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Screening and identification of rice genotypes with drought tolerance under stress and non-stress condition

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Abstract
Climate change needs us to look at various alternatives for more drought tolerant and tougher strains. Rice (*Oryza sativa* L.) is the most important food crop of the world; drought stress is a serious limiting factor to rice production and yield stability in rainfed areas. In order to design efficient varieties with virtues of drought tolerance and high yielding ability is necessary. A set of 33 rice genotypes including four checks *viz*., Sahbhagidhan, Vandana, Rasi and APO were evaluated under vegetative and reproductive stage, drought stress and normal conditions during kharif 2011-12 with objectives to estimate genetic variability, character association and path analysis for various traits to identify stress tolerant genotypes. Analysis of variance revealed highly significant variation among the genotypes for all the characters under study in both conditions (stress and normal). The effects of water deficit on various morpho-physiological traits associated with drought tolerance were also studied. Result revealed that significant yield decline was observed almost in all rice genotypes grown under water stress condition compared to normal irrigated situation. Out of these 33 rice genotypes, RAU-1428-31-5-4 (8.39*),RAU-1428-54-35-5-5 (8.38*) and 21284-BAU445-06 (8.38*) under stress condition, whereas under normal condition, the genotypes namely RAU-1428-31-5-4-3-2-2-2 (14.82*), RAU-1428-31-5-4 (14.31*) and RAU-1451-66-1-1-5-2 (13.69*) showed superior in terms of grain yield and yield attributes. Significant variation was also observed among the genotypes for drought susceptibility index, canopy temperature, relative water content, leaf rolling at vegetative stage, leaf drying at vegetative stage, chlorophyll content, days to fifty percent flowering, days to maturity, plant height and seed yield per plant under both stress and normal (irrigated) condition. The tolerant lines maintained high leaf water status and plant biomass under vegetative and reproductive stage drought condition. Based on yield and yield attributes results under drought and irrigated condition, rice genotypes RAU-1428-31-5-4 (8.39*), RAU-1428-54-35-5-5 (8.38*) and 21284-BAU445-06 (8.38*) under stress condition, whereas under normal condition, the genotypes namely RAU-1428-31-5-4-3-2-2-2 (14.82*), RAU-1428-31-5-4 (14.31*) and RAU-1451-66-1-1-5-2 (13.69*) were recommended for use in drought breeding programme as well as adoption in rainfed lowland ecosystem. The present study also indicates the agro-morphological and physiological traits that have direct and indirect effect on yield performance of rice genotypes under drought stress condition.

Keywords: rice genotypes, drought tolerance, Climate change, morpho-physiological

Introduction

Rice (*Oryza sativa* L.) is one of the major staple food crops for about 65% of the world's population. Rain-fed rice accounts for around 45% of the world's rice area and around 40 million ha of rain-fed area is concentrated in South and South East Asia alone (Maclean *et al*., 2002). Rain-fed rice-growing areas are highly prone to abiotic stresses such as drought, high temperature and submergence depending upon the distribution of rainfall and topography. Current speculations about increase in the frequency of droughts along with a 1.1-6.4oC increase in global average surface temperature by the end of this century poses serious threat to rice production and thus, food security of Asia. Among the different stresses, drought is the single largest yield reducing factor in rain-fed areas of South and Southeast Asia, affecting more than 23 million ha area (Huke *et al*., 1997). Out of the total 20.7 million ha located in India, approximately 16.2 million ha is in eastern India (Singh and Singh, 2000), of which 6.3 million ha of upland and 7.3 million ha of lowland area are highly drought prone (Pandey *et al*., 2008). Rice crop is highly sensitive to soil moisture deficit and high/low temperature stresses at reproductive stage.

Losses due to reproductive-stage drought stress are most severe in the Chhattisgarh, Orissa, Jharkhand, Bihar, and eastern Uttar Pradesh which are key rice-producing states of eastern India. Most of the traditional as well as high yielding varieties cultivated in the eastern region are highly susceptible to drought. Drought is a major abiotic stress that causes severe yield loss in rice as a staple food crop affecting 20% of the total ricegrowing area in Asia (Pandey and Bhandari, 2008). Improvement of drought resistant rice varieties has become an urgent task under the background of global crisis of water resource. Grain yield may drastically reduce when water deficit coincides with reproductive or intermittent stage. Rice plants respond to drought through alternation in morphological, physiological and metabolic traits. Hence, traits associated with improved performance under water limited condition or improved survivals to extremely low water availability are diverse (Slafer *et al*., 2005). Drought impacts include growth, yield, membrane integrity, pigment content, osmotic adjustment, water relation and photosynthetic activities (Praba *et al*., 2009). Physiological basis of yield gap between drought stress and irrigated condition has not been studied extensively. Understanding of physiological and biochemical mechanism that enable plants to adapt to water deficit and maintain growth and productivity during stress period could help in screening and selection of tolerant genotypes and using these traits in breeding programme (Zaharieva *et al*., 2001). Therefore, selection using morph-physiological and metabolic traits can improved the drought tolerance in rice. Variation in maintaining internal plant water status at vegetative and flowering was associated with grain yield under drought condition (Pantuwan *et al*., 2001). The maintenance of plant water status, more than plant functions, controls crop performance under drought (Blum, 2002). Leaf rolling is one of the visible physiological responses to plant water deficit. It is an adaptive response to water deficit which helps in maintaining favorable water balance within plant tissues with resultant benefit to plants under conditions of water scarcity and depleting soil moisture (Singh and Singh, 2000). Plant recovery from desiccation in agricultural crops is primarily a function of the capacity for maintaining higher RWC during desiccation (Blum *et al*., 1999). The identification or development of rice cultivars that could resist drought stress and produce economic yields is imperative in order to alleviate that increasing food crisis. Most improved cultivars grown in drought prone rainfed lowlands were originally bred for irrigated conditions and were never selected for drought tolerance (Kumar *et al*., 2008). under rain-fed condition of eastern India.

Materials and Methods

Experimental site and plant materials

Field experiments were carried out during Kharif 12 at Research Farm of Rajendra Agricultural University, Pusa, Samastipur, Bihar. Geographically, University Farm is situated between 25.980 N latitude and 85.670 longitudes at 51.8m above mean sea level. The experimental site was typical rainfed having clay loam soil with pH 7.5. 33 rice genotypes comprising of breeding lines and check varieties including viz., Sahbhagidhan, Vandana, Rasi and APO were evaluated for vegetative and reproductive stage were used for testing under irrigated (normal) and stress condition. The rice genotypes used under present study were collected under Stress-Tolerant Rice from RAU, PUSA, (Bihar), IRRI, India, IGKV, Raipur and BAU, Ranchi-Jharkhand.

Field and lab experiments

The field experiments were conducted under reproductive stage water stress and irrigated non-stress (control) condition. 33 genotypes were grown under two environments *viz*, Rainout shelter (stress condition) and Normal (irrigated**)**. The experiment in each environment was laid out in Completely Randomized Block Design with three replications. In each replication each genotype was grown in a plot of 4 rows of 1 meter length each with a spacing of 20 cm between rows under both stress and under irrigated condition. Both water stress and non-stress control field were fertilized @ 60:40:30 kg (N: P: K) per ha. respectively. Nitrogen was applied on three occasion (1/3rd each at basal, maximum tillering and panicle initiation stage), while the P_2O_5 and K_2O were applied as a basal application. The stress condition was created by the technique involved irrigation until 45 days from sowing of rice seed, withholding water for about 15 days till the susceptible checks showed permanent wilting, drought scoring of test entries, rewatering, and then screening for recovery ability. Water tension by tension-meter was also monitored during the stress period. The relative yield (yield potential) under drought stress was calculated as the yield of specific genotypes under drought divided by that of the highest yielding genotype in the population. The data were recorded on five randomly selected plants from each genotype in each replication leaving the first two border rows from all the four sides, in order to avoid the sampling error. The observations were recorded as per the following procedure. Readings from five plants were averaged replication wise and the mean data was used for statistical analysis for 17 characters *viz*, Days to fifty per cent flowering, days to physiological maturity, plant height, flag leaf area, chlorophyll content, number of tillers per plant, leaf rolling at vegetative stage, leaf drying at vegetative stage, relative water content, panicle length, canopy temperature, recovery percentage after stress, drought susceptibility index, number of grains per panicle, 1000 grain weight, harvest index and seed yield per plant. was calculated as the yield of specific genotypes under drought divided by that of the highest yielding genotype in the population. The drought scores, leaf rolling, leaf drying and stress recovery observations were taken as per SES method, 1 to 9 scales (IRRI, 1996) [23]. Leaf relative water content (RWC) was estimated by recording the turgid weight of 0.5 g fresh leaf sample by keeping in water for 4h, followed by drying in hot air oven till constant weight is achieved (Weatherly, 1950). It is given as Relative water content (%) = [(Fresh weight- Oven dry weight) x 100 / (turgid weight- Oven dry weight)]. Leaf chlorophyll content was recorded by measuring leaf greenness using a portal chlorophyll meter (Monilta Camera Co. Ltd., Japan). Canopy temperature was measured using a hand-held infrared thermometer. Measurements were taken in the afternoon (1:00 to 2:00) of full sunshine conditions. Yield attributes i.e. seed yield, straw yield, harvest index and dry matter was measured at maturity. Flag leaf area was measured with the following function by Muller (1991).

Flag leaf area = Flag leaf length × Flag leaf width × 0.74

Data Analysis

The agro-morphological data were analyzed by appropriate statistical analysis (Gomez and Gomez, 1984) using CropStat 7.2 (IRRI, 2009) programme. Physiological data was analyzed using OPSTAT software of Hisar Agricultural University, Hisar.

Results and Discussion

Yield and yield attributes performance under drought stress and irrigated (non-stress)

Analysis of variance revealed highly significant variation among the genotypes for all seventeen traits under study in both conditions (stress and irrigated-normal). The variability study indicated moderate to high phenotypic and genotypic coefficient of variation accompanied by high heritability (moderate for leaf rolling) and genetic advance as per cent of mean for traits like plant height, flag leaf area, chlorophyll content, leaf drying at vegetative stage. Seed yield per plant had showed high heritability coupled with high genetic advance as per cent of mean under both stress and normal conditions indicating their importance in selection for yield improvement under respective environments. The estimation of these parameters for all characters studied has been given in table 1, 2 and 3. This study indicates preponderance of additive gene effect, which will help to make selection in early segregating generation. The genetic advance as per cent mean suggesting that still there is scope for further improvement of genotypes for these characters. A similar result of yield reduction under drought stress condition was reported by Chen *et al*. (2001) [10], Pantuwan *et al*. (2002) [42], Muthuswamy and Kumar (2006 a) [34], Ouk *et al*. (2006) [38], Ganapathy *et al*. (2007) [9], Allah (2009) [3], Mina *et al*. (2011) [31], Gomez *et al*. (2003) [20]. The phenotypic variances for all the traits under study were higher than the genotypic variances (El-Kareem and El-Saidy, 2011) [15]. This may be due to the non-genetic factor which played an important role in the manifestation of these characters. Wide ranges of variance (phenotypic & genotypic) were observed in the experimental material for all the traits under investigation in both environments. The maximum phenotypic and genotypic variance was exhibited by the traits *viz.,* number of grains per panicle and plant height under both environments. These findings were in accordance of Mina *et al*. (2011) [31], Blum *et al*. (1988) [7] and Manickavelu *et al*. (2006b) [29] who also observed high variance for yield and yield component traits among rice genotypes. The relative water content (RWC) and Chlorophyll content exhibited high genotypic and phenotypic variance in stress condition indicating importance of these characters in stress condition for further improvement. Similar results were obtained by Chen *et al*. (2001) [10]. Characters which had high to moderate range of variation with maximum range were Number of grains per panicle followed by Plant height, Relative water content, Harvest index, Days to physiological maturity, Days to fifty per cent flowering and Chlorophyll content are quantitative in nature and influenced by macro and micro-environmental conditions under both conditions. The assessment of heritable and non-heritable components in the total variability observed is indispensable in adoption of suitable breeding procedure. The heritable portion of the overall observed variation can be ascertained by studying the components of variation such as GCV, PCV, heritability and genetic advance as per cent of mean. In the present investigation, Leaf rolling at vegetative stage, leaf drying at vegetative stage and seed yield per plant depicted very high GCV and PCV in both conditions, whereas drought susceptibility index and recovery percentage after stress in stress condition exhibited very high GCV and PCV, indicating the importance of these traits in evaluation and selection of superior genotypes. In this study, the phenotypic and genotypic coefficient of variance was found to be moderate for chlorophyll content and plant height under both environments (normal and stress condition). Similar results were reported by Roy *et al*. (1995) [47], Sarvanan and Senthil (1997) [48], Ganapathy *et al*. (2007) [9] and Sharma *et al*. (2000) [50]. These findings clearly indicated that selecting genotypes through these traits will be effective for drought tolerance. It is interesting to note that the differences between GCV and PCV values were minimum implying least influence of environment and preponderances of additive gene effects; indicating genotypes can be improved and selected for these characters under stress condition for improvement of drought tolerance.

Heritability in broad sense for all the characters, namely days to fifty per cent flowering, days to physiological maturity, plant height, flag leaf area, chlorophyll content, leaf drying at vegetative stage, relative water content (RWC), Panicle length, harvest index and seed yield per plant were found to be high in both (stress and normal) environments. These findings are in agreement with the findings of Venkataramana and Hittalmani (1999) [54] for seed yield per plant; Gomez *et al*. (2003) [20] for plant height; Wu *et al*. (2004) [58] for relative water content; Muthuswamy *et al*. (2006 b) [35] for panicle length, number of tillers per plant, number of grains per panicle and seed yield per plant; Manickavelu *et al*. (2006 a) [28] for leaf drying at vegetative stage, relative water content, harvest index and days to fifty per cent flowering. Farshadfar *et al.* (2011) [17] also reported high heritability for relative water content, Allah (2009) [3] also noticed high heritability value for days to fifty flowering, plant height, flag leaf area, number of grains per panicle, 1000 grains weight and seed yield per plant. Lin *et al*. (2009) [26] also reported the high heritability for days to fifty per cent flowering, plant height, seed yield per plant, 1000 grain weight and number of grains per panicle. Lush (1949) [27] pointed out that when heritability is high, emphasis should be mainly on mass selection or as heritability become lower, more emphasis should be placed on pedigree selection method.

In the present investigation the characters, namely plant height, flag leaf area, chlorophyll content, leaf drying at vegetative stage, and seed yield per plant had showed high heritability coupled with high genetic advance as per cent of mean under both stress and normal conditions. Hence, direct selection can be done through these characters for future improvement of genotypes under respective environment for improvement of drought tolerance and higher grain yield. Similar results were also reported by earlier workers viz., Muthuswamy *et al*. (2006 a) [34] for panicle length; Manickavelu *et al*. (2006 a) [28] for leaf drying at vegetative stage; Mondal and Kour (2004) [32] for flag leaf area and grain yield and Gomez *et al*. (2003) [20] for plant height.

The high heritability associated with high genetic advance indicated, the variation was mostly due to additive gene effects. It indicates that if these characters are subjected to any selection scheme for exploiting fixable genetic variance, a widely adopted genotype can be developed.

High heritability coupled with moderate genetic advance were observed for the traits, namely days to fifty per cent flowering and panicle length under both stress and normal conditions. Recovery percentage after stress depicted high heritability coupled with moderate genetic advance as per cent of mean under stress condition. This finding is in accordance of Manickavelu *et al*. (2006 b) [29] for recovery percentage after stress. These traits indicated that there manifestation is governed by both additive and non-additive genetic effects and therefore, selection should be practiced in later segregating generations i.e. by hybridization programme to exploit hybridity.

Drought susceptibility index showed moderate heritability coupled with high genetic advance as per cent of mean under stress condition reveals that the character is governed by additive gene effects. The moderate heritability is being exhibited due to high environmental effects. Selection may be effective in such cases.

Leaf rolling at vegetative stage exhibited high heritability coupled with high genetic advance as per cent of mean under stress condition reveals that the character is governed by additive gene effects and selection may be rewarding. This finding is in agreement with the finding of Manickavelu *et al*. (2006 a) [28]. However, under normal condition leaf rolling at vegetative stage exhibited moderate heritability accompanied with high genetic advance as per cent of mean revealing that the character is governed by additive gene effects and selection may be effective.

The results related to yield and yield attributes mean performance of rice genotypes under drought stress at vegetative and reproductive stage and irrigated condition has been presented in Table 4 and 5. Rice genotypes grown under water stress condition produced significantly lower grain yields than irrigated condition. Yield decline was observed almost in all the rice genotypes grown under stress condition. The range of yield declined was 3.36 to 8.39g grain yield/ plant under water stress condition as compared to non-stress (irrigated). The minimum yield reduction was observed in RAU-1428-31-5-4 (8.39*g) followed by RAU-1428-54-35-5-5 (8.38*g), Richharia (7.98*g) and 21284-BAU445-06 (7.67*g) whereas maximum yield reduction recorded in RAU-1451-35-7-6-9-5-1 (3.36 g) grain yield per plant. Significant decrease in plant height was also observed in rice genotypes grown under drought stress condition. Singh (2000) also reported that plant height reduced significantly due to drought in rice cultivars. Rice grown in drought stress condition produced significantly less total in performance than irrigated rice. The Similar trends were also observed for harvest index and seed yield per plant.

Correlation coefficient analysis and path coefficient analysis measure the natural relations between various plant characters and determine the component characters on which selection can be used for genetic improvement in yield. The breeder is always concerned for the selection of superior genotype on the basis of phenotypic expression. However, for the quantitative characters, genotypes are influenced by environment, there by effecting the phenotypic expression. Information regarding the nature and extent of association of morphological character would be helpful in developing suitable plant type, in addition to the improvement of yield a complex character for which direct selection is not effective.

The correlation coefficient estimated (Table 6 and 7) seed yield per plant exhibited highest genotypic and phenotypic significant positive association with relative water content, chlorophyll content, number of grains per panicle, flag leaf area, plant height and panicle length. While showed negative association with leaf drying at vegetative stage, canopy temperature and leaf rolling at vegetative stage under both stress and normal conditions as well as high significant negative association showed by recovery percentage after stress and drought susceptibility index under stress condition, indicating importance of these traits in selection of genotypes in respective environments. Seed yield per plant also showed non-significant negative correlation with days to fifty per cent flowering under stress condition. It indicated that under stressed condition early maturing genotypes will be preferred. These results were in accordance with the findings of Singh *et al*. (2004) [52] and Sheeba (2005) [51] for RWC; Raju *et al*. (2004) [44] for plant height; Surek and Beser (2003) [53] for number of grains per panicle; Zulqarnain *et al*. (2012) [61] for number of grains per panicle; Sheeba (2005) [51] for leaf drying at vegetative stage and recovery percentage after stress; Zulqarnain *et al*. (2012) [61] for leaf drying at vegetative stage; Ganapathy *et al*. (2007) [9] for leaf rolling at vegetative stage, leaf drying at vegetative stage and canopy temperature expressed significantly negative correlation with grain yield. Adhikary and Sarkar (2003) [1] for drought susceptibility index.

Further canopy temperature revealed strong genotypic negative association among the traits like seed yield per plant, relative water content, plant height, chlorophyll content, panicle length and flag leaf area under both stress and normal condition. Canopy temperature showed the important of this trait for selecting the genotypes under water stress condition. Because of major role of transpiration is leaf cooling, canopy temperature and its reduction relative to ambient air temperature are an indicator of how much transpiration cools the leaves under a demanding environmental load. Genotypes having lower canopy temperature indicate a relatively better capacity for taking up soil moisture or for maintaining a relatively better plant water status.

Recovery percentage after stress exhibited significant negative association with seed yield per plant, number of grains per panicle, harvest index and 1000 grain weight under stress condition. It indicated that after recovery the inter plant competition is more because more number of plants being recovered after stress being responsible for reduction of yield under stress condition. However, it showed strong positive correlation with drought susceptibility index under stress condition. Leaf rolling at vegetative stage exhibited significant positive association with leaf drying at vegetative stage and canopy temperature as well as with recovery percentage after stress and drought susceptibility index under stress condition. Leaf rolling at vegetative stage exhibited negative association with seed yield per plant and with most of the yield contributing traits (significantly or non-significantly) in both conditions. It indicated the importance of this trait in selecting genotypes especially in water limited condition. In general, if a certain cultivar does not show leaf rolling while others do, this is an indication that the cultivar has a relatively better water status. That may be a result of deeper roots that allow continued water uptake, effective osmotic adjustment that maintains turgor at a given leaf water status, or less leaf area and slower water use. Drought susceptibility index exhibited positive correlation with leaf rolling at vegetative stage and leaf drying at vegetative stage, whereas drought susceptibility index showed significant negative association with seed yield per plant and 1000 grain weight at under stress condition. This indicated that genotypes with short duration which can maintain high RWC and lower down the canopy temperature will be preferred under water stress condition. Leaf drying at vegetative stage exhibited significant negative association with relative water content and number of grains per panicle under both conditions; apparently because of leaf drying occur due to leaf water deficit can be further reduced beyond the point of turgor loss, reaching the point of tissue death that reduced the leaf area for photosynthesis and chlorophyll content. Leaf tissue may die (expressing desiccation) because of extreme loss of water or because of heat stress when leaf temperature rises because of inadequate transpirational cooling and ultimately affect the yield. It indicated that the genotypes have not an effective osmotic adjustment mechanism resulting inadequate transpiration cooling. It showed strong positive correlation with drought susceptibility index and recovery percentage after stress under stress condition.

Recovery percentage after stress should be given due weightage in selection, since this trait exhibited high negative correlation with seed yield per plant due to its high negative direct effect on seed yield per plant and also most of the traits exhibited high indirect effect via this trait. Thus, these traits may be used as selection criteria for stress (drought) environments.

Canopy temperature and relative water content have to be given importance in selection process for improvement in yield, since most of the traits had strong positive (negative-canopy temperature) correlation with seed yield per plant and positive direct and indirect effect on grain yield via this trait. Hence, selection based on this character will be more effective for yield improvement in rice under normal condition.

All genotypes showed higher yield under normal condition compared to stress condition, indicating the potential of genotypes to yield better if the favorable condition prevailed.

Path Coefficient Analysis under Stress and Normal Environment

Path coefficient analysis (Table-8 and 9) under stress condition, most of the component traits exhibited positive or negative negligible direct effect on seed yield per plant. However, strong negative direct effect was showed by the traits recovery percentage after stress with seed yield per plant. Supported results were also obtained by Mondal and Kour (2004) [32] found positive direct effect of number of tillers per plant on grain yield. Anbumalarmathi and Nadarajan (2008) [4] found positive direct effect for harvest index on seed yield per plant. Javed Iqbal *et al*. (2010) found positive direct effect on grain yield by number of tillers per plant, plant height, days to physiological maturity, flag leaf area, 1000 grain weight and harvest index on seed yield per plant except the days to fifty per cent flowering.

Relative water content, chlorophyll content, number of tillers per plant, harvest index, number of grains per panicle, days to physiological maturity, flag leaf area, panicle length, plant height and 1000 grain weight had high to moderate positive indirect effect on seed yield per plant via recovery per cent after stress, whereas leaf rolling at vegetative stage, drought susceptibility index, days to fifty per cent flowering, canopy temperature and leaf drying at vegetative stage showed high negative indirect effect via recovery per cent after stress. It indicates the true relationship of recovery percentage after stress with yield. Indicated that the recovery percentage after stress is an important trait for stress condition. Hence, selection based on these characters would be more effective for yield improvement in rice under stress condition.

Therefore, it implies from above discussion that the traits viz., recovery percentage after stress have to be given importance in selection process for improvement in yield, since most of the traits had strong positive correlation with seed yield per plant and positive or negative direct and indirect effect on seed yield per plant via this trait. Hence, selection based on this character will be more effective for yield improvement in rice under respective environment.

Under normal condition, strong direct effect exhibited by relative water content, plant height, chlorophyll content and number of tillers per plant, whereas strong negative direct effect showed by leaf rolling at vegetative stage and days to fifty per cent flowering. However, negative indirect effect on seed yield per plant were exhibited by relative water content, chlorophyll content, plant height, panicle length, flag leaf area, days to fifty per cent flowering and 1000 grain weight via canopy temperature, whereas positive indirect showed by only leaf rolling at vegetative stage. Under normal condition, high positive indirect showed by chlorophyll content and flag leaf area via relative water content, whereas high negative indirect effect exhibited by canopy temperature through relative water content. It indicated that most of the traits exhibited high to low positive or negative indirect effect via canopy temperature and relative water content under normal condition. Hence, selection based on these characters would be more effective for yield improvement in rice under respective environmental (normal) conditions.

Relative water content and canopy temperature should be given due weightage along with selection based on traits like Chlorophyll content, flag leaf area and panicle length since these traits exhibited strong positive correlation with seed yield per plant and high positive indirect effects on seed yield per plant via these traits indicating their true relationship with seed yield under normal condition.

Therefore, it can be presumed from above discussion that the traits viz., canopy temperature and relative water content have to be given importance in selection process for improvement in yield, since most of the traits had strong positive (negative-canopy temperature) correlation with seed yield per plant and positive direct and indirect effect on grain yield via this trait. Hence, selection based on this character will be more effective for yield improvement in rice under normal condition.

Table 1: Analysis of Variance for different quantitative characters in Rice under stress and normal condition.

No.	Characters	Mean sum of squares					
		Replication		Treatments		Error	
		Normal	Control(Stress)	Normal	Control(Stress)	Normal	Control(Stress)
1	Days to 50 % flowering	3.68	6.83	72.29**	53.06**	1.05	2.06
2	Days to maturity	8.68	1.12	63.22**	81.99**	4.24	8.43
3	Plant height (cm)	0.0078	1.30	224.77**	223.68**	0.41	1.45
4	Flag leaf Area (cm²)	0.023	1.59	194.31**	69.55**	0.21	1.72
5	Chlorophyll content (SPAD)	0.09	0.01	79.96**	73.91**	0.15	0.07
6	Number of tillers per plant	4.48	2.21	5.39**	6.28**	2.67	1.58
7	Leaf rolling at vegetative stage	0.28	1.40	0.54**	8.27**	0.12	0.90
8	Leaf drying at vegetative stage	0.21	0.94	0.96**	7.47**	0.15	0.54
9	RWC(%)	1.95	3.32	41.89**	137.25**	1.12	2.38
10	Panicle Length(cm)	0.54	10.61	15.73**	10.13**	0.42	1.30
11	Canopy Temperature(^{0}C)	0.44	4.13	3.84**	6.59**	1.61	1.86
12	Recovery percentage after stress	-	148.48	-	653.79**	-	100.57
13	DSI	-	0.18	-	0.19**	-	0.07
14	Number of grains per panicle	546.19	16.94	3096.46**	394.16**	701.40	0.46
15	1000 Grains weight	0.47	0.06	11.75**	71.21**	3.08	1.53
16	Harvest Index	0.76	2.54	68.86**	104.93**	0.24	1.44
17	Seed Yield / Plant	1.05	2.16	18.15**	6.67**	1.81	1.04

Table 2: Mean, range and coefficient of variance for various characters in rice under both conditions.

	Genotypes	Mean		Range		CV	
		Control	Normal	Control	Normal	Control	Normal
1	Days to 50% Flowering	69.83	75.28	62.66 -79.00	67.00-88.00	2.05	1.36
2	Days to Physiological Maturity	96.39	103.23	83.33 – 103.66	95.33-110.66	3.012	1.99
3	Plant Height(cm)	83.36	85.35	66.19 – 103.40	69.19-105.30	1.44	0.74
4	Flag Leaf Area (cm²)	29.61	33.82	20.76 - 39.33	19.57-47.40	4.43	1.36
5	Chlorophyll Content	32.74	35.42	22.90 - 39.43	21.47-42.62	0.81	1.10
6	Number of tillers per plant	5.24	9.54	3.33 - 8.66	7.33-12.33	23.95	17.12
7	Leaf Rolling at vegetative stage	2.31	0.26	0.33 -7.66	0.00-1.66	41.10	129.79
8	Leaf Drying at vegetative stage	1.60	0.36	0.00-5.66	0.00-2.33	45.90	106.37
9	Relative Water Content	77.72	85.28	62.70-87.67	77.16-92.66	1.98	1.24
10	Panicle Length (cm)	22.75	23.57	19.28-27.13	20.50-28.23	5.00	2.73
11	Canopy Temperature (^{0}C)	32.18	30.35	29.69-35.61	28.30-32.71	4.23	4.17
12	Recovery Percentage After Stress	55.45	-	30.00-80.00	-	18.08	-
13	DSI	0.90	-	0.31-1.41	-	28.25	-
14	Number of grains per panicle	79.12	186.80	62.66-105.66	108.73-234.66	0.85	14.17
15	1000 Grains Weight (g)	32.90	20.71	24.06-44.13	18.40-26.083	3.75	8.46
16	harvest Index	37.38	54.00	27.30-49.82	38.72-60.29	3.21	0.90
17	Seed Yield/ Plant (g)	5.59	10.38	3.36-8.39	6.31-14.81	18.19	12.95

Table 3: Genetic parameters of various characters in Rice under both conditions.

No.	Characters	σ^2_g		σ^2_p		GCV		PCV		h^2 (Broad sense) %		Genetic Advance as % of Mean	
		Normal	Control	Normal	Control	Normal	Control	Normal	Control	Normal	Stress	Normal	Control
1	DFF	23.74	17.00	24.79	19.06	6.47	5.90	6.62	6.25	95.80	89.20	13.05	11.49
2	DM	23.74	24.51	23.89	32.95	4.30	5.14	4.74	5.96	82.30	74.40	8.03	9.13
3	PH (cm)	74.78	74.07	75.19	75.52	10.13	10.32	10.16	10.42	99.50	98.10	20.82	21.06
4	FLA (cm²)	64.70	22.60	64.91	24.33	23.78	16.06	23.82	16.66	99.70	92.90	48.91	31.89
5	CHL (SPAD)	26.60	24.61	26.75	24.68	14.56	15.15	14.60	15.17	99.40	99.70	29.91	31.16
6	TPP	0.90	1.56	3.57	3.14	9.98	23.88	19.82	33.82	25.30	49.80	10.34	34.72
7	LR	0.14	2.45	0.25	3.35	23.83	67.74	29.77	79.24	54.70	73.10	21.14	42.43
8	LD	0.27	2.30	0.42	2.85	22.37	94.59	25.84	89.14	64.50	80.90	23.36	40.48
9	RWC (%)	13.59	44.95	14.70	47.33	4.32	8.63	4.50	8.85	92.40	95.00	8.56	17.32
10	PL (cm)	5.10	2.94	5.52	4.24	9.58	7.54	9.97	9.05	92.40	69.40	18.98	12.94
11	CT(^{0}C)	0.74	1.57	2.35	3.43	2.84	3.90	5.05	5.76	31.60	45.90	3.29	5.44
12	RAS	-	184.40	-	284.97	-	24.49	-	30.44	-	64.70	-	40.58
13	DSI (%)	-	0.04	-	0.10	-	22.58	-	36.17	-	39.00	-	29.04
14	GPP	798.35	131.23	1499.75	131.69	15.13	14.48	20.73	14.50	53.00	99.70	22.73	29.77
15	TWG	2.89	23.22	5.96	24.75	8.21	14.65	11.79	15.12	49.00	93.80	11.77	29.23
16	HI	22.87	34.49	23.11	35.93	8.86	15.71	8.90	16.04	99.00	96.00	18.15	31.71
17	SYP	5.44	1.87	7.25	2.91	22.47	24.49	25.94	30.51	75.00	64.40	40.09	40.49

Table 4: Mean performance of thirty three genotypes of rice for seventeen characters under stress condition.

No	Character Genotypes	DF	DM	PH (cm)	FLA	CHL	TPP	LR	LD	RWC	PL	CT	RAS	(DSI)	GPP	TGW	HI	SYP
1	RAU-1428-6-7-3-6	66.33	91.67	66.19*	24.93	36.77	4.67	3.67	1.67	76.51	20.78	33.63	70.00	0.63*	78.00	32.27	43.45*	4.31
2	RAU-1417-2-1-5-7-7	65.00*	91.33	76.65*	26.27	30.07	3.67	3.00	1.00	74.28	21.51	32.37	66.67	0.79	92.00	33.05	43.88*	4.25
3	RAU-1421-12-1-7-4-3	62.67*	93.00	75.33*	36.33*	37.43*	5.67	1.00	0.00*	77.18	23.04	30.58*	40.00	0.93	81.67	35.87*	47.34*	6.98
4	RAU-1415-35-76-9-5-3	63.00*	99.00	72.62*	36.17*	38.60*	5.00	1.67	0.33	79.49	22.09	30.52*	46.67	1.04	81.00	35.07*	49.47*	6.43
5	RAU-1401-18-1-4	75.67	101.33	80.02	24.13	30.60	3.67	2.33	1.00	74.24	22.01	33.03	70.00	1.10	76.00	32.67	37.48	4.05
6	RAU-1401-18-1-5	73.00	92.00*	79.32*	27.80	26.50	5.67	1.67	1.00	75.18	21.67	31.98	50.00	0.56*	66.00	36.53*	41.36	6.05
7	RAU-1428-43-2-7-26	69.33	97.33	81.00	28.03	22.90	3.33	5.00	4.33	62.73	23.02	32.61	73.33*	1.09	64.00	27.87	35.73	3.70
8	RAU-1478-52-2-4-6	68.33	95.67	79.25*	22.90	24.70	4.00	2.33	1.67	73.66	21.79	32.17	66.67	0.78	64.33	32.40	40.56	4.55
9	RAU-1428-54-35-5-5	66.00	92.67*	84.67	33.90	38.47*	6.67	0.33*	0.00*	87.67*	22.52	30.63*	30.00	0.67*	81.67	42.40*	38.34	8.38*
10	RAU-1421-15-3-2-5-3-7	71.67	90.00*	79.87*	24.40	29.50	4.67	1.00	0.00*	79.23	22.26	32.77	60.00	0.49*	73.33	36.53*	30.28	5.29
11	RAU-1421-12-1-7-4-3	65.00*	88.00*	87.05	28.13	30.43	3.67	3.67	5.00	62.71	23.78	34.48	73.33*	1.28	67.33	34.87*	29.05	3.56
12	RAU-1477-9-7-22-5-7-3	70.00	91.00*	79.10*	30.37	28.70	4.67	2.33	2.33	73.83	21.35	34.07	66.67	0.94	100.67*	32.27	33.13*	4.38
13	RAU-1451-66-1-1-5-2	74.33	96.67	91.67	39.33*	39.43*	7.00	1.00	1.67	80.57	27.14*	31.22	50.00	1.12	105.67*	36.13*	41.47	6.24
14	RAU-1416-4-2-5-2-2	75.00	97.67	83.28	27.63	30.43*	6.67	1.00	1.00	82.25	21.29	32.03	50.00	0.91	75.33	26.13	36.63	6.15
15	RAU-1397-25-8-1-2-5-4	65.33*	101.67	79.28	26.83	27.72	3.67	6.33	5.67	65.42	22.90	35.62	80.00	1.41	77.00	32.23	28.94	3.37
16	RAU-1417-11-1-74-3-2	75.67	93.33*	81.28	32.93	38.73	7.33	1.67	1.00	85.31	25.98	31.81	46.67	0.31*	83.00	43.33*	40.64	6.50
17	RAU-1421-15-3-2-5-7-3	67.00	83.33*	76.00*	24.93	30.53	3.33	3.67	2.33	70.14	20.07	32.93	73.33*	1.31	64.67	31.60	27.30	3.61
18	RAU-1451-35-7-6-9-5-1	67.33	85.33*	70.30*	23.97	27.77	3.33	4.33	1.67	68.96	19.28	33.56	80.00*	1.16	62.67	33.82	41.98	3.37
19	RAU-1426-43-2-5-7-2	68.00	94.33	81.26	23.30	29.33	5.33	7.67	5.67	75.85	21.86	34.83	63.33	0.99	77.00	32.53	32.87	4.78
20	RAU-1428-31-5-4	68.33	101.33	87.08	31.13	38.70*	8.67*	1.67	0.33	86.55	22.03	30.87*	30.00	0.84	83.00	36.67*	40.99	8.39*
21	RAU-1428-31-5-4-3-2-2-2	74.67	100.00	82.14	24.43	39.13*	4.67	2.33	1.00	84.81	23.35	30.68*	46.67	1.17	92.00	44.13*	49.83*	6.31
22	RAU-1463-16	75.00	103.00	91.33	34.60	27.63	4.00	3.00	2.33	76.96	24.00	32.73	66.67	0.82	67.67	32.00	30.57	4.40
23	RAU-1471-10	69.67	102.00	98.21	36.07	35.63	6.67	1.67	1.67	86.51	24.32	30.57*	50.00	0.83	90.67	37.47*	34.51	6.39
24	RAU-1463-15	69.33	100.33	101.92	30.53	37.53*	6.33	0.67*	0.33	85.46	26.06	30.88*	33.33	0.64	96.67*	32.30	36.02	7.60
25	RAU-1453-12	79.00	101.33	87.59	33.27	25.63	4.00	2.33	3.00	72.11	23.09	32.00	66.67	0.80	67.33	28.19	30.47	4.39
26	RAU-1415-8-6-4-3-3	66.67*	100.67*	85.01	29.13	27.67	4.33	2.33	2.33	75.12	21.42	29.70	60.00	1.10	73.33	26.00	28.50	4.99
27	21284-BAU445-06	66.67*	99.33	75.93*	30.17	36.60	6.33	2.33	1.00	82.17	23.82	30.39*	33.33	0.51*	63.67	29.50	36.62	7.67*
28	Sahbhagidhan(c.)	72.67	99.00	90.09	29.63	36.27	6.67	1.00	1.67	84.31	25.11	33.27	53.33	1.08	81.67	32.27	39.61	5.88
29	22823Rewa780-8	70.00	98.00	97.38	36.40	35.63	6.33	1.67	1.00	80.26	24.87	33.31	46.67	0.78	92.67	34.19	40.34	6.51
30	Richharia	67.67	101.67	76.00*	20.77	36.80	5.33	1.00	1.00	79.67	21.03	30.03*	30.00	0.81	82.00	29.50	37.54	7.98*
31	Vandana(check)	67.67	97.33	103.41	30.40	32.57	7.67	1.00	0.00	76.78	23.87	30.90	50.00	1.03	92.00	25.40	39.31	6.35
32	Rasi(c.)	72.00	98.00	81.97	32.77	35.43	6.00	0.67	0.00	84.71	19.67	32.63	50.00	1.11	77.33	24.07	35.84	6.32
33	APO(C.)	76.67	103.67	89.00	35.57	36.83	4.00	1.00	0.00	84.27	24.01	33.19	56.67	0.99	79.67	26.63	33.70	5.58
	Mean	69.84	96.39	83.37	29.61	32.75	5.24	2.31	1.61	77.72	22.76	32.18	55.45	0.91	79.12	32.91	37.39	5.60
	S.E.	0.83	1.68	0.70	0.76	0.15	0.73	0.55	0.43	0.89	0.66	0.79	5.79	0.15	0.39	0.71	0.69	0.59
	C.D. 5%	2.34	4.74	1.97	2.14	0.44	2.05	1.55	1.20	2.51	1.86	2.23	16.36	0.42	1.11	2.02	1.96	1.66

Table 5: Mean performance of thirty three genotypes of rice for fifteen characters under Normal condition

	Character Genotypes	DF	DM	PH	FLA	CHL	TPP	LR	LD	RWC	PL	CT	GPP	TGW	HI	SYP
1	RAU-1428-6-7-3-6	68.00*	97.33*	69.20*	26.52	40.03	9.33	1.41	1.27	85.59	21.13	30.73	108.73	18.67	59.20*	6.31
2	RAU-1417-2-1-5-7-7	70.00*	97.00*	80.70*	26.01	33.37	11.33	1.13	1.41	81.58	22.23	30.80	170.33	18.53	56.48	7.02
3	RAU-1421-12-1-7-4-3	71.00*	96.67*	80.40*	36.87	39.55	11.67*	1.13	1.00*	86.65	23.70	30.50	216.00	20.00	54.45	12.57
4	RAU-1415-35-76-9-5-3	73.33*	105.00	77.03*	36.02	39.72	12.33*	1.13	1.38	85.52	23.46	29.97	220.67	20.00	56.10	13.43
5	RAU-1401-18-1-4	78.66	107.33	83.97	28.05	33.33	10.67	1.13	1.27	89.04	22.52	30.23	208.33	20.67	56.30	9.71
6	RAU-1401-18-1-5	78.66	101.67	81.50*	24.65	28.47	10.33	1.00*	1.60	86.21	20.50	30.63	155.67	19.73	55.38	8.22
7	RAU-1428-43-2-7-26	72.33*	104.00	81.06*	23.51	21.48	10.67	1.60	1.41	81.49	20.93	31.71	154.67	20.00	50.95	7.91
8	RAU-1478-52-2-4-6	72.00*	104.00	80.13*	20.92	27.71	8.33	1.41	1.41	83.77	20.97	31.57	192.00	20.67	57.52*	7.51
9	RAU-1428-54-35-5-5	75.66	100.33	90.20*	38.62	41.48	12.33*	1.00*	1.13	88.54	22.86	29.36	233.33*	20.80	53.30	12.41*
10	RAU-1421-15-3-2-5-3-7	73.00*	101.33	80.77*	24.80	31.13	9.33	1.13	1.80	79.73	22.10	31.27	155.67	19.87	52.30	7.18
11	RAU-1421-12-1-7-4-3	67.00*	98.00	86.40	36.41	34.48	8.33	1.27	1.00*	81.85	22.30	31.39	157.00	19.60	59.69*	9.75
12	RAU-1477-9-7-22-5-7-3	72.33*	96.33*	81.03	30.54	30.53	9.00	1.00*	1.00*	85.46	23.88	30.96	118.67	19.07	55.74	7.98
13	RAU-1451-66-1-1-5-2	78.66	96.33*	96.40	47.22*	42.26*	8.67	1.00*	1.00*	89.29	28.21*	29.37	234.67*	23.83	56.30	13.69*
14	RAU-1416-4-2-5-2-2	83	110.00	85.27	31.70	33.21	9.33	1.00*	1.00*	85.26	28.23*	28.86*	153.33	18.40	50.55	10.93
15	RAU-1397-25-8-1-2-5-4	73.66	105.00	81.50*	30.52	30.62	11.33	1.00*	1.00*	81.42	21.22	30.83	199.67	18.67	56.44	11.29
16	RAU-1417-11-1-74-3-2	81.00	110.67	85.50	34.20	42.62*	8.00	1.13	1.27	85.99	25.96	29.84	164.33	25.53*	57.87*	8.18
17	RAU-1421-15-3-2-5-7-3	73.66	108.33	74.97*	31.50	32.58	10.00	1.00*	1.00*	84.28	21.91	32.26	194.67	19.73	60.29*	10.25
18	RAU-1451-35-7-6-9-5-1	68.33*	97.00*	71.47*	24.81	30.56	9.00	1.13	1.27	77.18	20.80	32.71	197.33	20.13	50.53	8.31
19	RAU-1426-43-2-5-7-2	72.33*	95.33*	80.90	19.57	32.57	9.67	1.00*	1.00*	82.34	21.00	30.70	164.00	22.87	39.26	9.37
20	RAU-1428-31-5-4	75.00	99.00	87.20	31.11	39.86	9.00	1.00*	1.00*	87.67	23.15	28.31*	212.33	26.08*	53.24	14.31*
21	RAU-1428-31-5-4-3-2-2-2	76.33	103.00	84.73	32.81	42.58*	10.00	1.00*	1.00*	90.63*	24.23	28.56*	229.00*	20.00	55.52	14.82*
22	RAU-1463-16	78.66	107.00	93.00	34.30	30.48	8.00	1.41	1.27	84.15	22.41	30.36	157.00	19.73	38.72	7.52
23	RAU-1471-10	78.66	106.67	100.63	44.17	38.71	8.67	1.00*	1.00*	88.19	25.55	29.66	219.33	23.75	53.49	12.22
24	RAU-1463-15	77.66	109.33	105.30	47.40*	36.75	10.00	1.00*	1.00*	84.35	28.15	28.64*	187.67	23.01	56.54	11.81
25	RAU-1453-12	82.66	107.00	87.90	34.36	33.48	9.67	1.41	1.41	77.17	28.23*	32.26	186.67	19.60	50.10	7.20
26	RAU-1415-8-6-4-3-3	75.33	107.00	87.60	40.95	30.35	11.67*	1.00*	1.00*	81.43	23.86	30.04	168.33	18.80	49.49	9.99
27	21284-BAU445-06	70.33*	107.00	76.70*	28.44	40.12	8.67	1.00*	1.00*	92.66*	23.80	29.58	163.67	18.41	53.16	9.56
28	Sahbhagidhan(check)	76.66	102.67	91.40	46.33	38.78	9.00	1.00	1.00	88.33	21.74	31.02	195.67	20.80	56.58	11.69
29	22823Rewa780-8	73.33	105.33	98.90	46.09	35.58	7.67	1.00*	1.00*	90.69	24.73	28.70*	185.00	20.77	56.19	10.64
30	Richharia	70.33*	103.67	76.17*	36.75	39.38	7.33	1.00*	1.00*	86.70	24.78	31.02	209.33	21.07	59.18*	13.15*
31	Vandana(check)	74.66	103.33	103.10	31.32	41.88	8.67	1.00	1.00	85.39	23.41	28.99	223.33	20.19	55.43	13.28
32	Rasi(c.)	84.00	104.67	84.17	43.38	36.79	8.33	1.00	1.00	89.48	24.51	30.67	220.00	22.23	53.40	13.82
33	APO(C.)	88.00	109.33	91.37	46.23	38.40	8.67	1.00	1.00	86.29	25.60	30.33	208.00	22.50	52.51	10.73
	Mean	75.28	103.23	85.35	33.82	35.42	9.55	0.26	0.36	85.28	23.58	30.36	186.80	20.72	54.01	10.39
	S.E.	0.59	1.19	0.37	0.27	0.23	0.94	0.20	0.22	0.61	0.37	0.73	15.29	1.01	0.28	0.78
	C.D. 5%	1.67	3.36	1.04	0.75	0.64	2.67	0.56	0.63	1.73	1.05	2.07	43.20	2.86	0.79	2.20

Table 6: Correlation coefficient for seventeen characters in stress condition

Character	DFF	DM	PH	FLA	CHL	TPP	LR	LD	RWC	PL	CT	RAS	DSI	GPP	TGW	HI	SYP
DFF	1.00	0.30**	0.30**	0.13	-0.05	0.06	-0.20*	-0.10	0.26**	0.25**	0.03	0.04	-0.07	0.03	-0.03	-0.12	-0.04
DM		1.00	0.40**	0.26**	0.18	0.19	-0.19	-0.07	0.34**	0.31**	-0.24*	-0.29**	-0.01	0.18	-0.21*	0.00	0.30**
PH (cm)			1.00	0.47**	0.14	0.37**	-0.31**	-0.08	0.31**	0.59**	-0.12	-0.24*	-0.00	0.43**	-0.08	-0.22*	0.25**
FLA (cm²)				1.00	0.41**	0.35**	-0.38**	-0.24*	0.36**	0.52**	-0.25*	-0.31**	-0.07	0.37**	0.09	0.10	0.33**
CHL					1.00	0.51**	-0.47**	-0.51**	0.74**	0.34**	-0.34**	-0.63**	-0.14	0.57**	0.38**	0.49**	0.64**
TPP						1.00	-0.39**	-0.35**	0.57**	0.31**	-0.21*	-0.61**	-0.23*	0.40**	0.17	0.24*	0.63**
LR							1.00	0.67**	-0.60**	-0.21*	0.41**	0.56**	0.30**	-0.33**	-0.06	-0.26**	-0.56**
LD								1.00	-0.66**	-0.01	0.44**	0.46**	0.25*	-0.27**	-0.10	-0.46**	-0.46**
RWC (%)									1.00	0.26**	-0.41**	-0.66**	-0.35**	0.47**	0.25**	0.33**	0.68**
PL (cm)										1.00	-0.09	-0.25*	-0.12	0.40**	0.23*	0.05	0.25*
CT(^{0}C)											1.00	0.46**	0.18	-0.16	-0.12	-0.28**	-0.45**
RAS												1.00	0.51**	-0.34**	-0.20*	-0.34**	-0.98**
DSI													1.00	-0.02	-0.22*	-0.12	-0.52**
GPP														1.00	0.24*	0.33**	0.35**
TGW (g)															1.00	0.41**	0.21*
HI																1.00	0.35**
SYP (g)																	1.00

** Significant at 1 % level = 0.258
*Significant at 5 % level = 0.198

Table 7: correlation coefficient for fifteen characters in rice under normal condition

Character	DFF	DM	PH (cm)	FLA(cm²)	CHL	TPP	LR	LD	RWC	PL	CT	GPP	TGW	HI	SYP (gm)
DFF	1.00	0.55**	0.46**	0.45**	0.14	-0.04	-0.18*	-0.05	0.19*	0.55**	-0.20*	0.22*	0.32**	-0.21*	0.19
DM		1.00	0.27**	0.28**	0.00	-0.08	-0.02	-0.02	0.13	0.37**	-0.12	0.04	0.07	0.00	0.07
PH (cm)			1.00	0.64**	0.28**	-0.10	-0.14	-0.22*	0.24*	0.50**	-0.43**	0.29**	0.35**	-0.10	0.34**
FLA(cm²)				1.00	0.50**	-0.07	-0.15	-0.35**	0.39**	0.61**	-0.30**	0.36**	0.28**	0.17	0.51**
CHL					1.00	-0.08	-0.15	-0.29**	0.58**	0.40**	-0.43**	0.39**	0.33**	0.30**	0.57**
TPP						1.00	-0.02	0.09	-0.14	-0.09	-0.06	0.04	-0.18	0.00	0.03
LR							1.00	0.01	-0.09	-0.12	0.16	-0.07	-0.07	-0.08	-0.19*
LD								1.00	-0.31**	-0.24*	0.15	-0.26*	-0.18	-0.03	-0.36**
RWC (%)									1.00	0.19	-0.48**	0.30**	0.24*	0.25*	0.48**
PL(cm)										1.00	-0.33**	0.21*	0.23*	0.01	0.28**
CT											1.00	-0.15	-0.19*	-0.01	-0.36**
GPP												1.00	0.27**	0.12	0.55**
TGW (gm)													1.00	-0.02	0.27**
HI														1.00	0.16
SYP (gm)															1.00

** Significant at 1 % level = 0.258
*Significant at 5 % level = 0.198

Table 8: Path coefficient analysis of seventeen characters on grain yield in rice under stress condition.

S.N.	Traits	DFF	DM	PH	FLA	CHL	TPP	LR	LD	RWC	PL	CT	GPP	TGW	HI	TGW(g)	HI
1	DFF	-0.01	-0.01	-0.01	-0.01	0.01	-0.01	0.01	0.01	-0.01	-0.01	-0.01	-0.01	0.01	-0.01	0.01	0.01
2	DM	0.02	0.03	0.01	0.01	0.02	0.01	-0.02	-0.01	0.01	0.01	-0.02	-0.11	-0.01	0.01	-0.01	0.01
3	PH(cm)	0.01	0.01	0.03	0.01	0.01	0.01	-0.01	-0.01	0.01	0.02	-0.01	-0.01	-0.01	0.01	-0.01	-0.02
4	FLA(cm²)	0.01	0.01	0.01	0.01	0.02	0.02	-0.01	-0.02	0.02	0.01	-0.01	-0.01	-0.01	0.02	0.01	0.01
5	CHL	-0.02	0.01	0.01	0.01	0.03	0.01	-0.01	-0.02	0.02	0.01	-0.01	-0.02	-0.02	0.02	0.01	0.01
6	TPP	0.01	0.01	0.01	0.01	0.01	0.03	-0.01	-0.01	0.02	0.01	-0.01	-0.02	-0.18	0.01	0.02	0.01
7	LR	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.01	0.01	-0.01	-0.01	0.01	0.01	0.01	-0.01	0.01	-0.01
8	LD	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.01	0.01	-0.01	-0.01	0.01	0.01	0.01	-0.01	-0.13	-0.01
9	RWC (%)	0.01	0.01	0.01	0.01	0.01	0.01	-0.01	-0.01	0.02	0.02	-0.01	-0.01	-0.02	0.01	0.01	0.02
10	PL(cm)	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	0.01	0.01	-0.01	-0.04	0.01	0.01	0.01	-0.01	-0.01	-0.01
11	CT	0.06	-0.01	-0.01	-0.01	-0.01	-0.01	0.01	0.02	-0.01	-0.01	0.01	0.01	0.01	-0.01	-0.01	-0.01
12	RAS	-0.04	0.26	0.22	0.28	0.57	0.54	-0.50	-0.41	0.59	0.23	-0.41	-0.89	-0.45	0.31	0.18	0.31
13	DSI	0.01	0.01	0.01	0.01	0.01	0.01	-0.01	-0.01	0.01	0.01	-0.01	-0.02	-0.04	0.01	0.01	0.01
14	Gpp	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	0.02	0.01	-0.01	-0.02	0.01	0.02	0.01	-0.02	-0.01	-0.01
15	TGW (g)	-0.01	-0.01	-0.01	0.01	0.01	0.01	-0.01	-0.02	0.001	0.01	-0.01	-0.01	-0.01	0.01	0.01	0.01
16	HI	-0.01	0.01	-0.01	0.01	0.01	0.01	-0.01	-0.01	0.01	0.01	-0.01	-0.01	-0.01	0.01	0.01	0.01
17	SYP(g)	-0.04	0.30**	0.25	0.33	0.64	0.63	-0.56	-0.46	0.68	0.25	-0.45	-0.98	-0.52	0.35	0.21	0.35

Residual effect = 0.1582

Table 9: Path coefficient analysis of fifteen characters on grain yield in rice under normal condition.

Character	DF	DM	PH (cm)	FLA(cm²)	CHL	TPP	LR	LD	RWC (%)	PL(cm)	CT	GPP	TGW (gm)	HI
DF	**-0.32**	-0.18	-015	-0.14	-0.04	0.01	-0.06	0.01	-0.06	-0.18	0.06	-0.07	-0.10	0.07
DM	0.06	**0.11**	0.03	0.03	0.01	-0.01	0.01	-0.01	0.01	0.04	-0.01	0.01	0.01	0.01
PH (cm)	0.31	0.18	**0.67**	0.43	0.19	-0.06	0.09	--0.15	0.16	0.33	-0.29	0.19	0.23	-0.06
FLA(cm²)	-0.09	-0.05	-0.13	**-0.20**	-0.10	0.01	0.03	0.07	-0.08	-0.12	0.62	-0.07	-0.05	-0.03
CHL	0.09	0.01	0.17	0.31	**0.61**	-0.05	-0.09	-0.18	0.35	0.24	-0.26	0.24	0.20	0.18
TPP	-0.01	-0.03	-0.03	-0.02	-0.03	**0.38**	-0.01	0.03	-0.05	-0.03	-0.02	0.01	-0.07	0.01
LR	0.06	0.01	0.04	0.05	0.05	0.01	**-0.34**	-0.01	0.03	0.04	-0.05	0.02	0.02	0.02
LD	0.01	0.01	0.01	0.01	0.01	-0.01	-0.01	**-0.02**	0.01	0.01	-0.01	0.01	0.01	0.01
RWC (%)	0.16	0.13	0.20	0.33	0.49	-0.11	-0.08	-0.26	**0.84**	0.16	-0.41	0.25	0.20	0.21
PL(cm)	0.16	0.10	0.14	0.18	0.11	-0.02	-0.03	-0.07	0.05	**0.29**	-0.09	0.06	0.06	0.01
CT	-0.33	-0.20	-0.70	-0.48	-0.71	-0.10	0.26	-0.25	-0.79	-0.54	**0.62**	-0.25	-0.31	-0.01
GPP	0.03	0.01	0.04	0.06	0.06	0.01	0.01	-0.04	0.05	0.03	-0.02	**0.17**	0.04	0.02
TGW (gm)	0.01	0.01	0.01	0.01	0.01	-0.01	-0.01	-0.01	0.01	0.01	-0.01	0.01	**0.01**	-0.01
HI	0.05	-0.01	0.02	-0.04	-0.07	-0.01	0.02	0.01	-0.06	-0.01	0.01	-0.03	0.01	**-0.24**
SYP(gm)	**0.19**	**0.07**	**0.36**	**0.51**	**0.57**	**0.03**	**-0.19**	**-0.36**	**0.48**	**0.28**	**0.36**	**0.55**	**0.27**	**0.16**

RESIDUAL EFFECT = 0.631

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