.5	23.6	23.1
	3	IET 21515	26.9	28.8	23.9	33.0	32.3	24.6	21.5	27.3
	4	IET 21577	20.1	29.3	21.2	19.8	22.3	23.7	22.4	22.7
	5	IET 22116	22.3	28.0	24.3	25.2	28.6	24.5	22.2	25.0
	6	IET 22218	23.2	26.8	21.3	21.3	26.4	23.5	23.8	23.8
	7	IET 22308	25.8	29.3	24.3	25.6	30.9	25.9	22.1	26.3
	8	IET 22894	22.9	28.7	18.9	24.5	30.2	22.9	21.6	24.2
	9	IET 22896	20.8	28.8	18.4	21.7	24.4	25.4	19.9	22.8
	10	IET 22905	23.3	27.5	23.2	23.1	30.7	25.4	23.8	25.3
	11	IET 23275	27.7	25.8	25.7	28.1	32.6	25.8	22.7	26.9
	12	IET 23279	17.8	29.2	18.2	17.9	21.2	26.0	21.7	21.7
	13	IET 23283	23.5	29.5	20.0	24.0	30.4	24.3	22.3	24.8
	14	IET 23296	21.0	27.2	20.4	22.4	23.1	23.6	22.9	22.9
	15	IET 23297	23.9	28.2	21.8	23.2	27.7	22.1	21.2	24.0
	16	IET 23299	26.7	29.2	21.3	28.3	34.2	27.0	21.2	26.8
	17	IET 23300	22.5	28.8	21.3	22.2	29.5	25.3	20.8	24.3
	18	IET 23315	22.4	28.0	20.4	22.6	28.6	23.2	21.5	23.8
	19	IET 23324	21.0	25.5	23.1	21.1	23.5	23.6	24.2	23.2
	20	IR-64	27.0	28.2	26.6	23.2	29.0	25.5	20.8	25.8
	21	Lalat	23.8	29.3	25.7	25.4	28.4	25.9	22.1	25.8
	22	MTU-1010	25.1	28.7	25.2	24.1	24.4	25.0	20.7	24.7
	23	N-22	18.8	27.0	22.2	21.2	18.6	22.6	23.3	22.0
	24	Sasyasree	26.3	28.5	19.9	26.5	31.3	24.4	21.2	25.4
	25	US-312	19.9	29.2	20.4	17.4	22.6	25.2	20.5	22.2
	26	US-382	22.1	29.2	21.6	29.2	27.5	24.9	21.1	25.1
		Control Mean	**23.1**	**28.1**	**22.2**	**23.8**	**27.0**	**24.6**	**22.1**	**24.4**
Heat Stress	1	IET 21404	22.5	26.3	23.0	19.1	0.0	23.4	17.8	18.9
	2	IET 21411	22.3	24.2	21.8	20.1	0.0	23.4	17.2	18.4
	3	IET 21515	25.4	26.8	23.0	26.8	0.0	24.1	18.4	20.6
	4	IET 21577	20.4	28.3	20.4	18.2	0.0	22.1	17.0	18.1
	5	IET 22116	21.4	27.3	23.4	20.3	0.0	22.6	16.2	18.8
	6	IET 22218	21.5	26.5	19.9	20.3	0.0	22.1	19.8	18.6
	7	IET 22308	24.5	28.3	23.0	23.5	0.0	24.6	18.1	20.3
	8	IET 22894	23.1	28.7	17.1	22.6	0.0	21.1	15.4	18.3
	9	IET 22896	20.2	27.7	17.6	20.2	0.0	22.9	18.0	18.1
	10	IET 22905	21.9	27.5	22.4	22.2	0.0	24.0	15.7	19.1
	11	IET 23275	22.9	24.3	24.6	27.0	0.0	25.3	19.2	20.5
	12	IET 23279	15.9	26.8	16.8	16.5	0.0	23.6	17.5	16.7
	13	IET 23283	21.0	27.8	19.3	22.0	0.0	23.2	17.5	18.7
	14	IET 23296	21.8	26.0	18.8	21.4	0.0	20.2	17.9	18.0
	15	IET 23297	22.5	26.8	20.8	22.3	0.0	20.2	20.3	19.0
	16	IET 23299	25.1	28.2	20.4	24.1	0.0	24.6	15.6	19.7
	17	IET 23300	21.0	27.3	20.4	20.0	0.0	24.5	15.9	18.5
	18	IET 23315	19.4	26.8	19.5	20.7	0.0	23.3	19.6	18.5
	19	IET 23324	20.1	24.5	22.5	20.2	0.0	23.6	15.7	18.1
	20	IR-64	25.3	27.2	25.2	22.4	0.0	20.9	18.1	19.9
	21	Lalat	23.7	28.2	24.3	23.3	0.0	21.5	18.9	20.0
	22	MTU-1010	22.8	27.2	23.7	21.3	0.0	23.9	15.2	19.2
	23	N-22	19.4	25.8	21.3	20.4	0.0	22.3	20.0	18.5
	24	Sasyasree	21.6	27.0	18.8	23.0	0.0	22.6	17.4	18.6
	25	US-312	18.0	27.3	19.6	16.4	0.0	22.7	16.2	17.2
	26	US-382	20.0	28.5	20.8	22.0	0.0	21.6	17.8	18.7
		Stress Mean	**21.7**	**27.0**	**21.1**	**21.4**	**0.0**	**22.9**	**17.6**	**18.8**
		Grand Mean	**22.4**	**27.6**	**21.6**	**22.6**	**13.5**	**23.7**	**19.8**	**21.6**
		Treatment				0.09				
		LSD(Location x Treatment)				0.25				
		LSD(Genotype)				0.77				
		LSD(Location x Genotype)				2.03				
		Treatment x Genotype				1.09				
		Location x Treatment x Genotype				2.87				
		CV(Residual) %				6.31				

Table 6.3.6 Influence of high temperature stress on filled grain/panicle recorded at different AICRIP centres

Treatment		Genotype	DRR	FZB	MTU	PNR	PTB	REWA	TTB	Mean
Control	1	IET 21404	86	200	125	178	115	103	146	136
	2	IET 21411	121	121	97	153	176	94	178	134
	3	IET 21515	120	154	116	156	148	112	135	134
	4	IET 21577	110	141	131	244	259	86	123	156
	5	IET 22116	124	139	126	145	172	100	137	135
	6	IET 22218	88	149	113	134	129	89	157	123
	7	IET 22308	81	119	112	211	154	135	121	133
	8	IET 22894	178	111	95	219	376	88	119	169
	9	IET 22896	144	170	96	221	210	113	133	155
	10	IET 22905	125	167	108	147	152	102	147	135
	11	IET 23275	100	105	123	129	125	145	168	128
	12	IET 23279	175	171	98	244	153	137	128	158
	13	IET 23283	68	136	114	131	119	133	128	118
	14	IET 23296	92	141	102	174	142	103	147	129
	15	IET 23297	116	155	94	204	105	93	143	130
	16	IET 23299	116	104	101	113	73	137	110	108
	17	IET 23300	147	150	78	179	119	109	118	129
	18	IET 23315	122	145	105	156	100	98	127	122
	19	IET 23324	166	170	94	285	160	103	166	163
	20	IR-64	86	133	91	118	102	130	143	115
	21	Lalat	77	148	94	121	120	119	134	116
	22	MTU-1010	114	154	91	148	110	104	140	123
	23	N-22	66	115	87	138	135	87	135	109
	24	Sasyasree	47	156	102	82	90	112	139	104
	25	US-312	96	99	105	198	250	125	106	140
	26	US-382	76	153	98	184	108	121	123	123
		Control Mean	**109**	**142**	**104**	**170**	**150**	**111**	**137**	**132**
Heat Stress	1	IET 21404	62	174	105	108	10	94	84	91
	2	IET 21411	68	110	81	128	69	89	97	92
	3	IET 21515	66	143	86	129	52	89	84	93
	4	IET 21577	86	125	103	129	17	74	72	87
	5	IET 22116	82	132	87	60	101	86	72	89
	6	IET 22218	56	143	98	71	6	89	96	80
	7	IET 22308	52	106	87	96	29	104	71	78
	8	IET 22894	123	97	81	60	49	81	81	82
	9	IET 22896	84	155	83	85	91	96	88	97
	10	IET 22905	91	150	89	100	53	85	78	92
	11	IET 23275	78	89	104	51	64	103	122	87
	12	IET 23279	156	153	84	49	18	91	76	90
	13	IET 23283	69	125	88	45	30	92	83	76
	14	IET 23296	49	127	89	44	60	83	80	76
	15	IET 23297	71	139	81	52	54	80	97	82
	16	IET 23299	79	94	89	36	55	111	74	77
	17	IET 23300	64	136	65	55	32	105	95	79
	18	IET 23315	80	129	75	61	54	86	91	82
	19	IET 23324	41	144	80	67	84	79	86	83
	20	IR-64	42	124	76	41	74	87	107	79
	21	Lalat	42	134	75	50	10	85	83	68
	22	MTU-1010	65	135	85	48	10	115	80	77
	23	N-22	47	101	80	115	63	73	90	81
	24	Sasyasree	62	135	85	58	46	102	89	82
	25	US-312	48	88	88	51	165	89	74	86
	26	US-382	57	136	81	59	3	87	98	75
		Heat Stress Mean	**70**	**128**	**86**	**71**	**50**	**91**	**87**	**83**
		Grand Mean	**90**	**135**	**95**	**120**	**100**	**101**	**112**	**107**
		Treatment				5.69				
		LSD(Location x Treatment)				15.04				
		LSD(Genotype)				14.57				
		LSD(Location x Genotype)				20.60				
		Treatment x Genotype				20.60				
		Location x Treatment x Genotype				54.51				
		CV(Residual) %				24.05				

Table 6.3.7 Influence of high temperature stress on unfilled grain/panicle recorded at different AICRIP centres

Treatment		Genotypes	DRR	FZB	MTU	PNR	PTB	REWA	TTB	Mean
Control	1	IET 21404	68	22	37	55	89	18	37	46
	2	IET 21411	57	14	37	45	42	21	39	36
	3	IET 21515	48	18	35	82	15	25	53	39
	4	IET 21577	54	15	31	72	75	23	39	44
	5	IET 22116	39	8	34	57	71	19	22	36
	6	IET 22218	45	20	45	20	42	24	33	33
	7	IET 22308	27	11	39	15	13	29	38	25
	8	IET 22894	85	12	23	69	117	17	26	50
	9	IET 22896	60	23	46	54	51	21	48	43
	10	IET 22905	47	18	29	41	60	21	25	34
	11	IET 23275	23	16	26	38	11	32	43	27
	12	IET 23279	118	19	54	89	51	24	39	56
	13	IET 23283	19	12	27	26	18	33	37	24
	14	IET 23296	11	10	36	9	19	24	38	21
	15	IET 23297	16	21	30	33	19	22	30	25
	16	IET 23299	24	12	33	23	27	33	38	27
	17	IET 23300	73	18	43	45	15	26	33	36
	18	IET 23315	65	23	37	108	30	32	40	48
	19	IET 23324	23	22	49	27	14	32	33	28
	20	IR-64	14	18	41	11	19	33	57	28
	21	Lalat	23	18	45	61	37	29	43	37
	22	MTU-1010	20	11	39	30	41	28	29	28
	23	N-22	12	15	34	3	16	24	37	20
	24	Sasyasree	20	20	58	50	45	24	34	36
	25	US-312	31	14	48	53	33	28	37	35
	26	US-382	34	22	45	131	36	34	41	49
		Control Mean	**41**	**17**	**39**	**48**	**39**	**26**	**37**	**35**
Heat Stress	1	IET 21404	71	27	62	113	191	37	91	85
	2	IET 21411	58	23	58	89	109	34	55	61
	3	IET 21515	57	23	70	105	64	35	52	58
	4	IET 21577	88	21	64	113	120	34	37	68
	5	IET 22116	64	16	79	190	90	40	44	75
	6	IET 22218	67	24	66	42	132	39	40	59
	7	IET 22308	94	18	69	40	130	43	30	61
	8	IET 22894	99	18	43	241	94	41	27	80
	9	IET 22896	142	29	64	113	136	42	38	81
	10	IET 22905	115	25	54	125	136	35	100	84
	11	IET 23275	73	23	51	111	55	41	53	58
	12	IET 23279	128	23	74	224	137	44	61	99
	13	IET 23283	42	18	58	119	89	34	26	55
	14	IET 23296	43	16	54	126	41	37	48	52
	15	IET 23297	51	28	48	102	57	35	40	52
	16	IET 23299	38	19	51	149	96	38	33	61
	17	IET 23300	83	25	61	121	81	35	23	61
	18	IET 23315	97	27	72	155	72	39	70	76
	19	IET 23324	118	21	69	213	48	42	86	85
	20	IR-64	52	19	61	94	99	40	38	57
	21	Lalat	62	26	70	127	108	35	63	70
	22	MTU-1010	42	19	50	149	105	27	47	63
	23	N-22	15	17	47	33	9	32	41	28
	24	Sasyasree	34	26	81	89	72	39	39	54
	25	US-312	82	20	71	187	66	36	30	70
	26	US-382	63	31	67	74	127	40	30	62
		Heat Stress Mean	**72**	**22**	**62**	**125**	**95**	**37**	**48**	**66**
		Grand Mean	**56**	**20**	**50**	**86**	**67**	**32**	**43**	**51**
		Treatment				3.26				
		LSD(Location x Treatment)				8.64				
		LSD(Genotype)				11.00				
		LSD(Location x Genotype)				29.11				
		Treatment x Genotype				15.56				
		Location x Treatment x Genotype				41.16				

Table 6.3.8 Heat Stress Tolerance study at IARI during Kh 2013

S. No.	Genotypes	Plant Height (cm)	No. of Tillers /m2	No. of Pan /m2	Total Panicle wt. Plant (gm-2)	Total Shoot Wt. Plant (g m-2)	Grain Wt. (g m-2)	Plant Height (cm)		No. of Tillers /m²	
								AT	HT	AT	HT
1	IET 21404	2	-1	-3	-28	-19	-26	104.5±1.6	106.3±2.9	444±25.7	438±25.3
2	IET 21411	3	-33	-36	-41	-24	-33	111.9±1.4	115.0±1.2	456±41.2	306±22.3
3	IET 21515	-4	-16	-20	-36	-18	-28	122.7±1.9	117.7±1.7	546±72.3	456±34.4
4	IET 21577	3	-24	-21	-46	-7	-25	129.7±1.4	133.83±1.60	480±74.2	366±45.0
5	IET 22116	0	-5	-13	-16	-4	-6	95.8±3.4	95.83±1.90	366±23.5	348±28.9
6	IET 22218	3	-8	-8	-24	-11	-15	111.7±1.4	114.83±1.14	450±24.2	414±15.4
7	IET 22308	-4	-23	-23	-52	-19	-21	139.7±1.3	134.67±1.56	264±12.0	204±12.0
8	IET 22894	0	-14	-11	-23	-13	-35	106.2±1.3	106.2±2.1	480±52.3	414±40.2
9	IET 22896	-3	-4	-4	2	-16	-12	98.5±1.0	95.2±1.7	498±36.5	480±40.2
10	IET 22905	2	-42	-38	-45	-27	-26	105.7±0.61	107.5±1.6	708±70.6	414±27.5
11	IET 23275	-4	9	12	-35	-9	-3	105.8±1.0	101.7±0.4	474±39.9	516±30.4
12	IET 23279	-3	-28	-25	-46	-22	-25	98.3±2.6	95.2±1.3	630±47.2	456±68.1
13	IET 23283	3	-38	-34	-25	-38	-15	106.5±0.6	109.3±1.2	642±58.4	396±13.1
14	IET 23296	8	-20	-20	-20	-15	-19	104.8±1.1	113.3±3.4	564±34.4	450±49.8
15	IET 23297	-1	-6	-6	-45	-11	-16	107.2±1.6	106.3±1.4	486±39.2	456±63.5
16	IET 23299	-4	13	18	-44	8	-1	117.0±1.4	112.2±1.6	414±45.3	468±33.5
17	IET 23300	-2	-5	-11	-17	-6	-24	131.5±0.92	129.0±1.5	336±42.3	318±21.6
18	IET 23324	-6	-25	-37	-65	-31	-51	90.7±1.6	85.2±2.0	684±44.6	516±49.0
19	IR 64	-10	-2	1	-40	-10	-12	118.2±1.1	106.3±0.8	540±41.6	528±57.8
20	LALAT	-5	-8	-8	-32	-35	-50	116.2±1.9	110.2±1.6	510±61.2	468±45.5
21	MTU 1010	5	-4	-3	-29	-4	-25	110.7±1.0	116.5±1.8	582±45.0	558±64.9
22	N 22	4	-1	20	-12	-5	-8	134.2±1.8	140.2±2.2	570±49.5	564±34.0
23	Sasyasree	3	-36	-35	-36	-4	-20	120.7±1.4	124.8±1.2	642±17.2	414±57.9
24	US 312	-5	-21	-31	-33	-24	-49	124.3±1.3	117.7±1.1	450±46.2	354±21.6
25	US 382	-2	-37	-37	-40	-31	-51	144.7±1.7	141.2±1.5	420±36.8	264±25.7
	CD at 5% P							0.94		25.02	
	Temp							ns		2.00	
	Genotype * Temp							1.89		50.04	

Table 6.3.9 Heat Stress Tolerance study at IARI during Kh 2013

S. No.	Genotypes	No. of pan./m²		Panicle dry weight (gm⁻²)		Shoot dry weight (gm⁻²)		Grain weight (gm⁻²)	
		AT	HT	AT	HT	AT	HT	AT	HT
1	IET 21404	444±25.7	432±29.4	837.0±63.5	600.0±57.2	853.2±54.3	687.0±26.5	603.0±22.7	447.0±31.7
2	IET 21411	450±43.4	288±16.1	945.0±134.3	555.0±75.3	1035.0±104.7	789.0±19.9	654.0±92.2	438.0±46.2
3	IET 21515	540±68.9	432±20.8	1104.0±196.6	708.0±64.5	1146.0±213.1	939.0±79.5	675.0±87.3	486.0±34.8
4	IET 21577	456±76.5	360±45.5	1035.0±137.5	555.0±64.3	1047.0±119.3	969.0±129.4	780.0±91.6	588.0±12.9
5	IET 22116	366±23.6	318±39.9	591.0±34.3	498.0±42.8	834.0±67.3	801.0±41.2	531.0±31.1	499.8±22.9
6	IET 22218	444±25.7	408±12.0	1236.0±68.7	936.0±55.0	837.0±47.6	747.0±28.2	861.0±32.0	729.0±46.0
7	IET 22308	264±12.0	204±12.0	2001.0±129.3	954.0±99.1	987.0±73.0	804.0±68.3	1062.0±80.6	837.6±49.2
8	IET 22894	456±41.2	408±44.3	987.0±80.7	759.0±100.1	804.0±77.2	702.0±83.4	744.0±34.1	486.0±36.0
9	IET 22896	492±34.4	474±39.9	849.0±89.9	870.0±69.2	789.0±60.8	660.0±69.5	744.0±44.3	657.0±60.2
10	IET 22905	672±57.1	414±27.5	1566.0±140.5	864.0±74.8	1281.0±140.8	936.0±46.5	906.0±78.8	666.0±37.2
11	IET 23275	462±32.8	516±30.4	1581.0±161.8	1020.0±54.9	771.0±70.2	705.0±67.9	774.0±30.1	747.0±37.7
12	IET 23279	606±53.7	456±68.1	1689.0±165.8	912.0±147.2	906.0±162.2	705.0±109.3	903.0±90.2	681.0±94.9
13	IET 23283	600±54.7	396±13.2	945.0±57.8	705.0±27.3	963.0±87.5	594.0±30.8	762.0±50.0	651.0±28.1
14	IET 23296	564±34.4	450±49.8	1125.0±51.1	897.0±43.2	873.0±47.6	738.0±44.3	894.0±58.4	726.0±29.6
15	IET 23297	486±39.2	456±63.5	1668.0±100.0	912.0±125.6	873.0±77.0	780.0±121.3	849.0±75.0	717.0±78.9
16	IET 23299	396±46.5	468±33.5	1668.0±91.6	942.0±110.2	717.0±66.0	774.0±59.3	783.0±64.2	774.0±86.8
17	IET 23300	336±42.3	300±22.1	741.0±75.6	618.0±37.7	924.0±83.5	864.0±73.2	600.0±35.9	459.0±31.1
18	IET 23324	684±44.6	432±37.2	1359.0±125.9	474.0±76.5	789.0±83.3	546.0±51.9	1035.0±89.3	507.0±56.2
19	IR 64	522±39.2	528±57.8	1476.0±73.0	879.0±110.4	801.0±87.2	720.0±83.4	711.0±34.1	627.0±78.1
20	LALAT	510±61.3	468±45.5	1113.0±63.1	759.0±50.8	1005.0±26.0	651.0±40.6	945.0±30.7	474.0±32.8
21	MTU 1010	576±43.6	558±64.9	912.0±42.5	651.0±137.9	1128.0±81.9	1086.0±59.8	714.0±35.9	537.0±30.6
22	N 22	474±50.4	570±30.0	990.0±102.1	867.0±21.5	741.0±32.3	705.0±20.5	681.0±77.0	624.0±70.3
23	Sasyasree	576±16.1	372±46.2	939.0±74.7	600.0±41.5	669.0±39.3	640.8±34.3	690.0±48.5	549.0±35.6
24	US 312	444±41.2	306±15.4	1017.0±79.2	678.0±65.3	1023.0±101.8	777.0±71.2	822.0±58.9	420.0±48.5
25	US 382	420±36.8	264±25.7	924.0±70.0	552.0±77.0	1176.0±113.7	807.0±71.3	864.0±73.5	423.0±54.4
	CD at 5% P								
	Genotype	24.21		53.88		47.35		32.95	
	Temp	1.94		4.31		3.79		2.64	
	Genotype * Temp	48.41		107.76		94.70		65.89	

6.4 Screening of elite rice cultures for drought tolerance

Centres: BHU, FZB, CTK, HAT, PTB and REWA

In the next two decades, water scarcity will increase dramatically in many parts of the world. This will have significant social and economic repercussions. The climate change is expected to exacerbate current stresses on water resources from population growth and economic and land-use change, including urbanization. By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. Rice production depends heavily on water availability and irrigated lowlands account for 55% of the total area of harvested rice and typically produce two to three times the crop yield of rice grown under non-irrigated conditions (IRRI 2002). Global warming will generally increase evaporation, total precipitation, and the spatial variability of precipitation, leading to less rainfall in the tropics and more rainfall at higher latitudes. In India, Upland rice areas lies in eastern zone comprising of Assam, Bihar, Eastern M.P., Orissa, Eastern U.P., West Bengal and North-Eastern Hill region and rain fed low land rice area in India is about 14.4 million hectares, which accounts 32.4 % of the total area under rice crop in the country. Drought is one of the most important constraint adversely affecting the yield in upland and rainfed low land cultivation.

Identification of suitable rice cultures for rainfed conditions is one of the priority research area of Plant Physiology group under AICRIP. The drought tolerance traits of rice cultures with respect to yield and other attributes under dry spells was investigated at 6 centres. In this trial 17 rice cultures consisting of 6 AVT-VE-DS and 10 IVT-VE-DS cultures and Anjali as check variety were included. At PTB, REWA and CRRI the rice cultures were grown under rain fed and irrigated conditions which facilitated computing yield based stress tolerance indices. Important weather parameters were recorded during the crop growth period and based on the rainfall received dry spells were identified. A dry spell was defined as 7 consecutive rainless days during the crop growth.

BHU (Varanasi)

At BHU, Varanasi centre the crop was grown under only rainfed condition and the crop never received any supplementary irrigation. The crop received 609 mm rain from sowing until maturity with 41 rainy days. The rainfall was evenly distributed during the vegetative stage with 31 rainy days and 509.6 mm rain fall. However, the crop experienced 12-13 days dry

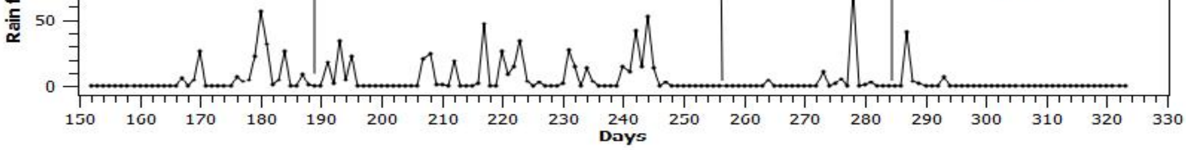


Fig.1: Distribution of rain fall during the crop growth period at BHU centre (Kharif 2013)

spell during early tillering stage and a second dry spell of >10 days between PI and flowering stages (Fig. 1). However, the crop was subjected to prolonged dry spell during reproductive stage. The crop received a total of 100 mm rain with 10 rainy days with 3 major rainfall events which enabled the crop to withstand the dry spells. The germination percentage was good under field condition with a mean germination percentage of 78%. Significant differences were noticed between the tested entries for per cent germination. Significant variation were observed between the entries for days to flowering and days to maturity (Table 6.4.1). The days to flowering varied between 63 (IET 23390) and 71 days (IET 23377). Similarly significant differences were noticed amongst the entries for days to maturity. The days to maturity varied between 87 (IET 24064) and 101 (IET 23367) with a mean of 98 days. Out of the 16 tested cultures, five cultures (IET 24062, IET 24064, IET 24069, IET 24065 and IET 24061) matured 7 days earlier than the test variety Anjali (Table 6.4.1).

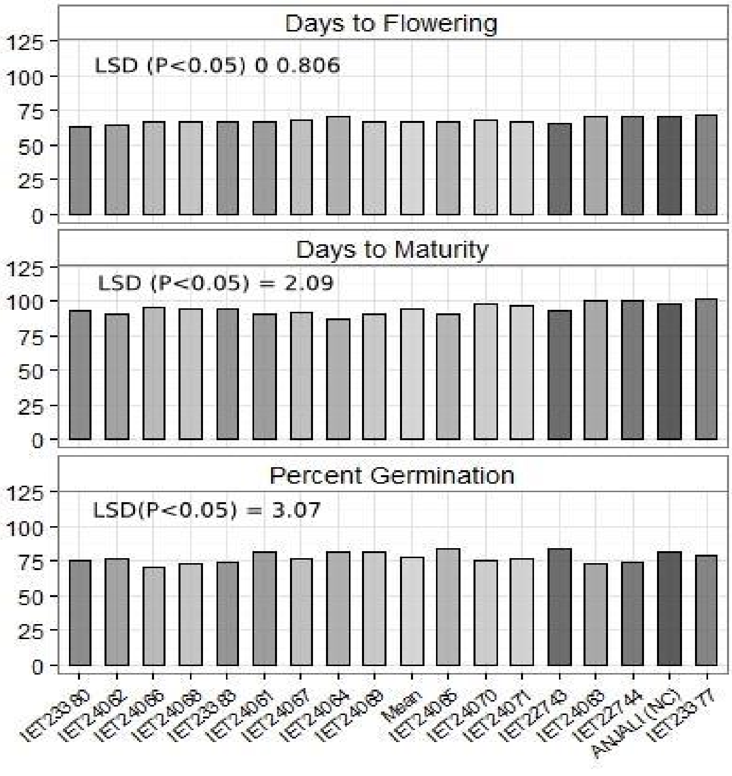


Fig.1 : Variation in days to flowering, days to maturity and germination percentage under rainfed condition at BHU centre during Kharif-2013.

Significant variation in plant height was recorded between the tested cultures. Plant height was between 153.5 cm (IET 24063) and 119.6 cm (IET 24061) with a mean of 125.4 cm (Table 6.4.1). No. of panicles per sq.m was an important yield component which varied significantly amongst the genotypes. The No. of Panicles/m^2 varied between 372 (IET 24061) and 244 (IET 24069) with a mean value of 291 panicles/m^2. Filled and un-filled grains per panicle were determined and the data revealed that the differences observed amongst the tested entries were statistically significant. The mean number of unfilled grains per panicles was 26. Maximum (57) number of unfilled grains were recorded in IET 24063 where as the IET 24067 recorded the lowest number (7) of unfilled grains per panicle. IET 24060 is another entry which recorded only 11 unfilled grains indicating relatively higher spikelet fertility in these entries. The number of filled grains per panicle also recorded significant differences amongst the tested entries. The filled grain number varied between a maximum of 148 (IET 22744) and 86(IET 24068) with a mean value of 117 for all the tested entries (*Table 6.4.1 and Fig. 2*).

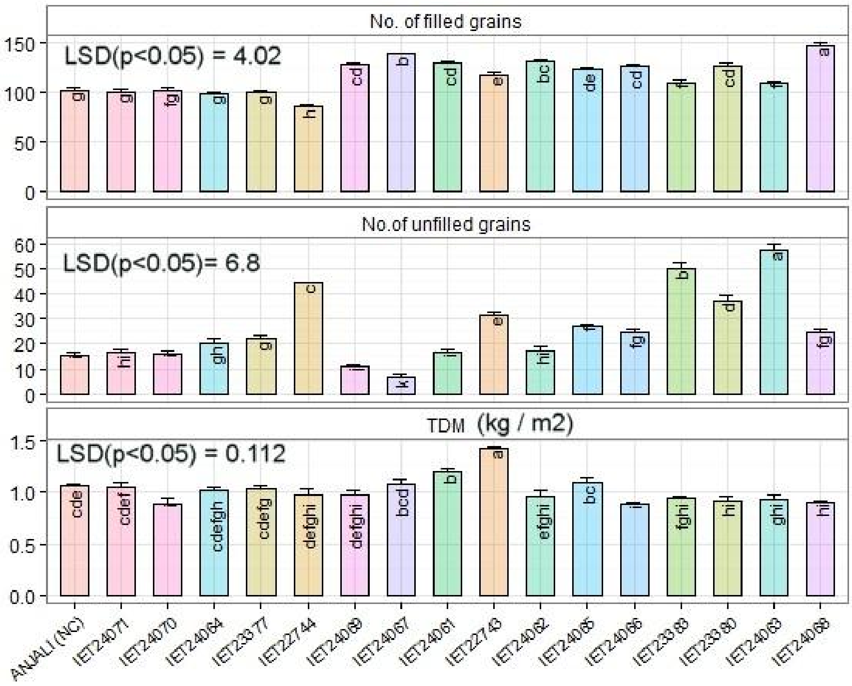


Fig.2: Variation in number of filled and un-filled grains per panicle and total dry matter recorded at harvest in different rice genotypes at BHU, Varanasi during Kharif-2013. Each bar represents mean of 3 replications. The bars marked with same letters are not statistically significant.

Total above ground biomass was measured after harvest. Significant variation was observed among the tested entries (Fig.3). Highest TDM was recorded in IET22743 which was higher than the check variety Anjali. IET 24061 also produced significantly higher biomass than the check variety. Significant variation was also observed in the number of productive tillers per plant. The tiller no. varied between 9.3 (IET 24061) and 5.5 (Anjali). Amongst the tested cultures, IET 24069 had the lowest (6.1) tiller number. All other entries produced higher tiller number than the check variety Anjali (Table 6.4.1).

Varietal differences were observed in the test weight (100 grain weight). The test weight varied between 2.56 (IET 24068) and 3.46 (Anjali). Amongst the tested entries, maximum test weight of 3.39 was recorded in IET 24065. IET 24071 and IET 24061 are other entries with significantly higher test weight (Table 6.4.1). The grain weight recorded at harvest also showed significant variation amongst the tested genotypes. The mean grain yield of all the entries was 373 g m^{-2} and it varied from 567 (IET 22743) to 300 g m^{-2} (IET 24068). IET 24061(440 g m^{-2}) , IET 23377 (421 g m^{-2}) and IET 24065(407 g m^{-2}) are the other entries which produced significantly higher yield than the grain yield produced by the check (Anjali) and the mean grain yield for all the entries (Table 6.4.1 & Fig.3).

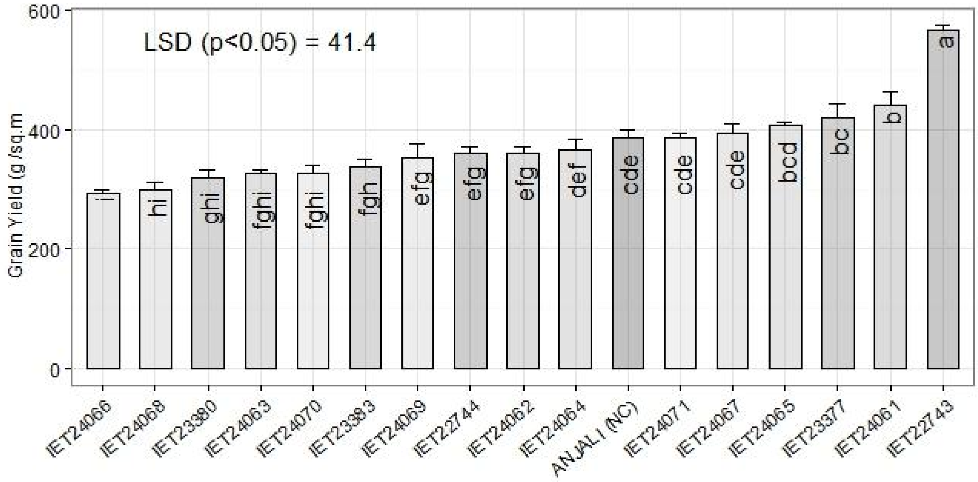


Fig.3: *Grain yield (g m^{-2}) produced by different test entries at BHU during Kharif-2013*

FZB (Faizabad)

At Faizabad (FZB) centre the crop was grown under only rainfed condition with out any additional irrigation inputs. No parallel irrigated treatment was imposed at this centre. The crop received 351.8 mm rain with 45 rainy days from sowing to harvesting. During the vegetative stage the crop received 176.9 mm rain with 33 rainy days. However, the crop was exposed to prolonged dry spell of >20 days, which was interrupted by 3 rain fall events of <10 mm intensity, just before the crop attained 50% flowering stage. During the reproductive phase, the crop received a total of 174.9 mm rain in 12 rainy days, out of which 2 days recorded rain fall of >25 mm. However, the crop was exposed to a brief dry spell of >6 days at the fag-end of grain filling and maturity.

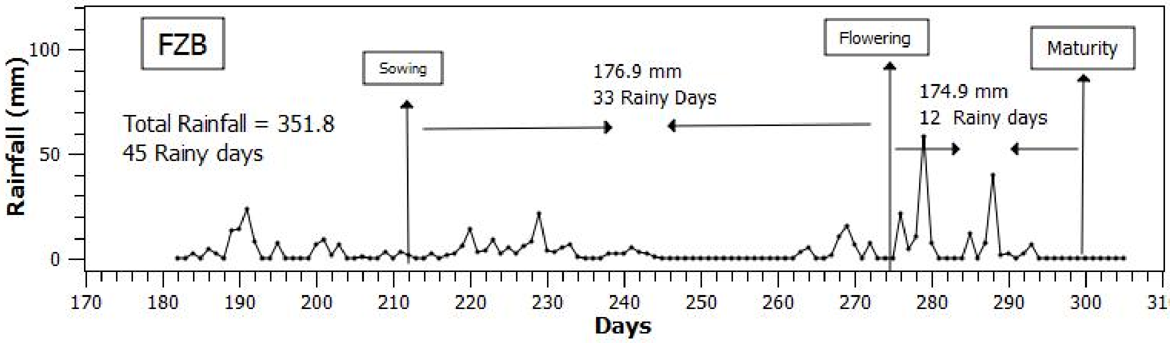


Fig.4: Distribution of rain fall during the crop growth period at Faizabad centre during kharif-2013

The mean days to flowering and maturity for all the tested entries were 61 and 86 days, respectively. The days to flowering varied between 54 (IET 23380 and IET 24062) and 71days (IET 24063 and 24064). Similarly, the days to maturity varied between 78 days (IET23380) to 98 days(IET 24063). The entries IET 24061, 24068, 24062 and IET 23380 flowered earlier than the check variety Anjali (*Table 6.4.2 and Fig. 5*). Significant variation was observed in both number of un-productive and productive tillers between the tested entries. The productive tiller no varied between 275 (IET 24061) and 368 (IET 24063) with a mean value of 302 tiller m^{-2}. Similarly, the variation in number of un-productive amongst the tested entries was also found to be significant. The un-productive tiller number ranged 25 (IET 24063) and 12 (IET 24062 and 23380) with a mean of 18 tillers m^{-2} (*Table 6.4.2 & Fig. 5)*

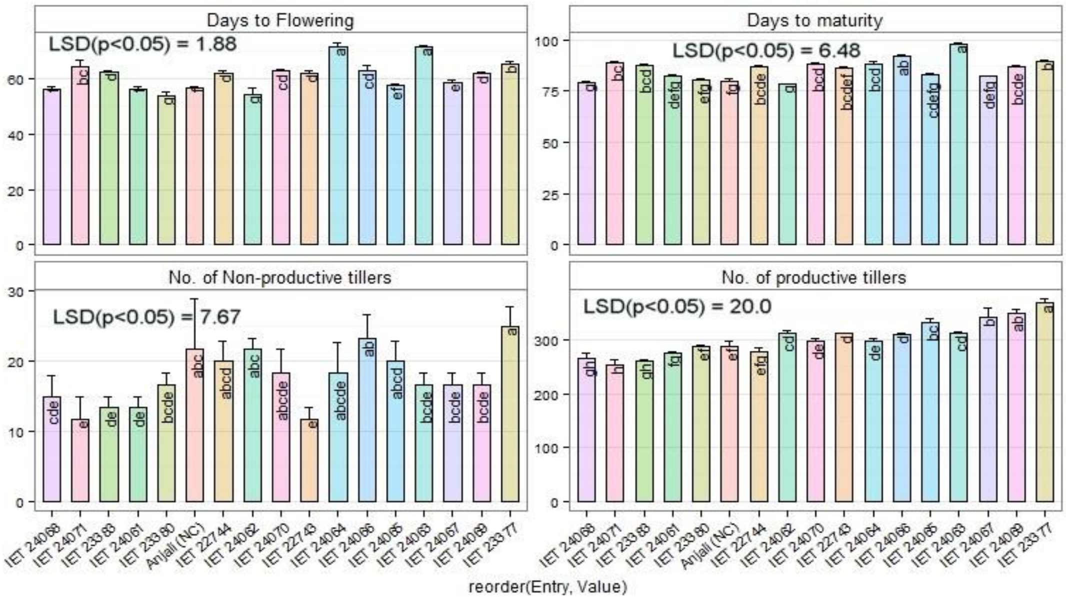


Fig. 5: Variation in important physiological characteristics in different rice genotypes at Faizabad (FZB) centre during kharif-2013. Each bar represents the mean of three independent replications±SE. Bars with similar letters are statistically non-significant.

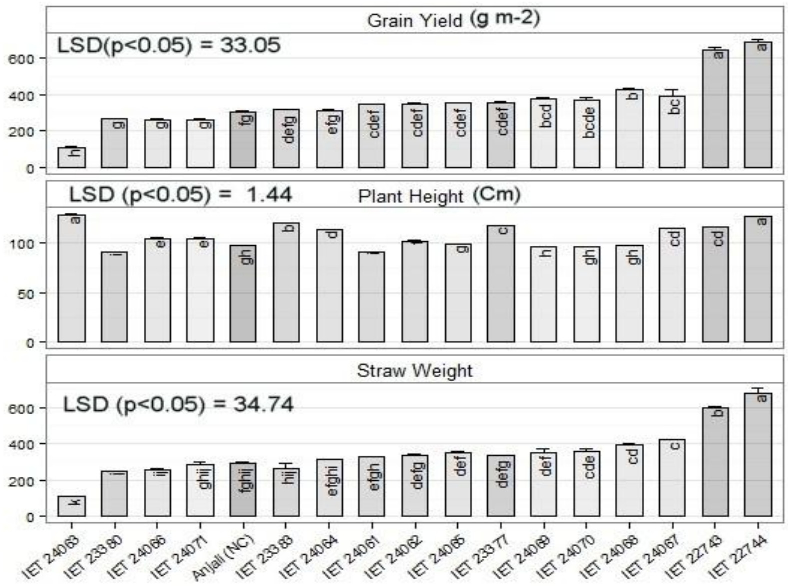


Fig. 6: : Variation in plant height, straw weight and grain yield in different rice genotypes at Faizabad (FZB) centre during kharif-2013. Each bar represents the mean of three independent replications±SE. Bars with similar letters are statistically non-significant.

Plant height recorded at harvest varied significantly amongst the tested lines. Plant height ranged between 129(IET 24063) and 91 (IET 23380 and IET 24062) with a mean of 107 cm *(Table 6.4.2 and Fig.6).*

Significant variation was noticed between the tested lines regarding number of grains and number of unfilled grains per sq.m. Highest number of grains per sq.m were observed in IET 24063 and chaff number per sq.m was also higher in this entry. On the other hand IET 23380 recorded lowest grain number per sq.m and chaff number per sq.m was also lowest in this entry (Table 2). The mean grain yield for all the genotypes was 359 g m^{-2}. Grain yield varied between 683 g m^{-2} (IET 24063) and 112 (IET 23380). IET 24063 and IET 23377 are the other entries which recorded higher grain yield. The test variety Anjali produced 301 g m^{-2} grain yield which is significantly lower than the mean grain yield for all the genotypes. However, IET 24061, 24068, 24062 are the other genotypes which produced less grain yield than the check Anjali at this centres. The yield recorded in these lines was significantly lower than the mean grain yield recorded for all the tested genotypes (*Table 6.4.2 and Fig.6).*

CTK (CRRI)

At Central Rice Research Institute (CRRI) the experiment was conducted under both rainfed and irrigated conditions. Analysis of rainfall pattern revealed that at this centre, the crop received 931 mm rain with 65 rainy days. The rain fall during the crop growing period was fairly uniform, especially during reproductive period with as many as 24 rainy days with 519.4 mm rain received between flowering and maturity stages. However, during this period a brief lull (>7 days) in rainfall was observed during this period. However, this dry cycle was preceded and followed by heavy rainfall events o f >60 mm. Similarly, during vegetative period the crop received 411 mm rain with 41 rainy days with 2 dry spells. Overall the crop received sufficient amount of rain during its growth at this centre.

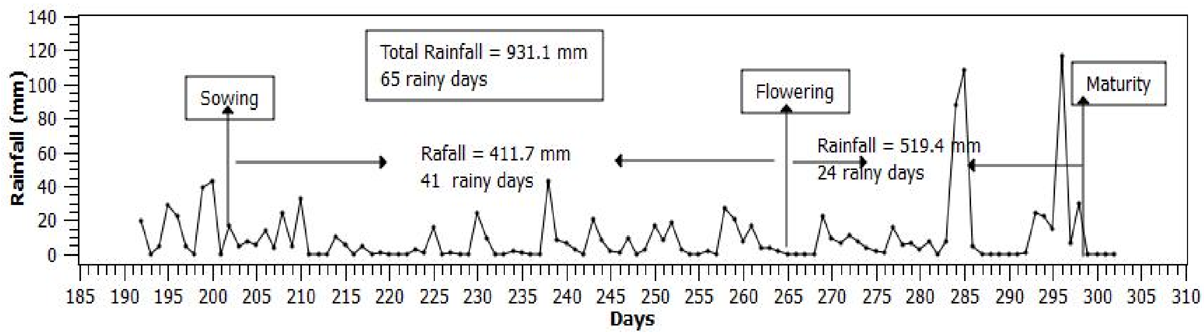


Fig.7: Distribution of rain fall during the crop growth period at CRRI, Cuttak centre during kharif-2013

At this centre crop was grown as both rain fed and irrigated conditions. The mean days to flowering for all varieties under rain fed condition was 63 days where as under irrigated conditions the mean days to flowering for all the entries was 78. Under rain fed treatment the flowering was advanced by 15 days. The advancement in flowering under rain fed treatment was more pronounced in IET 24070, 22743, 24069, 24068. In the check variety (Anjali) the flowering was 13 days earlier under rain fed treatment. Similarly, the days to maturity was also advanced under rain fed treatment. Under rain fed treatment the maturity was advanced by 13 days. The advancement in maturity was pronounced (>15 days) in IET 24063, 22743, 24068, 24062, 24065. However, no significant differences in the grain filling duration was noticed between rainfed and irrigation treatments (Table 6.4.3). Leaf area index was measured at flowering stage. The mean LAI was drastically reduced under rain fed treatment (87% reduction over irrigated treatment). The reduction in LAI under rain fed treatment was observed in all tested entries. The differences amongst the entries and the interaction between treatment x entries was found to be non-significant (Table 6.4.3). Similarly, the number of tillers recorded at flowering stage was also significantly reduced under rain fed condition (35% reduction). However, the differences amongst the genotypes and the interaction between treatment x genotype was also found to be non-significant (Table 6.4.3). Total dry matter recorded at harvest was significantly lower under rainfed treatment (Fig.8).

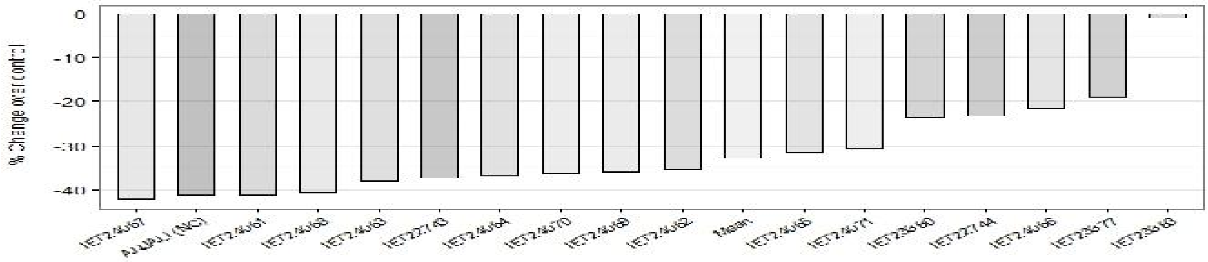


Fig.8: Per cent reduction in total dry matter (g m^{-2}) under rainfed treatment at CRRI centre during kharif-2013

Significant (*$p<0.01$*) reduction in TDM (g m^{-2}) was observed in all the entries under rainfed treatment. The differences between the genotypes was also found to be significant. the interaction between genotype x treatment was also found to be significant (*$p<0.05$*) *(Table 6.4.3).*

The reduction in TDM was negligible (<5%) in IET 23383. IET 23377, 24086 are the other entries in which the reduction in TDM was <25%. Maximum reduction was observed in IET 24067, Anjali and IET 24061 (Fig.8). Similarly grain yield recorded at harvest was also significantly reduced under rainfed treatment (Fig.9). However, the differences amongst the genotypes for grain yield was found to be non-significant. Similarly, the interaction between genotype x treatment was also non-significant (Table 6.4.3).

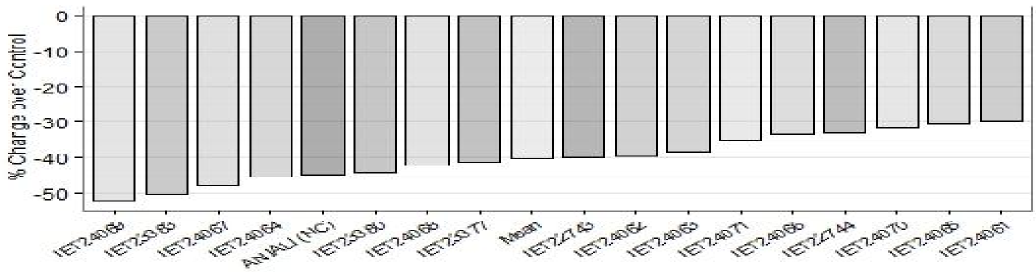


Fig.9: Per cent reduction in grain yield (g m^{-2}) under rainfed treatment at CRRI centre during kharif-2013

Although, the grain yield was reduced in all the genotypes including the check variety (Anjali). Marginal differences were noticed between the genotypes in their response to irrigation. The reduction in grain yield under rainfed treatment was relatively lower in IET 24061, 24065, 22744 and IET 24066 which is less than the reduction in mean grain yield or the check variety (Fig. 9). IET 24089, IET 23383 and IET 24084 are the other entries which produced grain yield significantly lower than the check variety and the yield levels are also very much lower than the mean grain yield produced by all the tested genotypes. Significant differences are noticed in the mean harvest index (HI) for all genotypes grown under irrigated and rain fed conditions. The HI was significantly ($p<0.01$) lower under rainfed treatment (Table 6.4.3). However, the differences in HI between the genotypes was non-significant. The interaction between genotypes x irrigation treatment was also found to be non-significant (Table 6.4.3 & Fig.9).

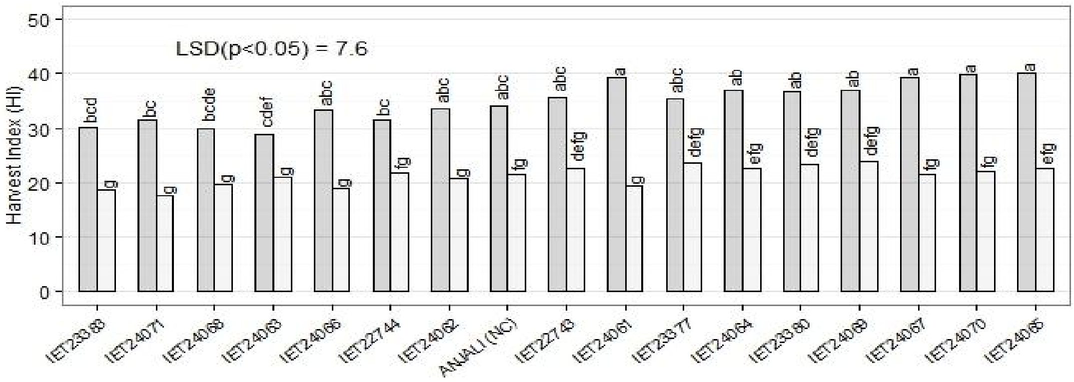


Fig. 10: Changes in HI of rice genotypes grown under contrasting water regimes (Irrigated and rainfed). Each bar represents the mean of 3 replications. Bar with similar letters are statistically non-significant.

Based on the yield, plant height and total dry matter recorded under rainfed and irrigated conditions, different drought stress indices were computed. The drought susceptibility index (DSI) was computed as per Fisher and Maurer(1978) as: DSI = $1-(Y_s/Y_{ns}) / D$, where Y_s = Yield under rainfed condition and Y_{ns} = Yield under irrigated condition. D is calculated as $D = (Y_{sm}/Y_{nsm}) \times 100$, where Y_{sm} = mean yield of all genotypes under rainfed condition and Y_{nsm} = mean yield of all genotypes under irrigated (control) condition. The Yield stability ratio (YS) was calculated as $YS = Y_s/Y_{ns} \times 100$.

Plant Height Stress Index (PHSI) is calculated according to Islam et al. (1998) as PHSI=Plant height (cm) under rainfed condition/ Plant height under Irrigated condition x 100. Grain Weight Susceptible Index (GWSI) was calculated as GWSI=(Grain weight recorded under irrigated control-Grain weight under rainfed treatment)/Grain weight recorded under control) x 100. The Dry Matter Stress Index (DMSI) was calculated as DMSI=(TDM produced under rain fed condition/TDM produced under Irrigated condition)*100.

The drought susceptibility Index (DSI) was one of the important drought index which is used to differentiate drought tolerant and susceptible genotypes. The DSI value >1.0 generally indicate susceptibility and <1.0 indicate relative tolerance for drought. At CRRI no significant differences were observed amongst the tested genotypes for DSI. The DSI for all the genotypes is >1.0 which indicate that none of the tested entries, including the check variety Anjali could be classified as drought tolerant as significant reduction in grain yield was observed for all the genotypes under rain fed treatment (Fig. 11).

The Plant Height Stress Index (*PHSI)* was computed based on the plant height (PH) recorded under both irrigated and rainfed conditions. The PHSI did not showed any variation amongst the tested entries. Though, the mean plant height for all genotypes was reduced (>11%), the differences in PH was not significant (Table 6.4.3). The interaction between genotype and treatments was also found to be non-significant. Since no significant differences in PHSI were observed (Fig. 12), this parameter may not be useful for delineating tolerant and susceptible genotypes.

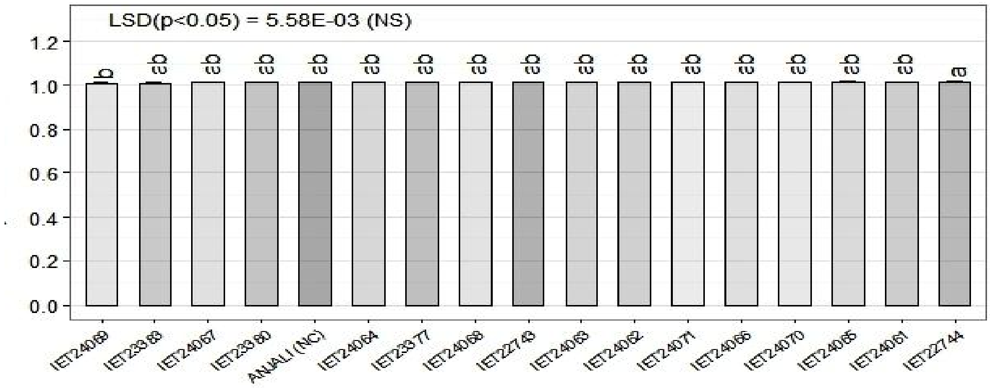


Fig. 11: Drought Susceptibility Index (DSI) of different rice genotypes at CRRI center during Kharif-2013. . Bars with similar letters are statistically non-significant.

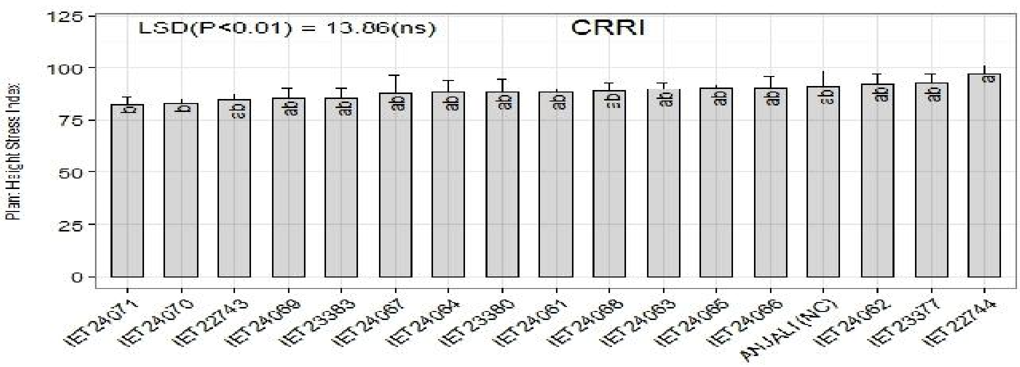


Fig. 12: Plant height stress Index of different rice genotypes at CRRI center during Kharif-2013. Bars with similar letters are statistically non-significant.

Similarly, the Yield Stability Ratio (YS) was computed on the basis of total grain yield according to Lewis(1956). The drought tolerant genotypes normally have YS >50. The YS values obtained at this centre show that majority of the varieties had YS values >50, indicating that the crop did not suffered severe water stress. The differences among the genotypes for YS was non-significant (Fig. 13). However, The entries IET 22744 and 24061 showed relatively higher YS. Since the differences in YS are non-significant, this parameter may not be useful for identification of suitable rice genotypes for rain fed conditions.

The Dry Matter Stress Index (DMSI) is another important index which is used to identity relative tolerance of genotypes to abiotic stresses. All tolerant genotypes normally show DMSI >50 under severe stressed condition. However, due to good rainfall received by the crop under rainfed conditions, the DMSI computed for all genotypes showed higher DMSI values. The differences amongst the genotypes were also not significant with a range of 50 (IET 24069) to 75 (IET 22744).

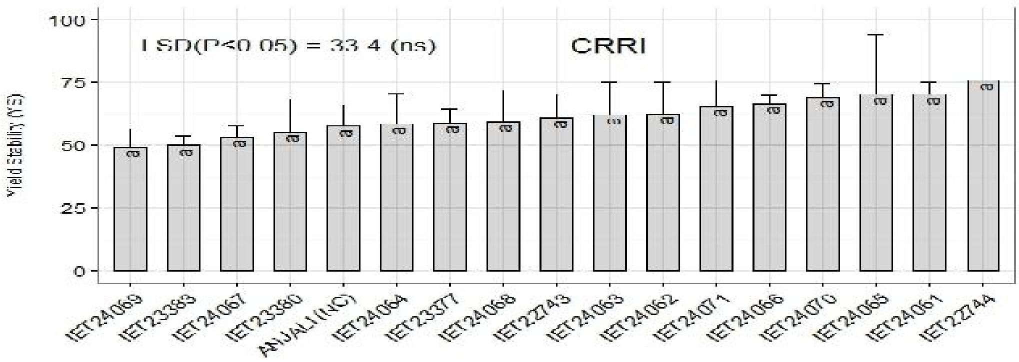


Fig. 13: Yield Stability Ratio (YS) of different rice genotypes at CRRI center during Kharif-2013. Bars with similar letters are statistically non-significant.

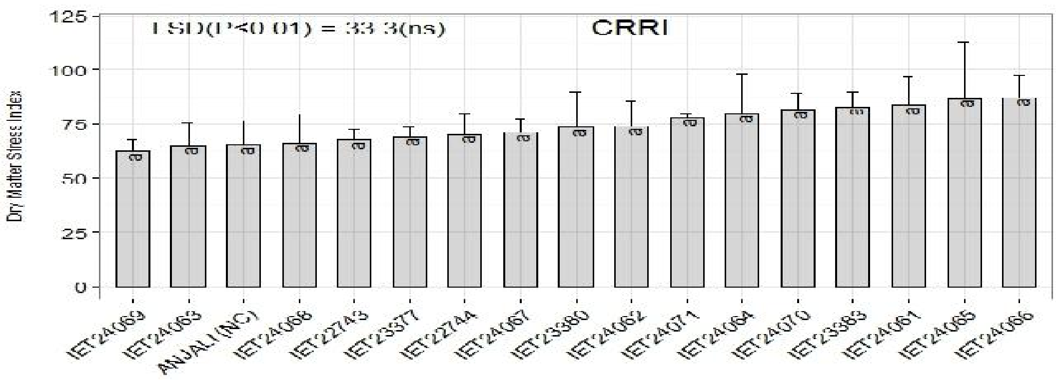


Fig. 14: Dry Matter Stress Index (DMSI) of different rice genotypes at CRRI center during Kharif-2013. Bars with similar letters are statistically non-significant.

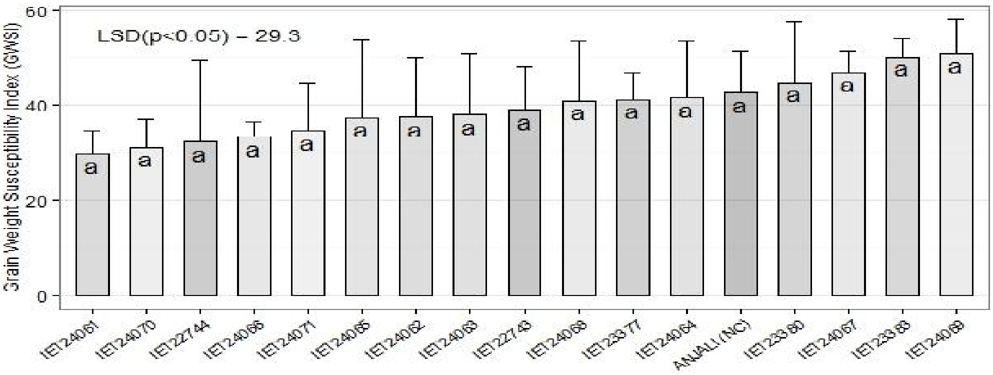


Fig. 14: Grain weight susceptibility index (GWSI) of different rice genotypes at CRRI center during Kharif-2013. Bars with similar letters are statistically non-significant.

The Grain Weight Susceptibility Index (GWSI) is another important parameter to id entify relatively tolerant genotypes to abiotic stresses. The GWSI varieties between 29.7 (IE T 24061) to 50.9 (IET 24069). The GWSI is >50% in IET 23383. However, the differences a mongst the genotypes was statistically non-significant. Based on the GWSI IET 24061, 2407 0 and 22744 are relatively tolerant amongst the tested genotypes.

HAT (Hathwara)

At Hathwara centre the experiment was conducted under rainfed condition only. T he crop received 886.5 mm rain fall with 56 rainy days from sowing to maturity stages. The crop suffered a brief dry spell of >6 days immediately after sowing and it received a total of 579.6 mm rain with 39 rainy days during the vegetative phase (sowing to flowering). After fl owering also the crop received good amount of rain (>309 mm) with 17 rainy days. Overall, the rain fall distribution throughout the crop growing period is very good and the crop was no t subjected to prolonged dry spells (>7 days) either during vegetative growth or during reprod uctive growth (grain filling) at this centre (Fig. 15).

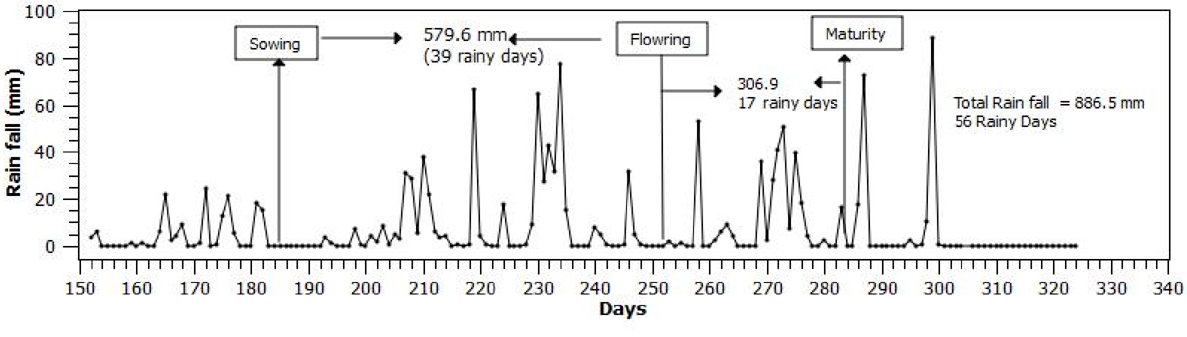


Fig. 15: Fig.7: Distribution of rain fall during the crop growth period at Hathwara (HAT) centre during kharif-2013

The germination percentage was good under field condition with a mean germination percentage of 92%. Significant differences were noticed between the tested entries for per cent germination. Significant variation were observed between the entries for days to flowering and days to maturity (Table 6.4.4). The days to flowering varied between 61 (IET 24062) and 78 days (IET 23377). Similarly significant differences were noticed amongst the entries for days to maturity. The days to maturity varied between 90 (IET 24868) and 107 (IET 23377) with a mean of 97 days. Out of the 16 tested cultures only IET 24068 matured 5 maturity earlier (5 days) than the check variety Anjali (Table 6.4.4)

The No. of panicles per sq.m was an important yield component which varied significantly amongst the genotypes. The No. of Panicles/m^2 varied between 200 (IET 24068) and 154 (IET 24062) with a mean value of 174 panicles/m^2 (Table 6.4.4). The differences amongst the tested genotypes was significant ($p<0.05$) for number of tillers per plant (Table 6.4.4). The number of tillers per plant varied from 3.4 (IET 24067) to 5.2 (IET 24063) with a mean of 4.4 tillers plant $^{-1}$. (Fig. 16).

Significant ($p<0.05$) differences were observed amongst the genotypes for total dry matter (g m^{-2}) recorded at maturity. The TDM varied between a 843 g m^{-2} (IET 24061) to 423 g m^{-2} (IET 23377). The mean TDM for all genotypes was 596 g m$^{-2.}$ IET 22743, 24066 and IET 24063 are the other genotypes which produced significantly higher TDM than the check variety Anjali or the mean TDM for all the genotypes (Table 6.4.4). The genotypes IET 24069 and IET 22744 produced TDM which is lower than the check Anjali.

Significant ($p<0.05$) differences were observed amongst the genotypes for grain yield (g m^{-2}) recorded after harvest. The grain yield varied between a 187 g m^{-2} (IET 24064) to 107 g m^{-2} (IET 22744). The mean grain yield for all genotypes was 146 g m$^{-2.}$ The entries IET 24068, 24066 and IET 24063 are the other genotypes which produced significantly higher TDM than the check variety Anjali or the mean TDM for all the genotypes (Table 6.4.4). The check variety Anjali produced grain yield of 117 g m^{-2} which is lower than the mean grain yield for all the genotypes. The genotype IET 22744 is the only entry which produced grain yield which is less than the check variety (*Fig. 16*)

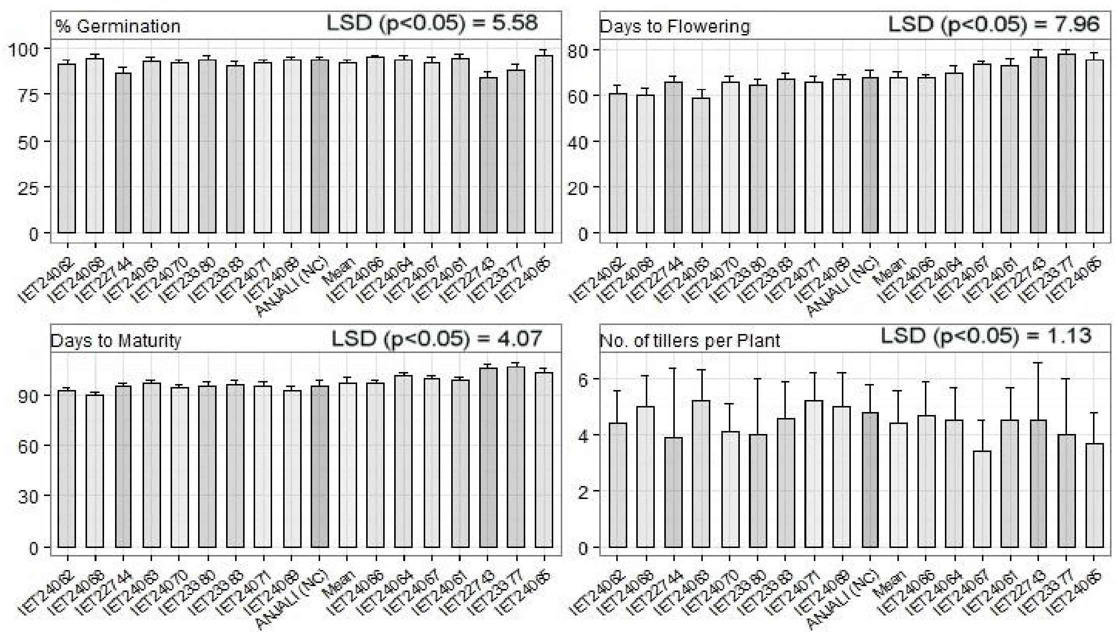


Fig.16: Variation in important physiological characters in rice genotypes at Hathwara centre during Kharif 2013.

PTB (Pattambi)

At Pattambi (PTB) centre the trail was conducted under both irrigated and rain fed conditions. The rain fed crop received high amounts of rain during the crop growth period. The crop received >1400 mm rain during the entire growth period with 71 rainy days. During vegetative stage the crop received 1256 mm rain in 54 rainy days with your any dry spells. Similarly, the crop received 183.9 mm rain with 15 rainy days between flowering and maturity (reproductive phase) with two distinct dry periods of >10 days and 8 days separated by a minor rainfall event of <6 mm during late grain filling phase. However, these dry spells are preceded by significant amount of rain (Fig. 17).

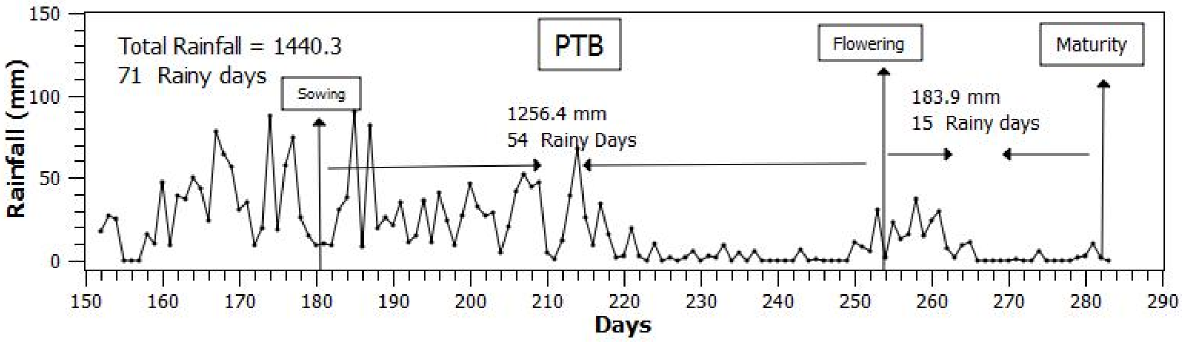


Fig. 17: Fig.7: Distribution of rain fall during the crop growth period at Pattambi (PTB) centre during kharif-2013

At this centre the crop was grown under two water regimes i.e. totally rainfed and irrigated. The mean days to flowering under rainfed and irrigated conditions were 75 and 72 respectively. Significant differences were observed amongst the genotypes for days to flowering. The entry IET 23380 flowered very early (59 days) and IET 22743 is relatively late as it reached 50% flowering in 82 days which is much longer than the check variety. No significant differences in days to maturity were noticed either between the two water regimes or between the genotypes. The mean days to maturity were 98 and 97 days under irrigated and rainfed treatments, respectively (Table 6.4.5).

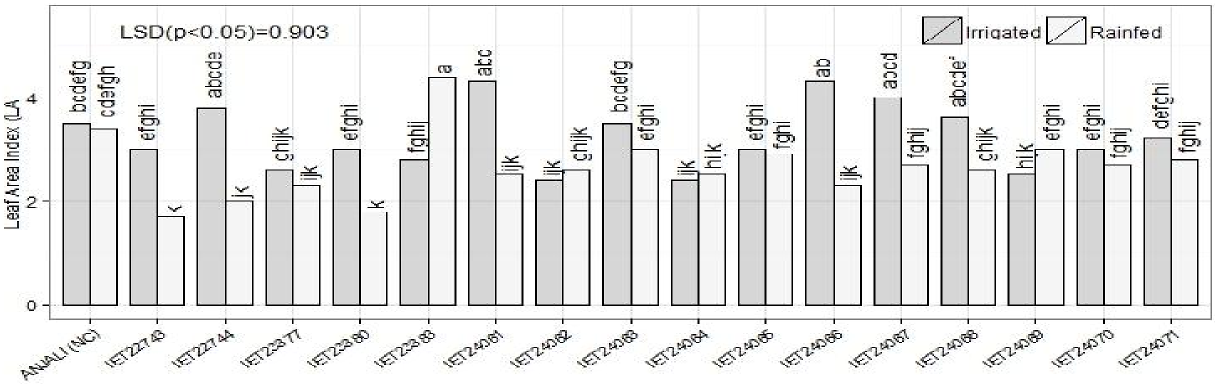


Fig.17: Variation in leaf area index of different rice genotypes under irrigated and rain fed conditions at Pattambi (PTB) during Kharif-2013.

Significant reduction in leaf area index was noticed under rainfed condition. The differences in LAI between the rice genotypes was significant (P<0.01). The interaction between treatment x genotypes was also found to be highly significant (P<0.01). The LAI recorded under rainfed treatment varied between 4.4 (IET 23383) and 1.7 (IET 22743) with a mean value of 2.65 (Fig. 17).

No. of tillers were recorded at flowering stage. Significant (p<0.05) reduction in the mean number of tillers per plants were noticed under rainfed treatment. No significant difference among the genotypes were noticed in the number of tillers per plant. However, the interaction between water regimes (rainfed and irrigated) and genotypes were found to be significant (p<0.01). No significant reduction in number of tillers per plant were noticed in IET 23383. In all other genotypes including the check Anjali, significant reduction was noticed (Fig.18).

Stem weight was recorded at flowering stage. The biomass accumulated before anthesis is very important as the stored carbon and nitrogen are remobilized during grain filling stage. This remobilization is very important source of carbon especially during post-anthesis water stress. At PTB centre the stem weight was recorded at the time of 50% flowering and significant differences were observed between irrigated and rainfed treatments. The stem weight was lower under rainfed condition. Significant genotypic differences were noticed under rainfed condition (Fig. 18). Anjali and IET 24069 accumulated relatively higher stem weight under rainfed condition than the other tested entries.

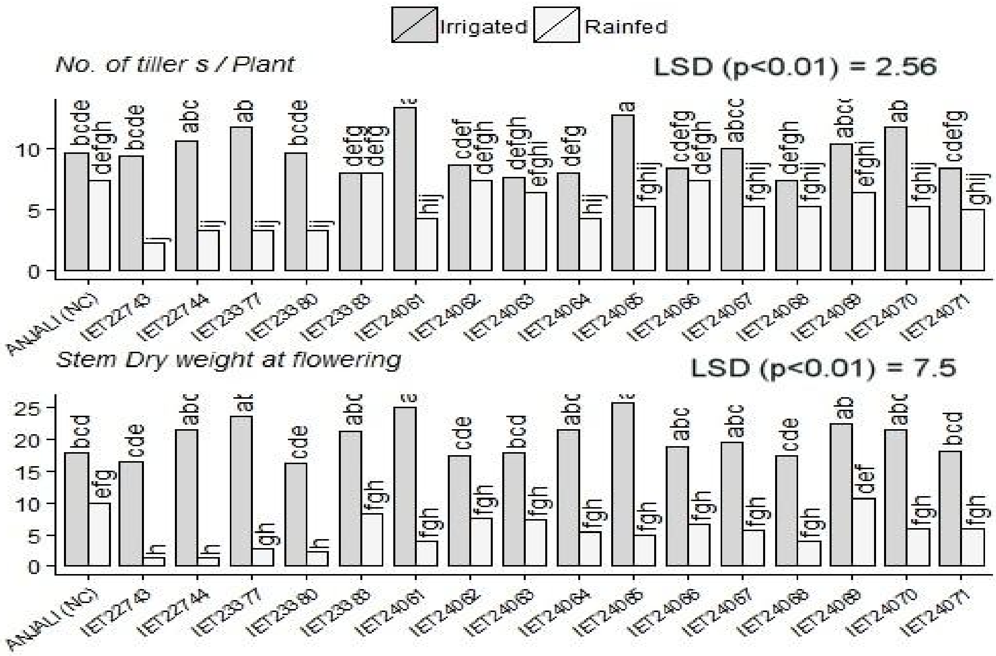


Fig.18: Variation in stem dry weight and No. of tillers per plant recorded at flowering stage under irrigated and rainfed conditions. Each value represents the mean of three replications. Bars marked with identical letters are statistically non-significant.

Significant differences were observed in the number of filled and unfilled grains . A significant reduction in number of filled grains per panicle with a concomitant increase in unfilled grains was noticed under rainfed treatment (Table 6.4.5). The differences amongst the tested entries for number of filled grains was significant ($p<0.05$). The interaction between the irrigation regimes and genotypes was also significant. However, under rainfed treatment the differences amongst the genotypes for number of unfilled grains was non-significant and the interaction between irrigation x genotypes was also found to be non-significant (Table 6.4.5).

The mean TDM for all the genotypes recorded at harvest was significantly lower (54 %) reduction under rainfed treatment (Table 6.4.5). Significant variation was observed amongst the tested entries for TDM. The interaction between irrigation regime x genotypes was also significant. The TDM varied between 853 g m^{-2}(IET 24064) and 549.6 g m^{-2} (IET 23380) with mean of 692 g m^{-2} (Table & Fig. 18) under irrigated condition. The TDM varied between 605 g m^{-2} (IET 24071) and 122 g m^{-2} (IET 22744). Other genotypes which produced high biomass under rainfed condition are IET 23377, 23380, 24065 and IET 24064.

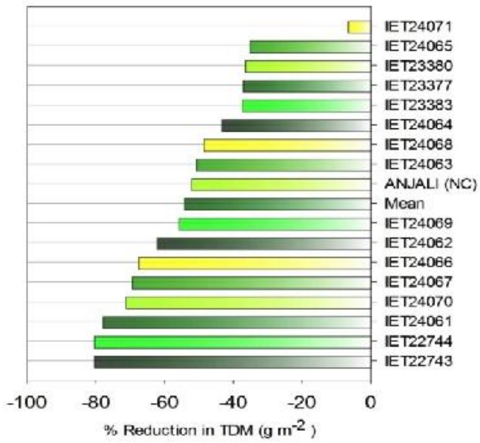


Fig. 18: Percent reduction in TDM recorded at harvest under rainfed treatment at PTB during kharif-2013.

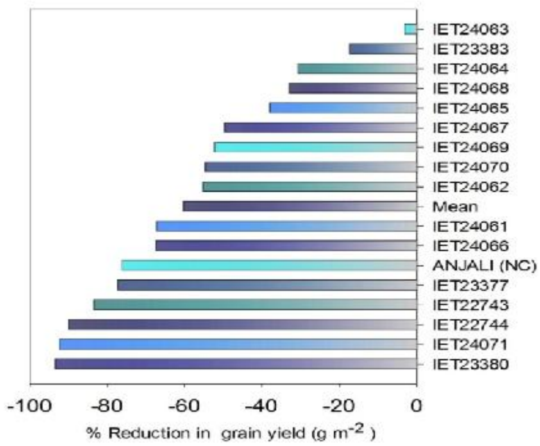


Fig. 18: Percent reduction in grain yield under rainfed treatment at PTB during kharif-2013.

Grain yield (g m^{-2}) was significantly reduced under rainfed condition. The percent reduction in grain yield was highest (>50%) in IET23380, 24071, 22744, 22743, 23377,24061 and 24066. The reduction in grain yield was >60% in the check variety, Anjali. The reduction in yield was <50% in IET 24063, IET 23383, IET 24064 and IET 24065. In IET 24063 the reduction in grain yield under rainfed treatment was <10% (Fig. 19). IET 23383 produced highest grain yield under rainfed condition.

Based on the grain yield and total dry matter produced, different drought susceptibility indices were calculated.

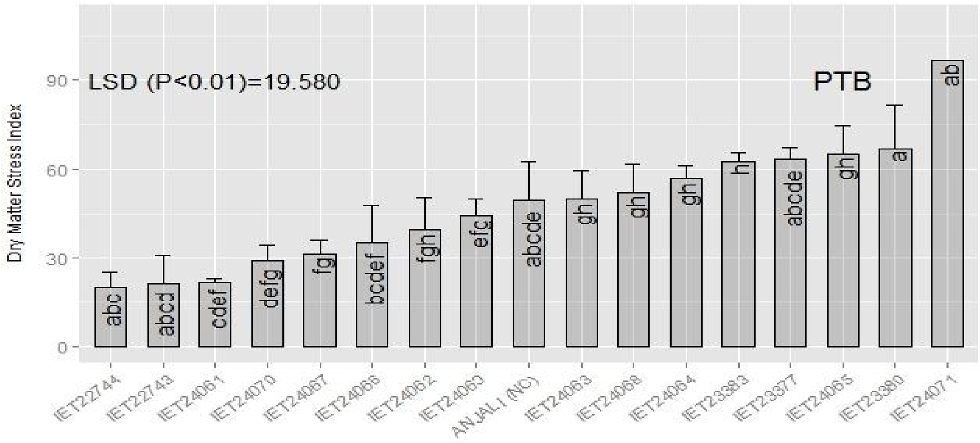


Fig. 19 *Variation in Dry matter stress index of different rice genotypes. Each value represent represents the mean of three replications ±SE.*

The Dry Matter Stress Index (DSMI) showed significant differences between the genotypes DMSI >50% indicate relative tolerance to water stress. The genotypes IET 24071, IET 23380, IET 23377 and IET 24065 showed DSMI >60% and these genotypes are relatively tolerant to drought.

The drought susceptibility Index (DSI) was one of the important drought index which is used to differentiate drought tolerant and susceptible genotypes. The DSI value >1.0 generally indicate susceptibility and <1.0 indicate relative tolerance for drought. No significant differences were observed amongst the tested genotypes for DSI. The DSI for all the genotypes is >1.0 which indicate that none of the tested entries, including the check variety Anjali could be classified as drought tolerant as significant reduction in grain yield was observed for all the genotypes under rain fed treatment. (Fig.20).

Yield Stability Ratio (YS) was computed on the basis of total grain yield produced under irrigated and rainfed condition according to Lewis(1956). The drought tolerant genotypes normally have YS >50. The YS values obtained at this centre show that the varieties IET24060, IET 22383, 24068, 22465 and IET 24062 had YS values >50, indicating that these varieties performed relatively better under raifed conditions. The check variety Ajjali had YS<50. The differences among the genotypes for YS was significant (Fig. 21).

Grain Weight Susceptibility Index (GWSI) is another important drought tolerance index based on the yields produced under irrigated and rainfed treatments. Significant differences were observed in GWSI between the genotypes. The GWSI was lowest in IET 23383, IET 24064, IET 24068 and IET 24065 indicating relative tolerance of these genotypes to water stress. The GWSI was >5-% in IET 23380, IET 24071, IET 22743 and IET 22377. The check variety Anjali also recorded GWSI higher than 50% (Fig.22) suggesting that these varieties are relatively susceptible to water stress.

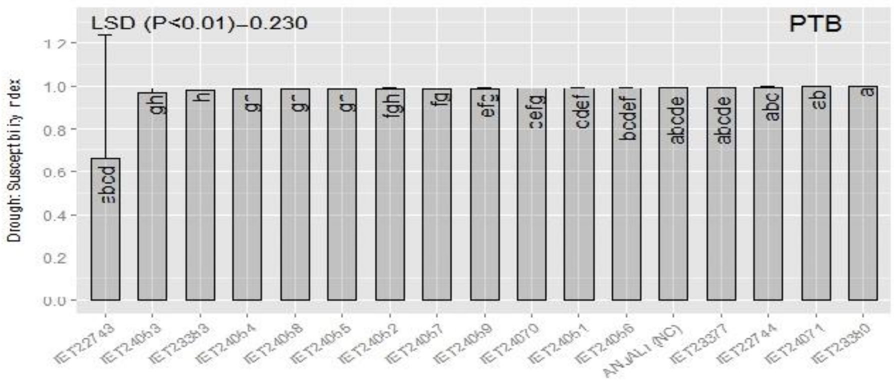


Fig. 20: Drought Susceptibility Index (DSI) of different rice genotypes at PTB enter during Kharif-2013. Bars with similar letters are statistically non-significant.

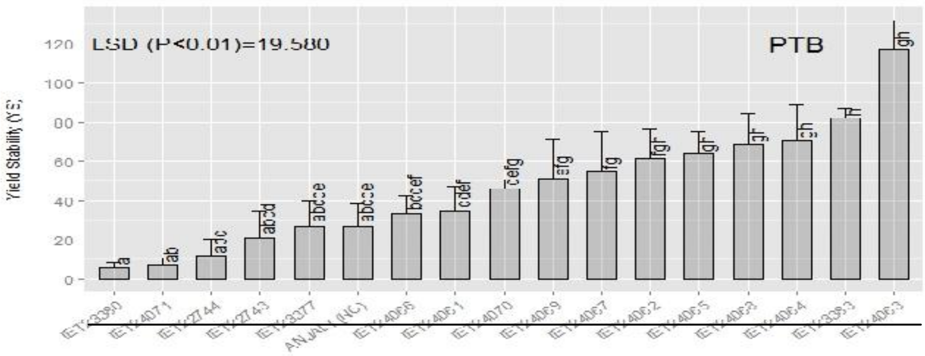


Fig. 21: Yield Stability Index (YS)) of different rice genotypes at CRRI center during Kharif-2013. . Bars with similar letters are statistically non-significant.

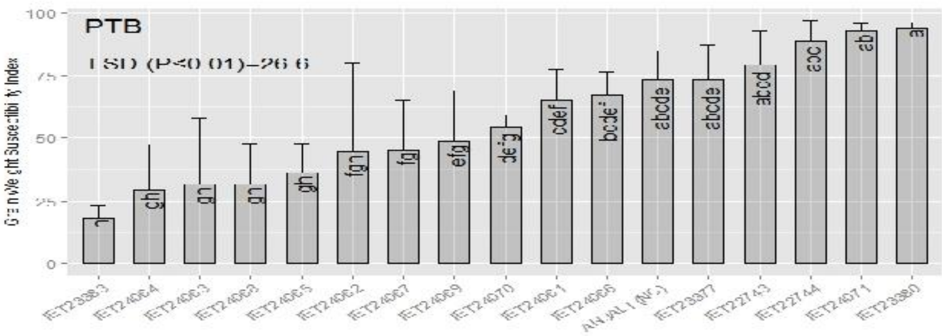


Fig. 22: Grain weight Susceptibility Index (GWSI) of different rice genotypes at PTB center during Kharif-2013. . Bars with similar letters are statistically non-significant.

REWA

At REWA centre also selected rice genotypes were tested under both rainfed and irrigated conditions. The crop received a total of 573.4 mm in 21 rainy days. During vegetative

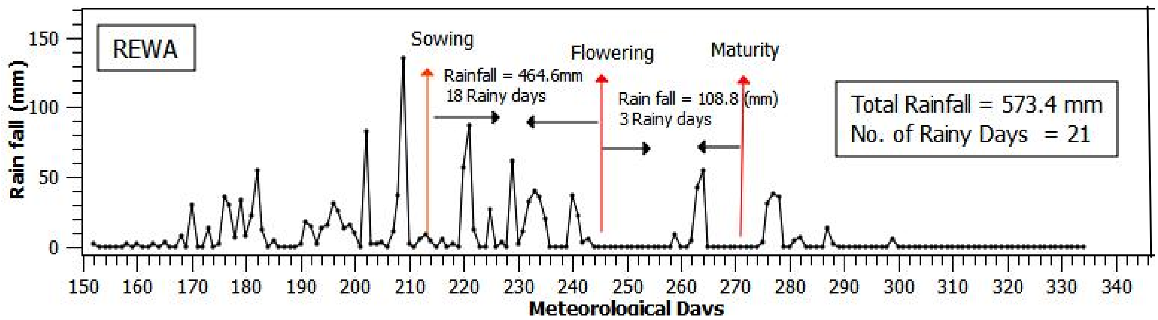


Fig. 23 Rainfall distribution during crop growth period recorded at REWA during Kharif-2013

period the crop received 464.6 mm rain in 18 rainy days and the crop was not exposed to any dry spells during this period. Between flowering and maturity the crop receive 108.8 mm rain with only 3 rainy days. The crop during reproductive growth was exposed to 2 distinct prolonged dry periods of (>10 days) and the crop received all the rain within 3 days.

Significant variation were observed between the entries for days to flowering and days to maturity (Table 6.4.6). The mean days to flowering for all varieties was 60 days under rainfed treatment which was 5 days earlier than the mean days to flowering at irrigated conditions. Significant differences were noticed amongst the genotypes for days to flowering under rainfed conditions. It varied between 57 days (IET 24069) to 64 days (IET 24065). Similarly, the days to maturity varied between 85 days (IET 23377 and IET 24071) and 93 days (IET 24062) under rainfed treatment. The crop under rainfed treatment matured 7 days earlier in comparison with irrigated treatment (Table 6.4.6).

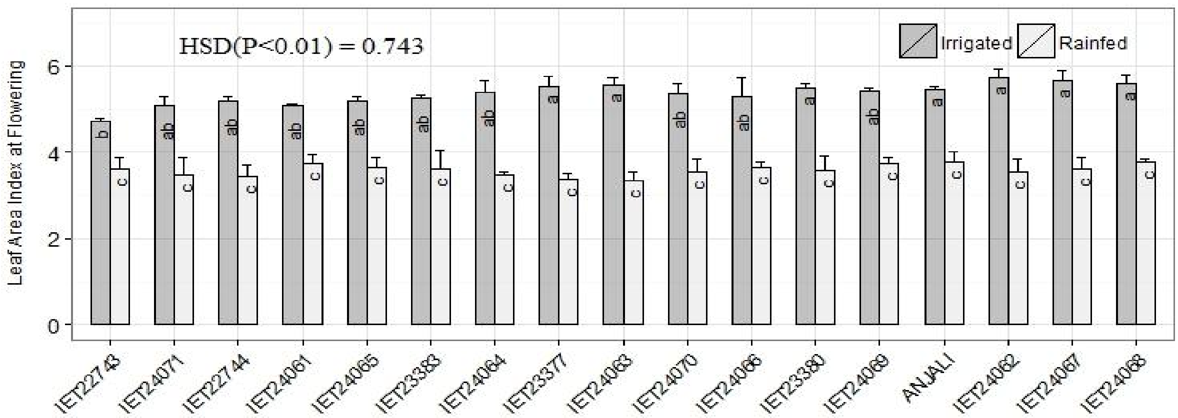


Fig. 24 Variation in Leaf Area Index measured at flowering stage at REWA centre during Kharif-213.

Leaf area index was estimated at flowering stage. LAI was reduced (33% reduction) under rainfed treatment (Table 6.4.6 & Fig. 24). The differences amongst the genotypes for LAI were not significant under both rainfed and irrigated treatments. The interaction between treatment x genotypes was also not-significant (Table 6.4.6).

Number of tillers per plants were measured at flowering stage. Significant differences were observed between two water regimes. A moderate reduction in tiller number was noticed under rainfed condition. The differences amongst the genotypes was significant (Table 6.4.6).

Number of tillers per sq.m were significantly affected by the irrigation regimes. Under rainfed treatment the No. of tiller m^{-2} was reduced by 8% over irrigated control treatment. The No. of tillers varied between 84 (IET 24069) and 137 (22743) under rainfed treatment (Table 6.4.6) with a mean of 115 tillers $m^{-1.}$ The interaction between treatment x genotypes was also found to be significant.

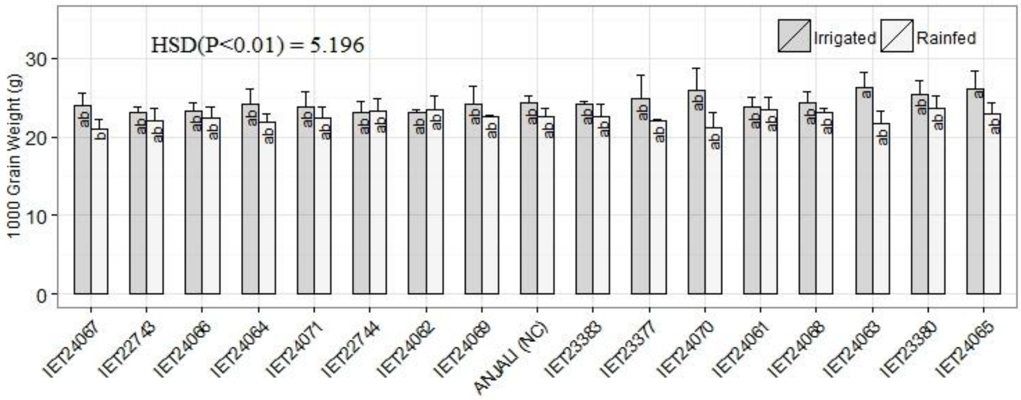


Fig. 25: Variation in 1000 grain weight under rainfed and irrigated conditions at REWA center during Kharif-2013.

The test weight was significantly ($P<0.01$) reduced (7.8% reduction over irrigated control) under rainfed treatment. The test weight varied between 23.57 (IET 23380) and 21.17 (IET 24070) under rainfed treatment. Minor differences were noticed between genotypes for 1000 grain weight both under rainfed and irrigated treatments. The interaction between water regimes and genotypes was also found to be non-significant (Table 6.4.6 &Fig.25).

The TDM recorded at harvest was not affected by the irrigation. The mean TDM for all genotypes was 1745 and 1735 g m^{-2}, at irrigated and rainfed treatment, respectively. The difference between the treatment was not significant (Table 6.4.6). However, significant differences were noticed between the genotypes. A significant reduction in TDM was observed in IET 24069,IET 23377, IET 24064 and IET 22744. An increase in TDM was recorded in IET 24061, IET 24062, IET 24068 and IET 22743 (Fig. 26).

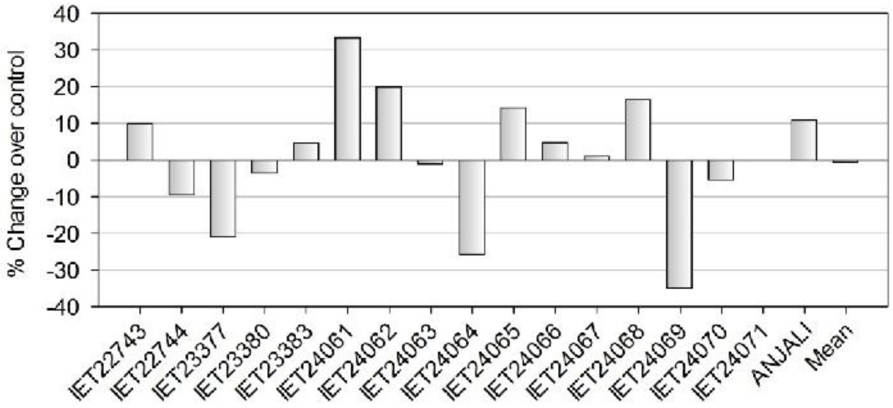


Fig.26: Per cent reduction in TDM (g m^{-2}) under rainfed treatment at REWA centre during kharif-2013

Significant reduction (37% reduction over control) in mean grain yield (g m^{-2}) was observed under rainfed treatment. Under rainfed condition the grain yield varied between 108 *g m^{-2}* (IET 24069) to 367 *g m^{-2}* (IET 23380). IET 24065, IET 24068, IET 22743, 24061, and IET 24062 are the other entries which produced relatively higher grain yield than the mean grain yield for all the genotypes (265 *g m^{-2}*) and the check variety Anjali (242 *g m^{-2}*).

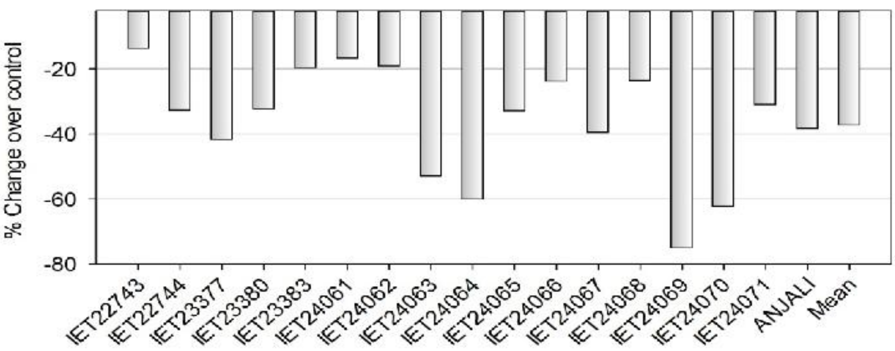


Fig.27: Per cent reduction in grain yield (g m^{-2}) under rainfed treatment at REWA centre during kharif-2013

The reduction in grain yield was lowest in IET 22743 followed by IET 22744 and highest reduction in grain yield under rainfed condition was observed in IET 24069, IET 24070 and IET 24064 (Fig. 27).

Based on the grain yield and total dry matter produced, different drought susceptibility indices were calculated.

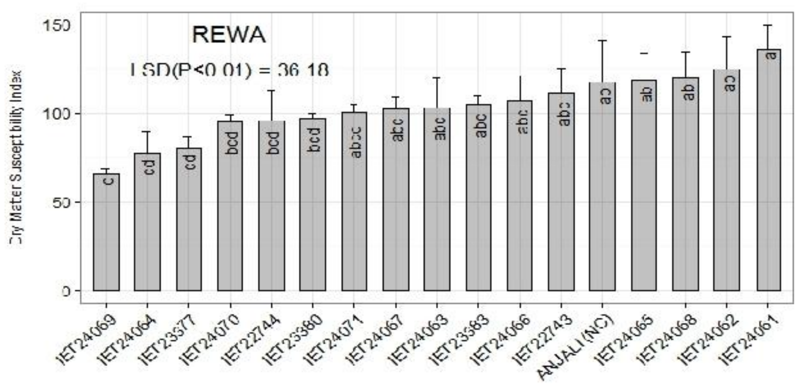


Fig. 28 *Variation in Dry matter stress index of different rice genotypes at REWA centre during kharif-2013. Each value represent represents the mean of three replications ±SE.*

The Dry Matter Stress Index (DSMI) showed significant differences between the genotypes DMSI >50% indicate relative tolerance to water stress. The genotypes IET 24061, IET 24062, IET 24068 and IET 24065 showed DSMI >100% .With the exception of IET 24069, IET 24064 and IET 23377 all other tested entries showed very high DMSI values. This parameter was unable to differentiate between tolerant and susceptible genotypes.

The drought susceptibility Index (DSI) was one of the important drought index which is used to differentiate drought tolerant and susceptible genotypes. The DSI value >1.0 generally indicate susceptibility and <1.0 indicate relative tolerance for drought. Significant differences were observed amongst the tested genotypes for DSI. The entries IET 23383, IET 22743, IET 24062, IET 24061 and IET 24068 showed very low DSI (<0.50) indicate relative tolerance of these genotypes to stress. Out of all the tested entries only IET 24070 and IET 24069 showed DSI of >1.0 (Fig. 28).

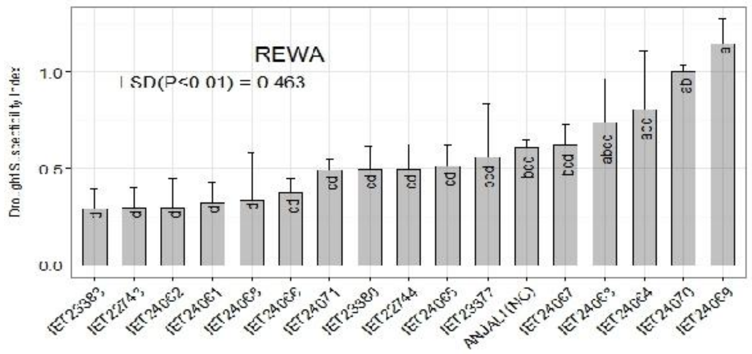


Fig. 29 *Variation in Drought susceptibility index (DSI) of different rice genotypes at REWA centre during kharif-2013. Each value represent represents the mean of three replications ±SE.*

Yield Stability Ratio (YS) was computed on the basis of total grain yield produced under irrigated and rainfed condition according to Lewis(1956). The drought tolerant genotypes normally have YS >50. The YS values obtained at this centre show that the varieties IET 22383, IET 22743, 24062, 22465 and IET 24061 had YS values >75%, indicating that these varieties performed relatively better under rainfed conditions. The check variety Ajjali had YS<60. The differences among the genotypes for YS was significant (Fig. 29). Only IET 24069 and IET 24070 showed YS of <50 indicating relative susceptibility of these genotypes.

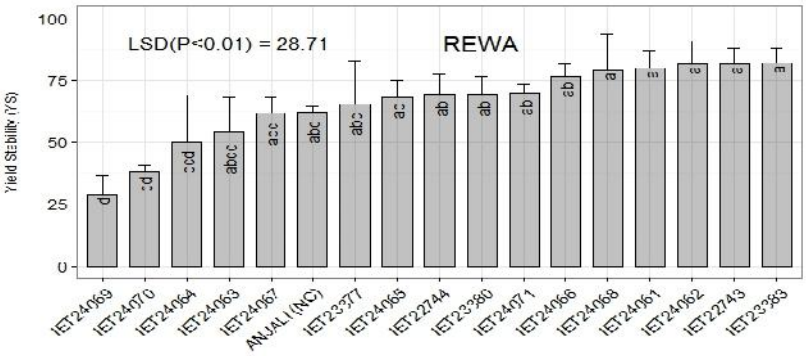


Fig. 30 *Variation in Yield stability of different rice genotypes at REWA centre during kharif-2013. Each value represent represents the mean of three replications ±SE.*

Grain Weight Susceptibility Index (GWSI) is another important drought tolerance index based on the yields produced under irrigated and rainfed treatments. Significant differences were observed in GWSI between the genotypes. The GWSI was < 20 in IET 23383, IET 24062, IET 22743, IET 24061 and IET 24068 indicating relative tolerance of these genotypes to water stress. The mean GWSI for all the genotypes was <35 indicating that a majority of the tested genotypes performed relatively better at this centre. Only IET 24069, IET 24064 and 24070 showed GWSI of >50. The differences amongst the genotypes was significant. This parameter is useful in differentiating tolerant and susceptible genotypes.

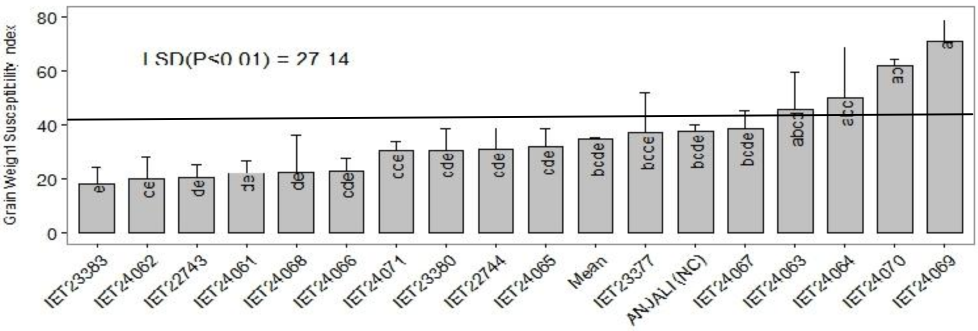


Fig. 31 *Variation in Grain Weight Susceptibility Index (GWSI) different rice genotypes at REWA centre during kharif-2013. Each value represent represents the mean of three replications ±SE.*

This trial was conducted at 6 AICRIP centres to screen elite rice cultures and identify suitable rice cultures for rainfed upland condition. During kharif-2013, the crop was exposed to dry spells during vegetative stage at Faizabad and CRRI centres, and during reproductive growth crop was exposed to brief dry spells at BHU(Varanasi) centre.

Table 6.4.1 Rainfed Upland study data at BHU during Kh 2013

S.No.	Genotypes	Days to flowering	Days to maturity	Germination (%)	Till. no/ plant	Plant height (cm)	Pan. No/m2 hst	Filled grain No/pan.	Unfilled grain/pan.	100 grain wt. (g)	Grain Yield (g/m2)
1	IET22743	65	93	84	7.5	125.3	299	117	32	3.06	567
2	IET22744	70	100	74	7.6	136.5	303	148	44	3.23	360
3	IET23377	71	101	79	6.8	125.6	273	132	22	3.03	420
4	IET23380	63	93	75	6.7	120.7	268	103	37	3.43	320
5	IET23383	67	94	74	6.5	131.6	259	127	50	2.95	337
6	IET24061	66	90	81	9.3	119.6	372	101	16	3.37	440
7	IET24062	64	90	77	8.1	121.5	325	100	17	3.41	360
8	IET24063	70	100	73	7.9	153.5	314	124	57	3.23	327
9	IET24064	70	87	81	6.9	131.3	277	139	20	3.02	367
10	IET24065	66	90	84	7.7	122.9	306	110	27	3.39	407
11	IET24066	66	96	71	7.5	128.3	301	109	24	3.26	293
12	IET24067	68	92	77	8.3	130.8	332	99	7	3.35	393
13	IET24068	66	94	73	6.3	121.5	251	86	24	2.56	300
14	IET24069	66	90	82	6.1	125.8	244	102	11	3.20	353
15	IET24070	68	98	75	8.2	131.8	328	128	16	3.02	327
16	IET24071	67	97	77	7.0	130.8	280	130	16	3.25	387
17	ANJALI (NC)	70	98	81	5.5	125.0	219	129	15	3.46	387
	Mean	**67**	**94**	**78**	**7.3**	**128.4**	**291**	**117**	**26**	**3.19**	**373**
	LSD ($p<0.05$)	0.806	2.09	3.07	0.65	2.25	26.26	6.850	4.07	0.18	41.6
	CV (%)	0.722	1.33	2.37	5.41	1.06	5.42	3.530	9.53	3.45	6.7

Table 6.4.2 Upland study data at FZB during Kh 2013

S.No.	Genotypes	Days to flow	Days to mat	No of un prod. Tillers/m2	No of prod. Till/m2	Plant ht at flow	TDM at flow	Straw wt at hst/m2	Grain yield g/m2	1000 gr wt (g)	Grain no/m2	Chaff no/m2
1	IET 24063	71	98	25	368	129	972	675	683	28.83	6496	1790
2	IET 24064	71	92	23	350	127	940	597	640	27.83	3239	1128
3	IET 23377	65	90	22	343	120	907	420	423	27.33	3231	1074
4	IET 24071	64	89	22	333	118	895	393	390	27.17	2843	1065
5	IET 24066	63	88	20	313	116	833	360	375	26.67	2751	728
6	IET 24070	63	88	20	313	115	822	352	369	26.33	2695	717
7	IET 23383	62	88	18	312	114	793	350	353	26.33	2670	696
8	IET 22743	62	87	18	310	105	770	336	352	26.17	2623	661
9	IET 22744	62	87	17	298	105	750	335	350	26.17	2608	658
10	IET 24069	62	86	17	297	102	732	327	343	26.17	2546	592
11	IET 24067	59	83	17	288	99	728	312	315	25.50	2446	591
12	IET 24065	58	82	17	288	98	667	292	313	24.50	2344	562
13	IET 24061	56	81	13	275	97	592	267	264	24.17	2014	537
14	IET 24068	56	80	13	267	96	533	255	263	24.00	1860	494
15	IET 24062	54	79	12	262	91	455	247	258	22.50	1843	493
16	IET 23380	54	78	12	253	91	108	108	112	22.17	777	480
17	Anjali (NC)	57	82	15	278	97	605	286	301	24.50	2040	538
	Mean	**61**	**86**	**18**	**303**	**107**	**712**	**348**	**359**	**25.67**	**2649**	**753**
	LSD (p<0.05)	1.88	6.48	7.67	20.02	1.44	55.64	34.74	33.05	0.62	116.76	57.49
	CV (%)	1.84	4.54	26.15	3.97	0.81	4.70	6.01	5.53	1.45	2.65	4.60

Table 6.4.3 Upland study data at CRRI during Kh 2013

S.No.	Genotypes	Days to flow			Days to Mat			Germination (%)			LAI			TDM g/m2		
		Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean
1	IET22743	87	68	78	119	100	110	98.3	96.3	97.3	11.07	1.20	6.14	1263	852	1058
2	IET22744	77	63	70	108	97	103	96.3	94.7	95.5	10.73	1.41	6.07	1146	801	973
3	IET23377	77	67	72	108	100	104	98.0	97.3	97.7	9.20	1.55	5.38	1175	815	995
4	IET23380	70	58	64	104	90	97	98.0	95.3	96.7	10.43	1.10	5.77	1108	802	955
5	IET23383	80	65	73	110	100	105	96.0	97.0	96.5	9.94	1.61	5.77	984	819	901
6	IET24061	76	63	69	108	97	103	96.3	95.3	95.8	12.74	1.60	7.17	1293	1056	1174
7	IET24062	73	58	65	107	90	98	97.7	95.3	96.5	10.15	0.99	5.57	1099	807	953
8	IET24063	88	68	78	121	100	111	98.3	97.3	97.8	11.49	1.87	6.68	1356	863	1109
9	IET24064	79	70	74	109	101	105	96.3	95.7	96.0	8.82	1.34	5.08	1138	873	1006
10	IET24065	74	58	66	108	90	99	97.7	96.3	97.0	9.88	1.19	5.53	1105	925	1015
11	IET24066	75	68	72	108	100	104	97.0	97.7	97.3	10.18	1.24	5.71	976	851	913
12	IET24067	79	65	72	110	100	105	96.0	97.0	96.5	12.82	1.15	6.98	1285	905	1095
13	IET24068	76	58	67	108	90	99	97.7	98.3	98.0	12.55	1.40	6.98	1330	852	1091
14	IET24069	78	60	69	109	93	101	99.3	95.3	97.3	10.08	1.81	5.95	1258	778	1018
15	IET24070	80	58	69	111	90	101	97.7	97.3	97.5	10.07	1.19	5.63	1035	842	939
16	IET24071	78	65	72	109	101	105	98.7	98.0	98.3	10.52	1.02	5.77	1045	814	930
17	ANJALI (NC)	78	65	72	109	101	105	98.3	97.3	97.8	10.71	1.12	5.91	1217	768	993
	Mean	**78**	**63**	**71**	**110**	**97**	**103**	**97.5**	**96.6**	**97.0**	**10.67**	**1.34**	**6.01**	**1166**	**848**	**1007**
	LSD (Treat)		4.06			3.09			NS			2.44			213.12	
	LSD (Entry)		2.86			3.11			NS			NS			NS	
	LSD(Treat x Entry)		4.04			4.40			NS			NS			NS	

Contd... Table 6.4.3 Upland study data at CRRI during Kh 2013

S.No.	Genotypes	Rip %			Pan no/m2			TDM at hst			Gr wt g/m2			HI		
		Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean
1	IET22743	76.11	82.02	79.07	317	294	306	1021	640	830	486	292	389	35.72	22.63	29.17
2	IET22744	70.58	79.34	74.96	350	267	309	809	621	715	420	281	351	31.54	21.70	26.62
3	IET23377	73.83	79.62	76.72	373	372	373	757	613	685	462	272	367	35.52	23.51	29.52
4	IET23380	72.89	77.40	75.14	405	406	406	827	632	730	466	261	363	36.61	23.45	30.03
5	IET23383	77.88	79.91	78.90	361	361	361	695	689	692	391	194	292	30.12	18.66	24.39
6	IET24061	75.28	82.00	78.64	356	344	350	1193	700	947	489	343	416	39.34	19.49	29.41
7	IET24062	72.32	77.30	74.81	306	278	292	918	593	756	421	254	337	33.55	20.71	27.13
8	IET24063	77.41	85.32	81.37	411	317	364	1075	665	870	462	286	374	28.90	21.05	24.98
9	IET24064	71.46	80.07	75.77	361	350	356	1002	632	817	473	259	366	37.06	22.53	29.79
10	IET24065	75.59	81.07	78.33	388	389	389	977	668	823	438	305	372	40.06	22.55	31.30
11	IET24066	76.85	80.21	78.53	333	328	331	821	642	731	365	243	304	33.24	18.85	26.05
12	IET24067	75.05	80.37	77.71	350	300	325	1184	683	933	513	269	391	39.22	21.58	30.40
13	IET24068	76.38	84.71	80.55	322	317	320	1040	617	829	444	256	350	30.04	19.67	24.86
14	IET24069	71.88	78.62	75.25	389	339	364	951	607	779	512	245	379	36.86	23.85	30.35
15	IET24070	72.15	80.21	76.18	300	361	331	969	617	793	420	288	354	39.73	21.99	30.86
16	IET24071	77.07	79.32	78.19	339	322	331	870	602	736	375	243	309	31.47	17.55	24.51
17	ANJALI (NC)	70.05	78.62	74.33	378	244	311	1007	591	799	431	238	334	34.10	21.55	27.83
	Mean	**74.28**	**80.36**	**77.32**	**355**	**329**	342	**948**	**636**	**792**	**445**	**266**	**356**	**34.89**	**21.25**	**28.07**
	LSD (Treat)		3.76			NS			218.71			169.84			10.41	
	LSD (Entry)		NS			NS			182.37			NS			NS	
	LSD(Treat x Entry)		NS			79.168			194.07			NS			NS	

Table 6.4.4 Rainfed Upland study data at HAT during Kh 2013

S.No.	Genotypes	Days to flow	Days to mat	Germination (%)	No. of tillers/plant	No. of pan/m2	TDM g/m2	Grain yield
1	IET22743	77	106	83.7	4.5	171	727	173
2	IET22744	66	95	86.7	3.9	147	473	107
3	IET23377	78	107	88.3	4.0	156	423	123
4	IET23380	65	95	93.7	4.0	149	453	123
5	IET23383	67	96	90.3	4.6	177	543	163
6	IET24061	73	99	94.3	4.5	173	843	183
7	IET24062	61	93	91.0	4.4	154	573	120
8	IET24063	59	97	93.0	5.2	189	690	173
9	IET24064	70	101	93.7	4.5	199	573	187
10	IET24065	76	103	96.3	3.7	162	617	143
11	IET24066	68	97	95.0	4.7	182	713	120
12	IET24067	74	100	92.0	3.4	164	697	157
13	IET24068	60	90	94.7	5.0	200	550	180
14	IET24069	67	93	93.7	5.0	198	487	147
15	IET24070	66	94	92.0	4.1	164	573	136
16	IET24071	66	95	92.0	5.2	200	613	123
17	ANJALI (NC)	68	95	93.3	4.8	179	577	117
	Mean	**68**	**97**	**92.0**	**4.4**	**174**	**596**	**146**
	LSD (p<0.05)	7.96	4.07	5.58	1.3	54.40	210.4	64.01
	C.V. (%)	7.01	2.51	3.64	18.0	18.76	21.2	26.43

Table 6.4.5 Rainfed Upland study data at PTB during Kh 2013

S.No	Genotypes	Days to flow			Days to mat			Stem.wt.			TDM		
		Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean
1	IET22743	83	82	83	108	108	108	21.3	4.5	12.9	26.5	5.2	15.8
2	IET22744	75	72	74	103	49	76	17.0	3.5	10.2	21.0	4.1	12.5
3	IET23377	77	76	77	103	103	103	23.4	14.6	19.0	28.3	17.8	23.0
4	IET23380	59	63	61	88	91	90	19.2	14.3	16.7	23.3	14.8	19.0
5	IET23383	72	79	76	101	108	105	15.8	8.4	12.1	18.3	11.4	14.9
6	IET24061	71	66	69	98	95	97	23.0	5.6	14.3	26.8	5.9	16.3
7	IET24062	66	72	69	94	98	96	20.6	8.3	14.5	24.7	9.2	17.0
8	IET24063	71	80	76	98	108	103	18.9	9.9	14.4	21.9	10.7	16.3
9	IET24064	74	75	74	98	101	100	24.3	14.0	19.2	28.5	16.1	22.3
10	IET24065	71	77	74	98	103	101	16.1	11.1	13.6	18.9	12.2	15.5
11	IET24066	69	68	69	95	95	95	20.7	6.0	13.4	24.6	7.9	16.3
12	IET24067	72	78	75	98	103	101	20.3	6.4	13.4	25.8	7.9	16.8
13	IET24068	67	75	71	95	101	98	20.2	8.9	14.6	19.8	10.1	15.0
14	IET24069	73	75	74	98	81	90	22.4	8.1	15.3	19.7	8.7	14.2
15	IET24070	73	76	75	98	81	90	19.1	5.7	12.4	21.3	6.1	13.7
16	IET24071	74	80	77	101	125	113	15.7	14.4	15.0	21.6	20.2	20.9
17	ANJALI (NC)	74	80	77	99	105	102	18.5	8.8	13.6	21.2	10.1	15.7
	Mean	**72**	**75**	**73**	**98**	**97**	**98**	**19.8**	**9.0**	**14.4**	**23.1**	**10.5**	**16.8**
	LSD (Treat)	0.19			NS			5.13			4.51		
	LSD (Entry)	0.90			NS			4.27			6.55		
	LSD(Treat x Entry)	1.27			NS			6.04			9.27		

Contd.. Table 6.4.5 Rainfed Upland study data at PTB during Kh 2013

S.No	Genotypes	No. panicle/m2			No. of filled\pan			No. unfilled			Grain Yield			TDM g\m2		
		Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean	Irrigated	Rainfed	Mean
1	IET22743	10	3	7	72	55	63	38	33	35	481	79	280	796.0	154.6	475.3
2	IET22744	11	3	7	51	35	43	22	35	29	574	56	315	629.0	122.3	375.7
3	IET23377	12	4	8	51	83	67	28	32	30	398	90	244	849.1	532.8	691.0
4	IET23380	10	4	7	72	14	43	29	37	33	500	32	266	698.7	443.2	571.0
5	IET23383	8	8	8	41	56	49	30	29	29	519	428	473	549.6	343.1	446.4
6	IET24061	13	5	9	43	48	46	18	36	27	426	139	282	804.0	175.9	490.0
7	IET24062	9	7	8	47	33	40	23	43	33	417	186	301	739.7	277.4	508.6
8	IET24063	8	7	7	58	72	65	22	35	28	278	269	273	656.3	321.7	489.0
9	IET24064	8	4	6	56	80	68	37	39	38	463	320	391	853.9	482.5	668.2
10	IET24065	13	6	9	54	59	57	24	18	21	398	246	322	566.5	366.4	466.5
11	IET24066	9	7	8	80	43	62	31	30	31	519	168	343	739.1	237.9	488.5
12	IET24067	10	6	8	67	66	67	24	38	31	454	228	341	774.0	235.6	504.8
13	IET24068	9	6	7	84	52	68	34	36	35	329	220	275	593.9	304.3	449.1
14	IET24069	10	6	8	57	38	48	24	39	31	431	205	318	591.1	259.6	425.4
15	IET24070	12	6	9	79	49	64	23	33	28	449	203	326	639.0	182.2	410.6
16	IET24071	9	5	7	68	14	41	20	30	25	519	39	279	648.8	605.1	627.0
17	ANJALI (NC)	10	7	9	55	16	36	32	47	40	495	117	306	636.0	303.3	469.7
	Mean	**10**	**6**	**8**	**61**	**48**	**54**	**27**	**35**	**31**	**450**	**178**	**314**	**692.0**	**314.6**	**503.3**
	LSD (Treat)	1.70			NS			6.10			472.53			135.44		
	LSD (Entry)	NS			24.45			NS			NS			196.68		
	LSD (Treat x Entry)	3.66			34.57			NS			170.97			278.15		

Table 6.4.6 Upland study data at REWA during Kh 2013

S.No	Genotypes	Days to flowering			Days to maturity			Leaf Area Index at Flowering			No. of tillers/plant			No. of tillers/m2		
		Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean
1	IET22743	62	67	65	87	96	92	3.60	4.70	4.15	12	12	12	137	97	117
2	IET22744	60	64	62	86	92	89	3.43	5.20	4.32	9	12	11	113	101	107
3	IET23377	63	68	65	85	92	89	3.37	5.53	4.45	9	13	11	101	127	114
4	IET23380	60	64	62	86	93	90	3.57	5.50	4.53	12	14	13	135	143	139
5	IET23383	62	66	64	91	96	93	3.60	5.27	4.43	10	10	10	113	122	118
6	IET24061	60	65	63	87	98	93	3.73	5.07	4.40	11	12	11	125	105	115
7	IET24062	58	62	60	93	99	96	3.53	5.73	4.63	11	12	12	121	109	115
8	IET24063	59	64	62	86	93	90	3.33	5.57	4.45	9	14	11	107	127	117
9	IET24064	61	66	64	86	93	90	3.47	5.40	4.43	8	14	11	92	133	113
10	IET24065	64	68	66	86	95	90	3.63	5.20	4.42	11	15	13	140	143	141
11	IET24066	59	65	62	88	97	93	3.63	5.30	4.47	9	11	10	116	132	124
12	IET24067	57	63	60	87	96	92	3.60	5.67	4.63	9	12	11	103	132	118
13	IET24068	59	64	61	92	100	96	3.77	5.60	4.68	12	14	13	134	140	137
14	IET24069	57	62	60	88	97	93	3.73	5.43	4.58	9	14	11	84	142	113
15	IET24070	60	66	63	87	96	91	3.53	5.37	4.45	9	14	12	95	135	115
16	IET24071	60	64	62	85	92	88	3.47	5.10	4.28	9	13	11	113	127	120
17	ANJALI	59	63	61	88	94	91	3.77	5.47	4.62	10	12	11	111	126	118
	Mean	**60**	**65**	**62**	**88**	**95**	**91**	**3.6**	**5.4**	**4.5**	**10**	**13**	**11**	**115**	**126**	**120**
	LSD (Treat)		0.49		0.93					0.09		0.53			6.624	
	LSD (Entry)		2.57		4.90					NS		2.80			34.771	
	LSD(Treat x Entry)		4.02		7.69					NS		4.39			54.5	

Contd...Table 6.4.6 Upland study data at REWA during Kh 2013

S.No	Genotypes	No. of unfilled grains/pan			1000 grain wt (g)			Yield (g/m2)			Total Dry matter (g/m2)		
		Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean
1	IET22743	20.7	18.3	19.5	22.0	23.0	22.5	317	367	342	1833	1667	1750
2	IET22744	17.7	22.0	19.8	23.2	23.1	23.2	258	383	321	1433	1583	1508
3	IET23377	19.0	21.7	20.3	22.1	24.9	23.5	258	442	350	1583	2000	1792
4	IET23380	21.0	21.7	21.3	23.6	25.5	24.5	367	542	454	2000	2075	2038
5	IET23383	20.3	24.7	22.5	22.7	24.2	23.5	275	342	308	1917	1833	1875
6	IET24061	21.7	27.7	24.7	23.4	23.8	23.6	317	380	348	2000	1500	1750
7	IET24062	18.7	17.7	18.2	23.5	23.1	23.3	317	392	354	2000	1667	1833
8	IET24063	18.3	22.3	20.3	21.7	26.3	24.0	217	460	338	1650	1667	1658
9	IET24064	25.7	30.0	27.8	21.8	24.1	23.0	167	417	292	1417	1908	1663
10	IET24065	20.3	22.3	21.3	23.0	26.2	24.6	358	533	446	2000	1750	1875
11	IET24066	22.7	23.0	22.8	22.4	23.3	22.9	267	350	308	1833	1750	1792
12	IET24067	21.7	22.0	21.8	20.9	24.0	22.5	217	358	288	1533	1517	1525
13	IET24068	21.3	24.3	22.8	23.1	24.3	23.7	350	458	404	2000	1717	1858
14	IET24069	23.3	23.3	23.3	22.5	24.2	23.4	108	433	271	1150	1767	1458
15	IET24070	26.7	24.0	25.3	21.2	26.0	23.6	208	550	379	1750	1850	1800
16	IET24071	23.7	19.7	21.7	22.3	23.9	23.1	242	350	296	1667	1667	1667
17	ANJALI	26.7	19.0	22.8	22.6	24.3	23.5	242	392	317	1683	1517	1600
	Mean	**21.4**	**22.8**	**22.1**	**22.5**	**24.4**	**23.4**	**265**	**422**	**344**	**1735**	**1745**	**1740**
	LSD (Treat)		2.17			0.631			35.804			88.44	
	LSD (Entry)		11.39			3.315			187.012			264.55	
	LSD(Treat x Entry)		17.84			5.196			294.588			727.00	

6.5. Physiological characterization of selected genotypes for multiple abiotic stress tolerance

Locations: CBT, CTK, DRR, KRK, MTU, PTB, REWA and TTB

Rice (*Oryza sativa* L) is one of the most ancient cereal crop cultivated in various agro-climatic situations across the country. In India it is cultivated in an area of 44.8 million hectares with total production of 102 million tons. A wide range of edaphic and biological factors affect the rice yields. Thus, the productivity of the various ecological zones in a given system is dependent upon the exposition of the crop to drought, floods, salinity which ultimately determining the potential production. On the other hand, as early as in 1968, Donald proposed ideotype concept focussing the attention towards enhancing physiological efficiency in the breeding program so as to improve the productivity and potential. Earlier, breeding approaches are mainly targeted to be environment specific such as drought, salinity or floods. The recent changes in climatic situations, makes the crop more vulnerable due to the fluctuation reduces the rice production. In this context, developing towards multiple biotic stress tolerance by pyramiding genes is gained momentum. Though, the efficiency in understanding the abiotic stress tolerance is relatively less, availability of land races, focussed breeding approaches, qtl pyramiding, introgression lines, recombinant lines etc., advances in molecular breeding techniques would lead us to understand the multiple abiotic stresses. Under different AICRIP trials rice lines superior in their performance such as photosensitivity, heat tolerance, rainfed upland systems were identified but were not subjected to validation for their suitability in other abiotic stress conditions. In this direction, as a first attempt, under AICRIP physiological characterization of selected genotypes for multiple abiotic stress tolerance is undertaken. During the first year, the standardized protocols using mannitol 1 and 2% for creating the water stress, NaCl stress (200mM equivalent to -1.26 Mpa water potential) cold temperature 8-10^{0}C, anaerobic environment (15 cm depth) are the abiotic stresses studied in the laboratory at seedling stage. Simultaneously, the genotypes were also studied for their field performance under irrigated situation in field. There were total 10 cultures, viz., 4 IET cultures selected from 2012-13 AICRIP physiology program, 4 promising lines from DRR biotechnology, AK Dhan variety and AC 39416-A from CRRI.

The first set of experiment independently carried out in a small way at 8 locations in laboratory conditions during August-September so as to maintain uniform temperature conditions and their field performance under irrigated situation at MTU. The surface sterilized seeds were distributed and 25-50 seeds were grown in four replications with 2% mannitol, 200 mM NaCl solution, at 8^{0}C and under anaerobic situation (15 cm depth water level). From PNR qualitative data received could not be used for statistical analysis. Several data points were generated by the co-operators during the course of investigation on all the types of abiotic stresses has been condensed in this report for brevity. Therefore, the time course of germination, from 15th day to 30th day collected at 5 day interval but 25 d data (cumulative) is presented for CBT, DRR, REWA, TTB and 20 d for KRK and 15 d PTB for all the abiotic stress environments including controls grown in Hoagland nutrient solution.

Root length, shoot length and seed vigour (Gupta 1998) were recorded during the experimental period.

Seed germination at 25 d (Table 6.5.1 a,b,c and d):

Control: The mean seed germination was 97.6% .DRR, PTB and TTB the seed % germination was 100 while a small insignificant amount of less than 5% germination was reported from the other three locations. Among the 10 entries % germination was low in IET 21515 in control.

NaCl stress: The mean % germination was 87.2 IET 20924 had lowest % germination recorded 76.9% followed by IET 21515 while it was as high as 94.5% in NS-1. Seed germination % from RWA was 79.4% while at CBT it was 94.8%. All the four cultures of NS series (1-4) and AC 39416-A were not influenced by 200mM NaCl salinity level.

Water stress: The mean of the germination varied between 77.9- 88.5% with a mean of 84.8%. Amongst the cultures, AK dhan followed by NS-4 exhibited relative sensitivity to water stress imposed using mannitol solution. Germination % reported from TTB (69.2%) and RWA (71.4%) was lower than the group mean while it was higher from CBT.

Anaerobic germination: The seeds germinated under anaerobic situation in 15 cm depth of water revealed that, only 68.6% germinability. Lowest being 53% AC 39416-A followed by AK Dhan (55%) while highest in NS-4 and NS-1 (80%). From KRK and CBT the % germination recorded values were 44% and 55% respectively.

From the above, it would be clear that the germinability of the genotypes varied widely with reference to the type of abiotic stress that was imposed independently at the above locations. The strength of the seed to germinate under the anaerobic situation seems to be relatively stronger compared to that of either water stress or NaCl Stress independently. The strength of stress signals appears to be varied independently, while genetic response appears to be relatively uniform particularly the NS –cultures. Rice culture AC-39416 A under NaCl salinity and water stress found to be superior, but not so under anaerobic situation. The extent of germination under varied stress environment should support the differentiation process such as root and shoot length as emerging seedlings suffers from one or other stress in the present scenario is further examined.

Root length (Table 6.5.2 a, b, c and d):

The mean root length varied between 9.9 cm to 12.1cm with a mean of 11cm. Genotypes under control situation did not vary with respect to this trait. Root length reported from REWA (20.7cm) was maximum while from other 5 locations the root length values recorded did not differ significantly. NS cultures, AC 39416 and AK dhan was had relatively longer roots compared to other test entries.

NaCl stress: The stress imposition resulted in reduced root lengths of 7.8 cm average. NS-5 NS-1, IET 20924 and AC 39416A had longer roots relative to other rice cultures. Seedling root emergence was severely affected by stress at DRR and TTB while low at RWA and moderate at other locations. NS rice cultures were found to be superior followed by AC39416 A and IET 20924.

Water stress: The water stress influence on root length was not very severe compared to that of NaCl stress. The mean root length was 9.1 cm. The maximum and minimum root lengths reported are from 20.4 cm (REWA) and 3.7cm (TTB). The trend with reference to root length did not vary with genotype and was similar as that of NaCl stress.

Anaerobic stress: There was very severe inhibition of root emergence under anaerobic situation reported from all the locations. All the genotypes exhibited similar response.

Thus, once again the intensity of the stress under anaerobic situation is evidenced followed by NaCl stress and water stress. However, the cultures responded uniformly under the various stresses.

Shoot length (Table 6.5.3 a, b, c and d):

Control: The values of shoot length varied between 12.4 cm (AC 39416 A, IET 20924) to 9.7 cm (IET 21515) with a mean of 11.5 cm. Except RWA where the shoot lengths were recorded to be higher (17.7 cm), the values from other locations were well within the range of 12.9cm (CBT) to 8.6cm (KRK). Uniformity was more in NS entries for this trait.

NaCl stress; A mean reduction of 3.0 cm shoot length relative to control was recorded. Shoot lengths recorded under stress was low at DRR (0.8cm) to as high as 16.2 cm (RWA). In the remaining three locations, the shoot lengths though was lower than that of control, moderate shoot lengths could be recorded. NS-1, IET 22116, IET 22218 had better shoot length after 25 d stress treatment.

Water stress: The shoot length mean was 8.5 cm. Maximum (16.2 cm) and minimum (4.9 cm) shoot lengths recorded at RWA and TTB respectively. AC 39419 A had superior shoot length and also NS 3 and NS 1. Genotypes did respond more uniformly to water stress similar to root length.

Anaerobic stress: Shoot length too was severely affected by anaerobic stress (mean 5.2 cm). Ns-1, AC39416 A, NS-3 were able to maintain shoot lengths better than other genotypes. The values of shoot length recorded were 7.8 cm (PTB) and 3.8 cm (DRR)

Though with reference to the of 25 d stress imposed, genotypic response appears to be maintained equally well except for the intensity. Per cent germination and shoot length characters were relatively less influenced while the root characteristics are prone to the stress has been established in the present investigation. Among the various stresses, anaerobic stress signals seems to be stronger followed by NaCl and water stress are evident.

Seed vigour (Table 6.5.4 a, b, c and d):

Seed vigour is one of the important quality parameter. Factors like genetic constitution, edaphic and nutrient and storage of metabolites within a seed would influence the seed vigour. All the more, the seed vigour under abiotic stress situations lead to poor stand establishment and reduces production and productivity. Seed vigour concept as calculated by the germination * total seedling length (i.e. root+ shoot fresh weight basis –unit less attribute) in the context of multiple abiotic stress relation is therefore a prerequisite need and the results obtained from the AICRIP locations is presented below.

Control: The mean seedling vigour (SV) of 10 entries was 1939. Five rice cultures had more than 2000 SV in the order were AC 39416A, AK dhan, NS-3,NS-1 and NS-2. IET 20924 had SV (1483) followed by IET 21515. The SV was maximum 3433 (RWA) and minimum 730 (TTB) followed by KRK (1035).

NaCl stress: Stress resulted lowering the SV to 1274 and to a lesser extent in NS-3, NS-1 and IET 21515. Recorded values of SV were as low as 76 (DRR) to as high as 2873 (REWA).NS-4 followed by AC 39416 A had lower SV under salinity was evident.

Water stress: Water stress reduced SV to the extent of 32% compared to control. Among the genotypes the % reduction was lower (<25%) in NS-1, NS-3, NS-2 and AC 39416A while it was higher in other genotypes. Once again the recorded values of SV were higher (more than the mean of locations) at RWA and almost 75% lower at TTB. Leaving the extremities, the data collected from other four locations was moderate and confirming the water stress effects on the SV.

Anaerobic stress: The mean value of SV was 639, lowest among the all the abiotic stresses imposed on the same genotypes. All four cultures of NS- series (>700) were found to have relative superior tolerance levels compared to the other entries. Among the four locations, PTB had recorded higher values of SV (1597) while the other three locations it is comparable.

Cold stress: Only CBT location could conduct the cold stress influence under laboratory by subjecting to temperatures of 8.0-10^{0}C. An average reduction of 7% germination, 2.0cm root length, 3.3cm shoot length and 638 SV. Once again NS series cultures were found to be relatively superior to other test entries. NS-1 and NS-3 were found to be consistent against all types of stresses indicating that cross talk among the various metabolic pathways related to antioxidant process and genetic traits seems to be working in a co-ordinated manner (Table 6.5.5).

The results of all the various stress experiments and the results obtained from CTK location and from the field evaluation of MTU are presented where in additional information on these genotypes has been gathered. For instance, Na: K ratio analyzed at CTK. NS-2, AC 39416 A and IET 21515 at these locations under NaCl stress indicated that, NS-4 AC 39416 A as moderately tolerant under anaerobic as well as water stress were ascertained (Table 6.5.6).

To create the all the different stresses is not feasible under field and therefore in the first year, under laboratory situation exploration of the influence on multiple abiotic stress was restricted to germination and to the seedling vigour stages. Performance of these genotypes, under irrigated field situation was carried at MTU to extrapolate the potential use of information generated under the laboratory situation and the various characters observed are presented (Table 6.5.7). From the results it was clear that, AC 39416 A , NS-4, NS-3were among the superior entries in terms of yield. Other than these, IET 22117 is one of the exception, with 458 g/m2 yield but could not confirm the multiple abiotic stress tolerance at any of the locations under laboratory. The other three entries as stated earlier had relative superiority in terms of multiple abiotic tolerance and also yield.

Table 6.5.1 a. Germination % (25 d) Control.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	TTB	Mean
1	AC. 39416 -A	100.0	100.0	95.4	100.0	93.0	100.0	98.1
2	AK. Dhan	97.0	100.0	87.0	100.0	96.3	100.0	96.7
3	IET 20924	100.0	100.0	91.8	100.0	89.3	100.0	96.9
4	IET 21515	100.0	100.0	88.2	100.0	89.7	100.0	96.3
5	IET 22116	97.0	100.0	93.5	100.0	-	100.0	98.1
6	IET 22218	100.0	100.0	87.8	100.0	93.7	100.0	96.9
7	NS-1 (S-40)	100.0	100.0	100.0	100.0	92.0	100.0	98.7
8	NS-2 (14-3)	100.0	100.0	99.1	100.0	92.7	100.0	98.6
9	NS-3 (S-463)	100.0	100.0	96.7	100.0	93.0	100.0	98.3
10	NS-4 (SM-686)	100.0	100.0	100.0	100.0	93.0	100.0	98.8
	Mean	**99.4**	**100.0**	**94.0**	**100.0**	**92.5**	**100.0**	**97.6**

Table 6.5.1 b. Germination % (25 d) NaCl Stress.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	Mean
1	AC. 39416 -A	100.0	100.0	92.1	85.3	77.7	91.0
2	AK. Dhan	90.3	90.0	81.5	100.0	82.0	88.8
3	IET 20924	100.0	60.0	91.3	53.3	80.0	76.9
4	IET 21515	89.7	72.0	86.6	64.5	79.0	78.4
5	IET 22116	88.0	98.0	82.6	84.7	79.7	86.6
6	IET 22218	86.0	96.0	71.9	82.9	81.3	83.6
7	NS-1 (S-40)	100.0	100.0	93.7	100.0	78.7	94.5
8	NS-2 (14-3)	100.0	92.0	93.5	85.8	78.0	89.9
9	NS-3 (S-463)	94.0	86.0	95.3	100.0	79.3	90.9
10	NS-4 (SM-686)	100.0	90.0	97.9	89.7	78.3	91.2
	Mean	**94.8**	**88.4**	**88.7**	**84.6**	**79.4**	**87.2**

Table 6.5.1 c. Germination % (25 d) water Stress.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	TTB	Mean
1	AC. 39416 -A	100.0	98.0	94.8	96.7	73.3	68.3	88.5
2	AK. Dhan	87.0	92.0	82.6	60.0	75.7	70.0	77.9
3	IET 20924	100.0	93.0	88.6	100.0	72.2	65.0	86.5
4	IET 21515	100.0	95.0	84.3	80.0	72.3	69.2	83.5
5	IET 22116	87.7	92.0	90.4	100.0	73.0	73.3	86.1
6	IET 22218	100.0	96.0	93.3	70.6	72.3	65.8	83.0
7	NS-1 (S-40)	100.0	98.0	96.1	90.0	68.2	74.2	87.7
8	NS-2 (14-3)	100.0	97.0	98.1	100.0	66.8	65.8	88.0
9	NS-3 (S-463)	93.0	100.0	97.6	85.0	70.2	70.8	86.1
10	NS-4 (SM-686)	94.7	100.0	99.3	50.0	70.3	69.2	80.6
	Mean	**96.2**	**96.1**	**92.5**	**83.2**	**71.4**	**69.2**	**84.8**

Table 6.5.1 d. Germination % (25 d) anaerobic Stress.

S.No.	Genotypes	TTB	DRR	KRK	PTB	Mean
1	AC. 39416 -A	40.0	60.0	50.0	63.3	53.3
2	AK. Dhan	55.0	60.0	46.7	60.0	55.4
3	IET 20924	45.0	96.0	43.3	83.3	66.9
4	IET 21515	65.0	96.0	46.7	83.3	72.8
5	IET 22116	65.0	100.0	40.0	83.3	72.1
6	IET 22218	25.0	100.0	43.3	93.3	65.4
7	NS-1 (S-40)	80.0	88.0	50.0	100.0	79.5
8	NS-2 (14-3)	33.3	94.0	30.0	100.0	64.3
9	NS-3 (S-463)	75.0	96.0	40.0	94.4	76.4
10	NS-4 (SM-686)	70.0	100.0	50.0	100.0	80.0
	Mean	**55.3**	**89.0**	**44.0**	**86.1**	**68.6**

Table 6.5.2 a. Root length cm (25 d) Control.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	TTB	Mean
1	AC. 39416 -A	8.1	11.0	11.0	15.3	20.5	6.7	12.1
2	AK. Dhan	9.5	10.1	8.4	12.8	20.8	7.4	11.5
3	IET 20924	7.9	8.3	8.9	8.1	20.8	6.3	10.1
4	IET 21515	6.7	9.5	8.8	11.9	21.9	6.3	10.8
5	IET 22116	7.8	9.7	7.9	14.4	21.5	5.3	11.1
6	IET 22218	7.6	9.0	4.8	11.4	21.0	5.3	9.9
7	NS-1 (S-40)	10.8	8.4	7.5	11.8	20.2	6.2	10.8
8	NS-2 (14-3)	10.2	9.8	7.1	13.5	20.4	5.3	11.1
9	NS-3 (S-463)	10.0	10.3	8.8	12.5	20.2	7.9	11.6
10	NS-4 (SM-686)	10.1	7.5	6.9	13.5	20.0	7.0	10.8
	Mean	**8.9**	**9.4**	**8.0**	**12.5**	**20.7**	**6.4**	**11.0**

Table 6.5. 2 b. Root length cm (25 d) NaCl Stress.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	Mean
1	AC. 39416 -A	6.4	0.0	6.0	7.8	19.7	8.0
2	AK. Dhan	7.8	0.0	5.4	4.4	20.2	7.6
3	IET 20924	6.1	0.0	3.4	10.8	19.7	8.0
4	IET 21515	5.0	0.0	4.2	9.0	19.8	7.6
5	IET 22116	6.0	0.0	5.0	11.1	20.3	8.5
6	IET 22218	5.9	0.0	3.8	6.1	20.3	7.2
7	NS-1 (S-40)	9.1	0.0	4.1	7.1	19.8	8.0
8	NS-2 (14-3)	8.5	0.0	3.8	7.1	20.1	7.9
9	NS-3 (S-463)	8.2	0.0	3.0	11.9	20.3	8.7
10	NS-4 (SM-686)	8.4	0.0	3.3	1.7	19.2	6.5
	Mean	**7.1**	**0.0**	**4.2**	**7.7**	**19.9**	**7.8**

Table 6.5.2 c. Root length cm (25 d) Water Stress.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	TTB	Mean
1	AC. 39416 -A	6.7	4.8	8.0	10.7	20.5	4.4	9.2
2	AK. Dhan	8.1	5.5	10.6	4.3	20.9	4.2	8.9
3	IET 20924	6.5	6.8	8.8	6.4	19.9	3.8	8.7
4	IET 21515	5.3	5.3	11.8	5.9	20.3	3.3	8.6
5	IET 22116	6.3	4.8	9.9	9.0	20.6	3.6	9.0
6	IET 22218	6.2	7.4	8.1	9.3	20.7	3.6	9.2
7	NS-1 (S-40)	9.4	5.4	8.8	11.3	20.2	3.4	9.7
8	NS-2 (14-3)	8.8	7.6	8.2	8.5	20.9	3.2	9.5
9	NS-3 (S-463)	8.5	6.8	8.0	5.5	19.8	3.9	8.7
10	NS-4 (SM-686)	8.7	6.2	8.0	12.3	20.5	3.3	9.8
	Mean	**7.4**	**6.0**	**9.0**	**8.3**	**20.4**	**3.7**	**9.1**

Table 6.5.3 a. Shoot length cm (25 d) Control.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	TTB	Mean
1	AC. 39416 -A	11.1	15.9	7.8	10.2	17.8	11.8	12.4
2	AK. Dhan	12.8	10.4	11.0	9.9	19.3	11.3	12.4
3	IET 20924	11.2	10.0	6.0	7.3	16.7	8.1	9.9
4	IET 21515	10.6	11.8	6.3	6.8	17.6	5.4	9.7
5	IET 22116	11.2	13.2	8.2	11.5	18.4	7.7	11.7
6	IET 22218	11.2	9.9	10.2	6.9	18.3	8.3	10.8
7	NS-1 (S-40)	14.7	12.3	7.9	11.0	16.1	9.7	12.0
8	NS-2 (14-3)	16.3	9.2	9.4	10.3	17.2	8.1	11.8
9	NS-3 (S-463)	16.2	11.2	9.3	9.7	17.8	8.5	12.1
10	NS-4 (SM-686)	13.9	11.5	10.0	7.8	18.2	8.9	11.7
	Mean	**12.9**	**11.5**	**8.6**	**9.1**	**17.7**	**8.8**	**11.5**

Table 6.5.3 b. Shoot length cm (25 d) NaCl Stress.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	Mean
1	AC. 39416 -A	6.3	1.7	4.7	7.1	16.4	7.2
2	AK. Dhan	6.2	0.9	9.9	4.1	17.6	7.7
3	IET 20924	6.6	0.2	4.3	5.9	15.5	6.5
4	IET 21515	9.2	0.3	5.6	6.4	15.8	7.5
5	IET 22116	9.0	1.1	5.3	8.9	15.7	8.0
6	IET 22218	9.0	1.1	7.7	5.7	16.6	8.0
7	NS-1 (S-40)	8.7	1.4	6.9	7.2	16.2	8.1
8	NS-2 (14-3)	7.5	0.4	6.9	4.3	16.3	7.1
9	NS-3 (S-463)	8.0	0.3	6.7	8.3	16.2	7.9
10	NS-4 (SM-686)	7.3	0.5	8.9	2.0	16.1	6.9
	Mean	**7.8**	**0.8**	**6.7**	**6.0**	**16.2**	**7.5**

Table 6.5.3 c. Shoot length cm (25 d) Water Stress.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	TTB	Mean
1	AC. 39416 -A	5.7	14.0	5.3	8.4	16.4	4.9	9.1
2	AK. Dhan	8.3	8.7	10.8	1.0	18.0	5.5	8.7
3	IET 20924	8.7	7.2	4.6	5.8	15.5	5.1	7.8
4	IET 21515	8.6	8.8	5.4	4.9	16.0	3.7	7.9
5	IET 22116	8.5	7.3	5.9	8.2	16.2	5.1	8.5
6	IET 22218	5.8	9.8	10.4	5.4	16.0	4.6	8.7
7	NS-1 (S-40)	6.9	8.9	8.5	7.6	16.0	5.3	8.9
8	NS-2 (14-3)	7.5	8.3	7.2	3.4	16.5	4.3	7.8
9	NS-3 (S-463)	6.8	9.5	9.5	4.6	16.1	5.3	8.6
10	NS-4 (SM-686)	7.0	8.7	9.1	8.3	15.8	4.8	8.9
	Mean	**7.4**	**9.1**	**7.7**	**5.7**	**16.2**	**4.9**	**8.5**

Table 6.5.3 d. Shoot length cm (25 d) anaerobic Stress.

S.No.	Genotypes	TTB	DRR	KRK	PTB	Mean
1	AC. 39416 -A	5.5	5.6	4.8	7.8	5.9
2	AK. Dhan	5.1	1.7	6.0	8.8	5.4
3	IET 20924	4.1	3.4	5.0	6.2	4.7
4	IET 21515	3.4	3.5	5.0	5.3	4.3
5	IET 22116	3.9	2.6	5.8	8.3	5.2
6	IET 22218	4.1	4.4	5.0	5.7	4.8
7	NS-1 (S-40)	3.6	4.7	7.0	10.1	6.4
8	NS-2 (14-3)	3.9	3.6	4.0	8.9	5.1
9	NS-3 (S-463)	4.3	4.4	4.0	9.0	5.4
10	NS-4 (SM-686)	3.1	3.8	6.8	7.5	5.3
	Mean	**4.1**	**3.8**	**5.3**	**7.8**	**5.2**

Table 6.5. 4 a. Seedling vigour (25 d) Control.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	TTB	Mean
1	AC. 39416 -A	1920.2	2683.3	980.0	2546.7	3565.0	895.3	2098.4
2	AK. Dhan	2160.4	2046.7	1163.3	2270.0	3862.3	921.2	2070.7
3	IET 20924	1911.7	1823.3	860.0	1536.7	2096.0	670.5	1483.0
4	IET 21515	1733.7	2133.3	986.7	1866.7	3539.8	563.3	1803.9
5	IET 22116	1840.8	2286.7	973.3	2586.7	3667.7	625.9	1996.9
6	IET 22218	1883.7	1890.0	1296.7	1823.3	3675.9	660.3	1871.6
7	NS-1 (S-40)	2551.7	2076.7	1056.7	2326.7	3345.7	766.2	2020.6
8	NS-2 (14-3)	2651.2	1903.3	1026.7	2380.0	3484.3	650.3	2016.0
9	NS-3 (S-463)	2616.7	2156.7	996.7	2223.3	3534.0	791.7	2053.2
10	NS-4 (SM-686)	2400.4	1906.7	1013.3	2226.7	3555.7	753.3	1976.0
	Mean	**2167.0**	**2090.7**	**1035.3**	**2178.7**	**3432.7**	**729.8**	**1939.0**

Table 6.5. 4 b. Seedling vigour (25 d) NaCl Stress.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	Mean
1	AC. 39416 -A	1268.8	173.3	620.0	1268.5	2803.9	1226.9
2	AK. Dhan	1259.4	81.0	1096.7	915.3	3099.6	1290.4
3	IET 20924	1274.0	14.0	690.0	891.6	2816.0	1137.1
4	IET 21515	1268.1	24.0	593.3	982.4	2814.2	1136.4
5	IET 22116	1322.7	107.8	646.7	1693.1	2867.7	1327.6
6	IET 22218	1280.7	102.4	966.7	977.0	2998.3	1265.0
7	NS-1 (S-40)	1778.5	143.3	1040.0	1430.0	2832.5	1444.9
8	NS-2 (14-3)	1591.2	36.8	996.7	986.1	2846.4	1291.4
9	NS-3 (S-463)	1521.9	28.7	1030.0	2023.3	2890.0	1498.8
10	NS-4 (SM-686)	1563.4	45.0	896.7	332.3	2770.5	1121.6
	Mean	**1412.9**	**75.6**	**857.7**	**1150.0**	**2873.9**	**1274.0**

Table 6.5.4 c. Seedling vigour (25 d) Water Stress.

S.No.	Genotypes	CBT	DRR	KRK	PTB	REWA	TTB	Mean
1	AC. 39416 -A	1240.3	1843.1	621.7	1825.3	2714.8	347.3	1432.1
2	AK. Dhan	1419.7	1098.4	1131.7	268.0	2949.2	351.3	1203.0
3	IET 20924	1514.5	1429.9	591.7	1079.3	2554.3	313.4	1247.2
4	IET 21515	1385.2	1413.6	806.7	762.7	2623.9	247.8	1206.6
5	IET 22116	1304.1	1111.7	743.3	1725.0	2690.5	325.6	1316.7
6	IET 22218	1203.8	1654.4	1036.7	1011.7	2663.2	278.6	1308.1
7	NS-1 (S-40)	1627.0	1400.7	925.0	1702.0	2487.3	334.7	1412.8
8	NS-2 (14-3)	1626.1	1539.7	953.3	1353.3	2513.2	264.0	1374.9
9	NS-3 (S-463)	1422.9	1625.0	1018.3	870.2	2532.2	324.8	1298.9
10	NS-4 (SM-686)	1490.2	1486.7	1166.7	1266.5	2561.0	284.8	1376.0
	Mean	**1423.4**	**1460.3**	**899.5**	**1186.4**	**2628.9**	**307.2**	**1317.6**

Table 6.5. 4 d. Seedling vigour (25 d) anaerobic Stress.

S.No.	Genotypes	TTB	DRR	KRK	PTB	Mean
1	AC. 39416 -A	218.7	336.0	426.7	1109.2	522.6
2	AK. Dhan	282.3	102.0	403.3	1092.0	469.9
3	IET 20924	186.0	326.4	330.0	1355.0	549.4
4	IET 21515	218.8	336.0	458.3	1457.5	617.7
5	IET 22116	255.7	256.7	400.0	1726.7	659.8
6	IET 22218	102.5	443.3	376.7	1444.7	591.8
7	NS-1 (S-40)	290.7	410.7	440.0	1876.7	754.5
8	NS-2 (14-3)	130.0	338.4	343.3	2100.0	727.9
9	NS-3 (S-463)	320.0	419.2	306.7	1812.0	714.5
10	NS-4 (SM-686)	219.3	383.3	540.0	1996.7	784.8
	Mean	**222.4**	**335.2**	**402.5**	**1597.0**	**639.3**

Table 6.5.5 a. Seed Germination (%) Root, Shoot lengths (cm) and Seed vigour at 8 ºC (25 d) Control.

S.No.	Genotypes	% Ger	RL (cm)	SL (cm)	SV
1	AC. 39416 -A	100.0	8.1	11.1	1920.2
2	AK. Dhan	97.0	9.5	12.8	2160.4
3	IET 20924	100.0	7.9	11.2	1911.7
4	IET 21515	100.0	6.7	10.6	1733.7
5	IET 22116	97.0	7.8	11.2	1840.8
6	IET 22218	100.0	7.6	11.2	1883.7
7	NS-1 (S-40)	100.0	10.8	14.7	2551.7
8	NS-2 (14-3)	100.0	10.2	16.3	2651.2
9	NS-3 (S-463)	100.0	10.0	16.2	2616.7
10	NS-4 (SM-686)	100.0	10.1	13.9	2400.4
	Mean	**99.4**	**8.9**	**12.9**	**2167.0**

Table 6.5.5 b. Seed Germination (%) Root, Shoot lengths (cm) and Seed vigour at 8 ºC (25 d) Cold Stress.

S.No.	Genotypes	% Ger	RL (cm)	SL (cm)	SV
1	AC. 39416 -A	94.0	6.1	8.9	1412.2
2	AK. Dhan	93.3	7.5	8.9	1529.4
3	IET 20924	94.0	5.9	7.5	1258.8
4	IET 21515	100.0	4.7	7.4	1216.2
5	IET 22116	91.3	5.7	8.9	1337.2
6	IET 22218	92.0	5.6	8.3	1279.9
7	NS-1 (S-40)	100.0	8.8	8.8	1754.7
8	NS-2 (14-3)	100.0	8.2	10.4	1865.0
9	NS-3 (S-463)	87.3	8.0	12.4	1778.3
10	NS-4 (SM-686)	82.0	8.1	14.6	1860.1
	Mean	**93.4**	**6.9**	**9.6**	**1529.2**

Pooled data analyzed for seedling characters across the locations

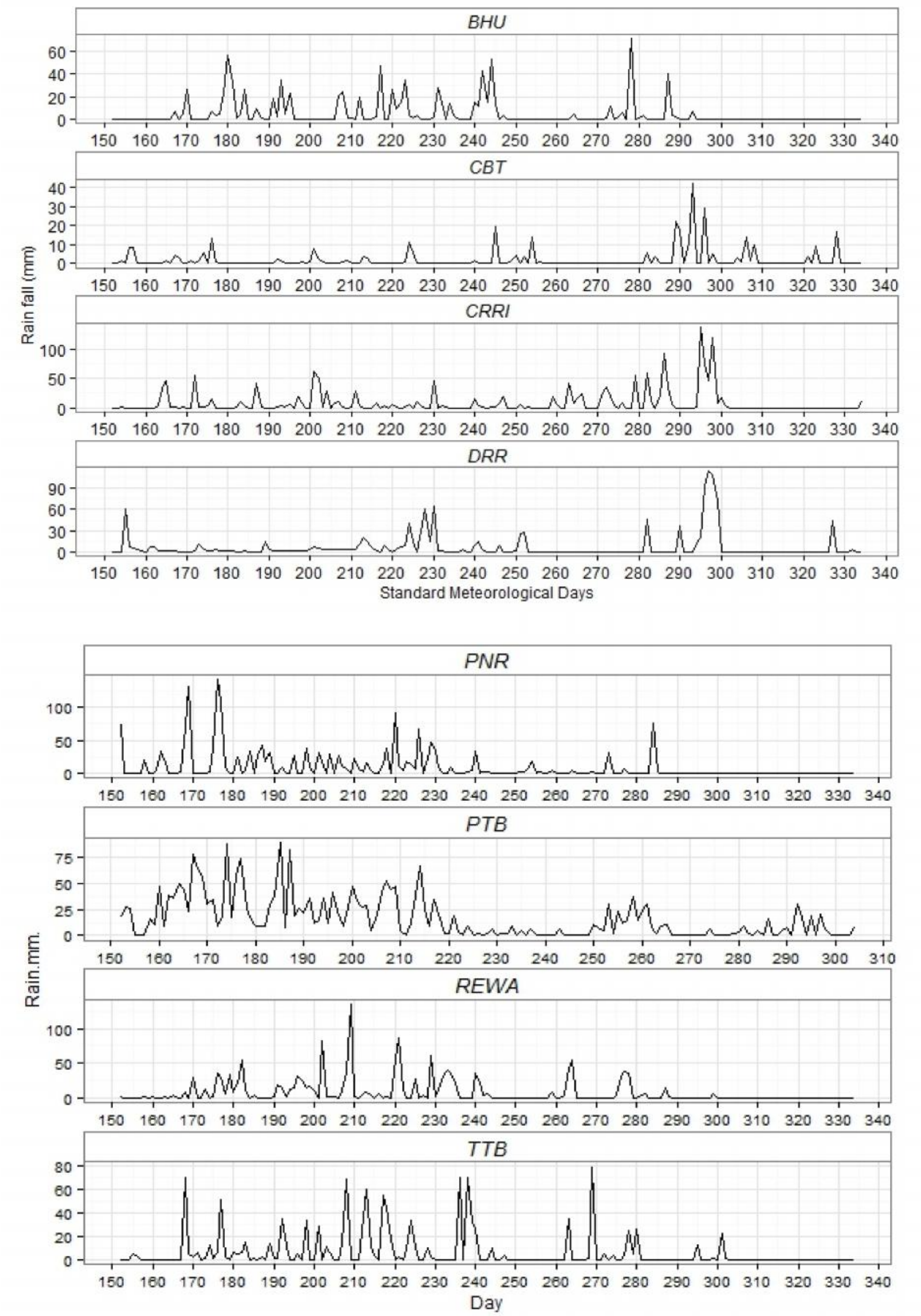
	Shoot length (25 days)	Root length (25 days)	Seedling viourh (25 days)
LSD (Stress)	0.49	0.41	43
LSD (Genotype)	0.69	0.57	82
LSD (Genotype x Stress)	1.55	1.28	180

Table 6.5.6. Na, K Content in rice cultures under NaCl Stress (CTK)

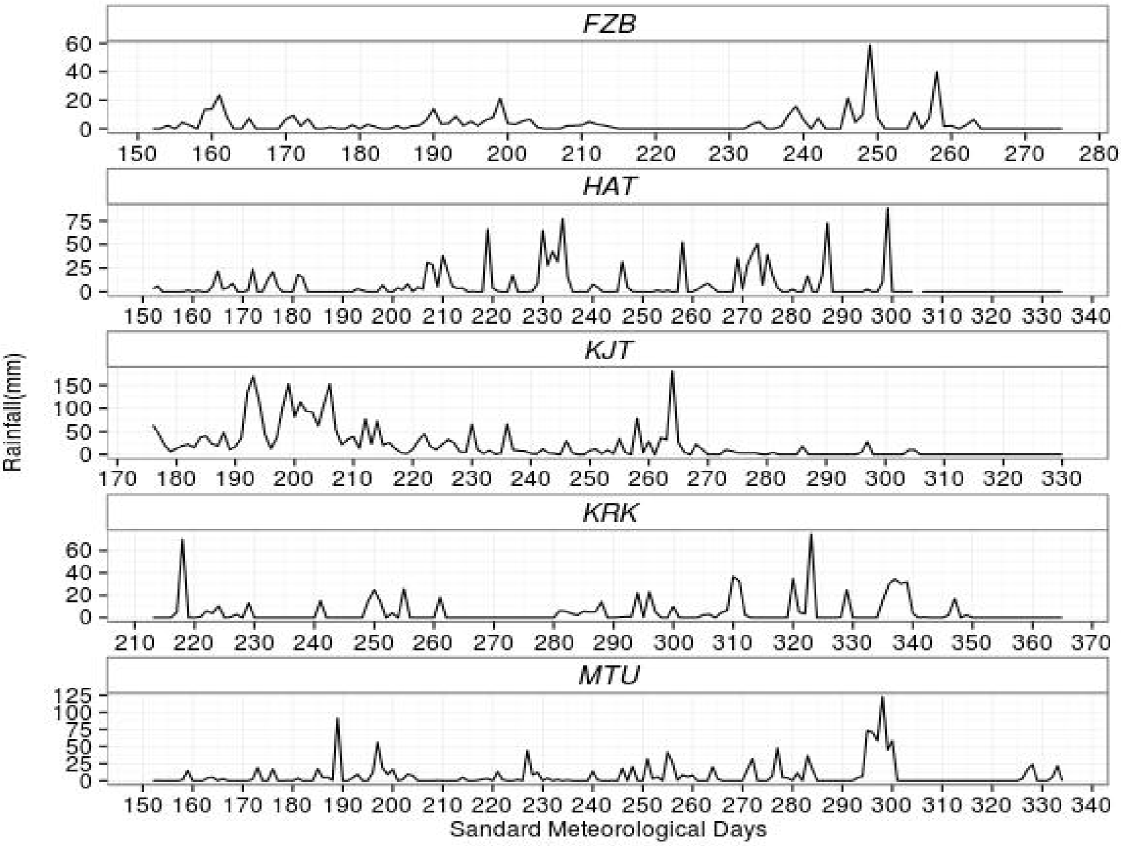
S.No	Genotypes	Sodium content (mg per g dry weight of shoot)		Potassium content (mg per g dry weight of shoot)		Na:K ratio	
		Control	Treatment	Control	Treatment	Control	Treatment
1	AC - 39416(A)	11.6	27.4	55.3	34.8	0.209	0.79
2	A.K.DHAN	11.9	34.7	47.6	29.1	0.25	1.194
3	IET - 20924	9.9	30.7	49.9	30.6	0.198	1.005
4	IET - 21515	9.6	22.9	55	19.9	0.175	1.153
5	IET - 22116	11.9	30.6	49.6	21.7	0.239	1.409
6	IET - 22218	10.5	35.3	43.4	30.9	0.243	1.142
7	NS-1 (S-40)	10.1	34.2	66	27.8	0.153	1.238
8	NS-2 (14-3)	11.3	30.3	50.2	32.4	0.224	0.933
9	NS-3 (S-463)	8.9	27.4	48.2	21.1	0.184	1.299
10	NS-4 (SM-686)	10.8	34.4	51.1	30.9	0.212	1.113
	CD= 0.05	1.3		2.6		0.115	

Table 6.5.7. Field performance of test entries studied at MTU: Multiple abiotic stress.

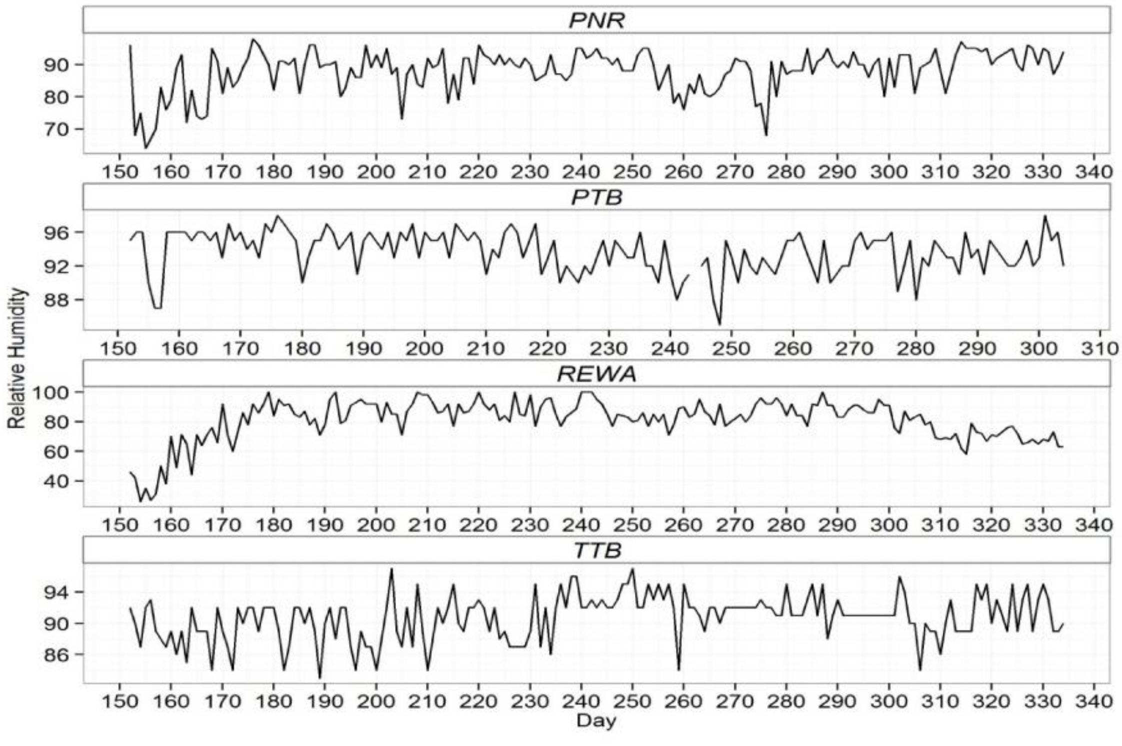
S.No	Genotype	LAI at flow	TDM_Tillering (g/m2)	TDM flow. (g/m2)	Pan/m2	filled grain no/pan	unfilleld grain/pan	GY (g/m2)	TDM Har. (gm2)
1	IET 20925	5.88	375	831	308	125	36.2 (161)	317	968
2	IET 21516	5.6	475	815	330	115	31.73(147	357	1095
3	IET 22117	6.13	440	771	354	128	36.17(164)	458	1276
4	IET 22219	5.45	395	807	340	107	39.33(146)	339	1021
5	AC. 39416 -A	6.19	374	782	372	133	28.03 (161)	527	1283
6	AK. Dhan	6.76	432	786	344	96	42.67(139)	345	1069
7	NS-1 (S-40)	5.86	405	797	328	116	40.97(157)	312	987
8	NS-2 (14-3)	5.16	374	776	246	85	64.77(150)	234	949
9	NS-3 (S-463)	7.52	383	781	323	95	35.63(130)	309	1130
10	NS-4 (SM-686)	6.49	374	743	343	118	33.1(151)	423	1277
	Mean	**6.1**	**402.72**	**788.87**	**328.89**	**108.81**	**41.56**	**358.6**	**1105.44**
	CD (0.05)	0.66	62.21	62.35	41.67	12.64	8.28	40.41	79.36
	Cv (%)	6.28	9	4.61	7.38	6.77	11.6	6.56	4.18
	Var	**	*	ns	**	**	**	**	**



Rain fall distribution during Kharif-2013 at different AICRIP centres

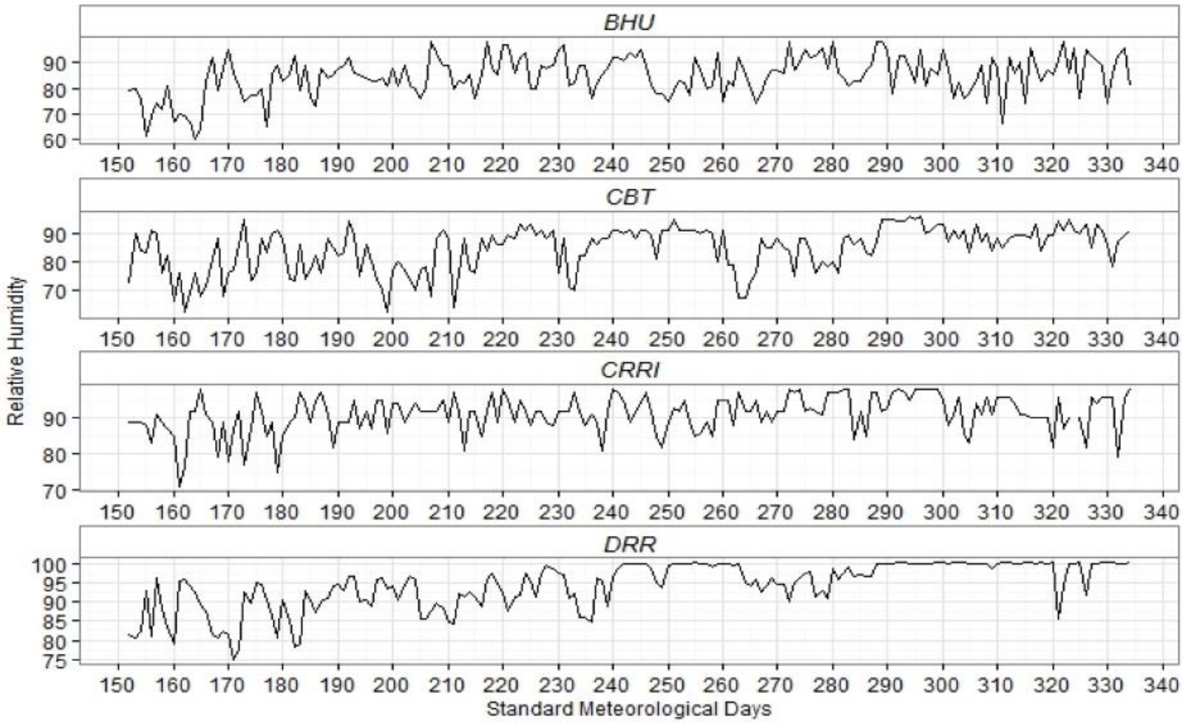


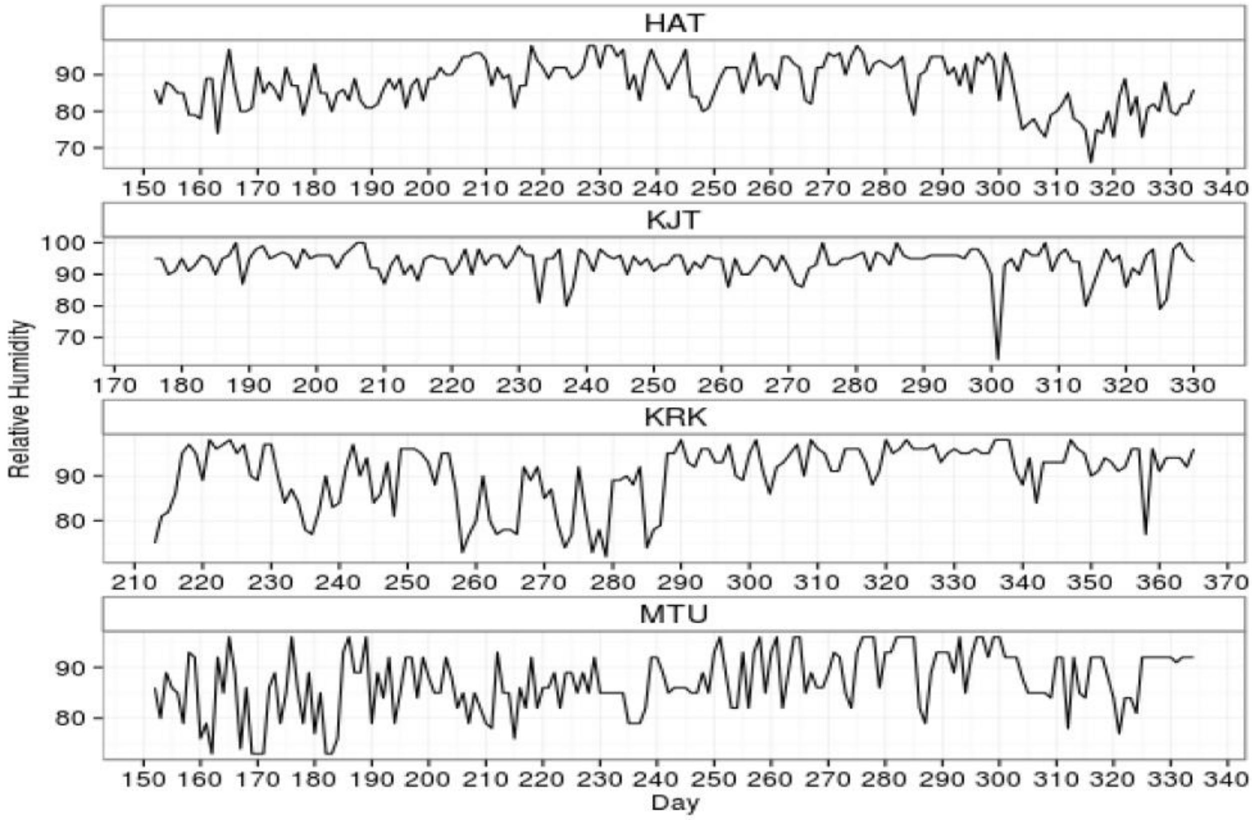
Rain fall distribution during Kharif-2013 at different AICRIP centres



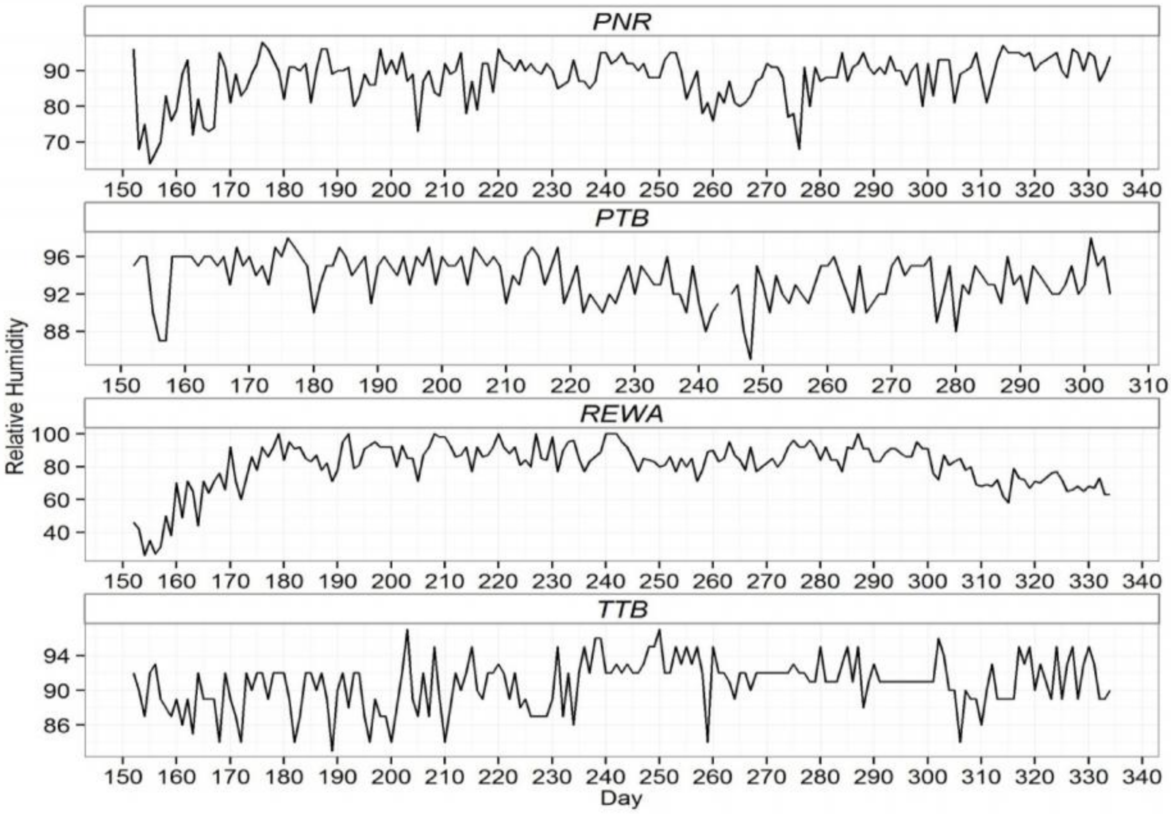
Relative Humidity (RH %) recorded at different AICRIP centres during

Kharif-2013

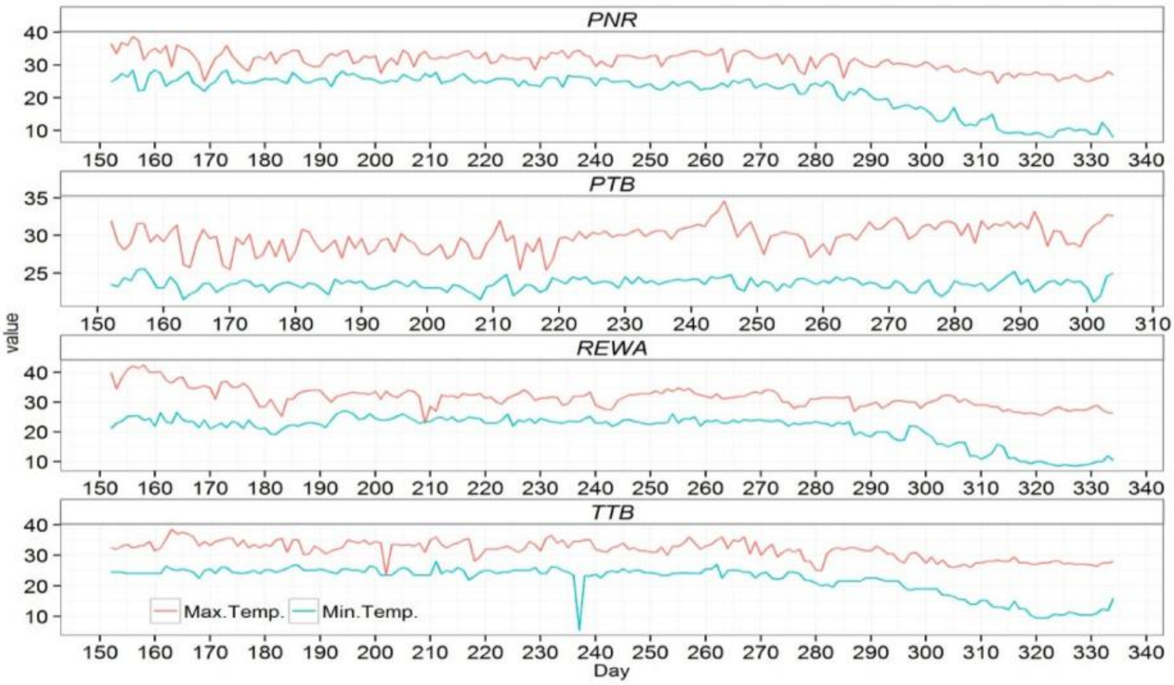




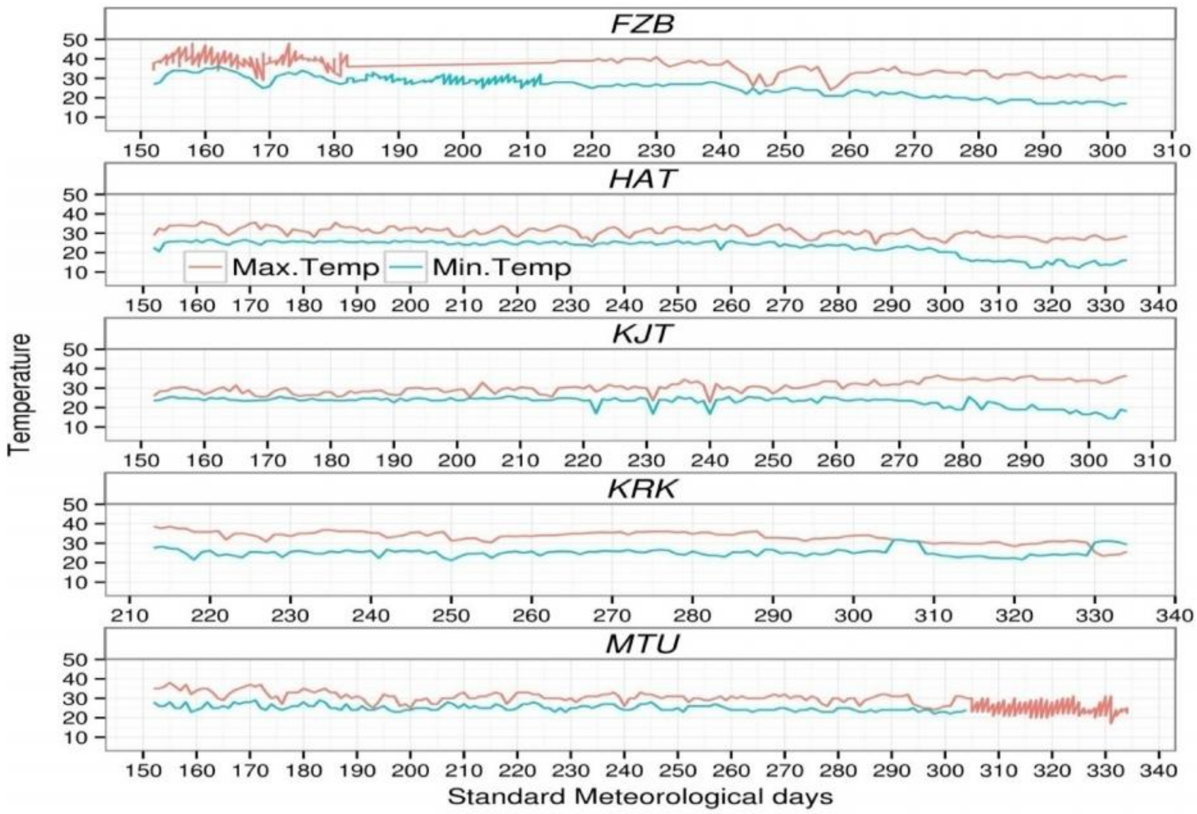
Relative Humidity (RH %) recorded at different AICRIP centers during Kharif-2013



Relative Humidity (RH %) recorded at different AICRIP centers during Kharif-2013



Maximum and Minimum temperatures (°C) recorded during kharif-2013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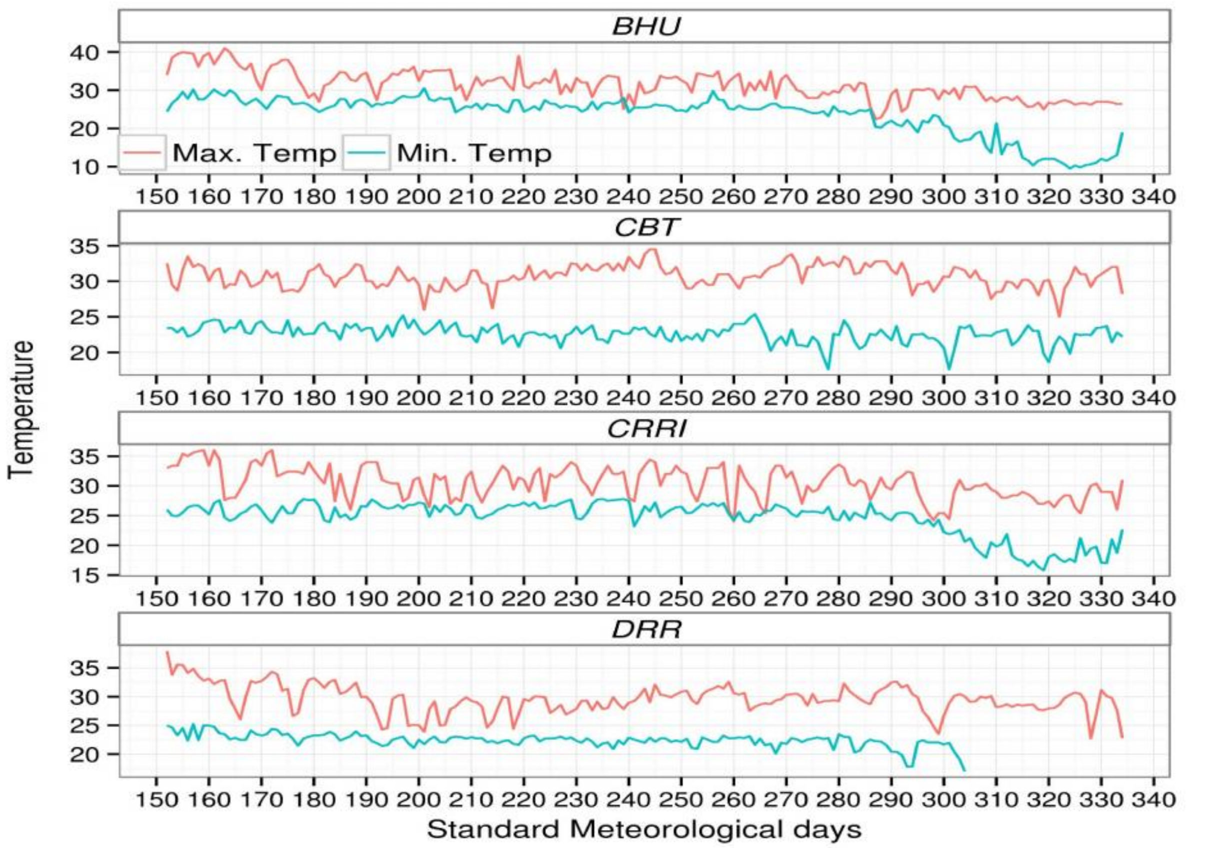
HAT
KJT
KRK
MTU
Max.Temp
Min.Temp
Temperature
Standard Meteorological days


BHU
CBT
CRRI
DRR
Max. Temp
Min. Temp
Temperature
Standard Meteorological days

A P P E N D I X -II

Rice cultures of Physiology

	PTI	**Year**		**HT**	**Year**		**RFU**	**Year**		**MAS**	**Year**
S.No.	Entries		S.No.	Entries		Vn	Entries		Vn	Entries	
1	IET20924	AVT 2 IME 2010	1	IET 21404	AVT 1 IME	1	IET22743	AVT-VE-DS	1	AC. 39416 -A	CRRI
2	IET22212	AVT 2 IME	2	IET 21411	AVT 1 IME	2	IET22744	AVT-VE-DS	2	AK. Dhan	
3	IET22084	AVT 2 IME	3	IET 21515	AVT 1 IME	3	IET23377	AVT-VE-DS	3	IET 20924	AVT 2 IME
4	IET22218	AVT 2 IME	4	IET 21577	AVT 1 IME	4	IET23380	AVT-VE-DS	4	IET 21515	AVT 1 IME
5	IET22568	AVT 2 IME	5	IET 22116	AVT 1 IME	5	IET23383	AVT-VE-DS	5	IET 22116	AVT 1 IME
6	IET22569	AVT 2 IME	6	IET 22218	AVT 1 IME	6	IET24061	AVT-VE-DS	6	IET 22218	AVT 1 IME
7	IET22580	AVT 2 IME	7	IET 22308	AVT 1 IME	7	IET24062	IVT-VE-DS	7	NS-1 (S-40)	Introgression lines
8	IET22592	AVT 2 IME	8	IET 22894	AVT 1 IME	8	IET24063	IVT-VE-DS	8	NS-2 (14-3)	
9	DRRH3		9	IET 22896	AVT 1 IME	9	IET24064	IVT-VE-DS	9	NS-3 (S-463)	
10	Lalat		10	IET 22905	AVT 1 IME	10	IET24065	IVT-VE-DS	10	NS-4 (SM-686)	
11	MTU1010		11	IET 23275	AVT 1 IME	11	IET24066	IVT-VE-DS			
12	PR113		12	IET 23279	AVT 1 IME	12	IET24067	IVT-VE-DS		**SILICA**	
13	RP-4918-166-30		13	IET 23283	AVT 1 IME	13	IET24068	IVT-VE-DS	S.No.	Entries	
14	Sasyasree		14	IET 23296	AVT 1 IME	14	IET24069	IVT-VE-DS	1	Akshayadhan	
15	US312		15	IET 23297	AVT 1 IME	15	IET24070	IVT-VE-DS	2	Varadhan	
16	Akshayadhan		16	IET 23299	AVT 1 IME	16	IET24071	IVT-VE-DS	3	Nagarjuna	
17	IR64		17	IET 23300	AVT 1 IME	17	ANJALI (NC)		4	Shanthi	
18	Shanti		18	IET 23315	AVT 1 IME				5	Sampada	
19	Sampada		19	IET 23324	AVT 1 IME				6	PA-6201	
20	NS5 (SM-219)		20	IR-64					7	PA-6129	
			21	Lalat					8	PA-444	
			22	MTU-1010					9	KRH-2	
			23	N-22					10	PHB-71	
			24	Sasyasree							
			25	US-312							
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