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GENETIC VARIABILITY AND ASSOCIATION OF MORPHO-PHYSIOLOGICAL TRAITS FOR DROUGHT RESISTANCE IN RICE

Rudra Bhattarai[1], Subarna Sharma[2], Bedananda Chaudhary[1], Shukra Raj Shrestha[1] & Surya Prasad Adhikari[1]
[1]Regional Agriculture Research Station, Nepal Agriculture Research Council, Tarahara, Nepal
[2]Regional Agriculture Research Station, Nepal Agriculture Research Council,Nepalgunj, Nepal

Abstract

Rice is the major staple food and had major role to raise the country economy. Nepal had around 30 percent of rice land prone to drought and yield of traditional varieties were even null in recent days. Main plot was water management and 48 genotypes were evaluated in sub plot and in both locations of Nepalgunj and Tarahara during 2013 monsoon season. Water had been stopped after 45th day of seeding and made of trench in upland filed to make plot suitable for reproductive stress to occur. Values of leaf rolling were high in stable entries IR87759-12-2-1-1, IR87753-11-2-1-1, IR 87759-22-1-1-2 and IR88836-39-2-3-2. The correlation coefficient for number of tillers per plant, harvest index with yield had been seen in stress condition. Identified genotypes will be suitable for stress environment of Nepal. The clustering of genotypes revealed the existence of variability present in these genotypes could be used as a parents for further breeding program.

Key Words: Drought, Resistance, Rice, Stress and Variability.

1. Introduction

Climate change threatens the sustainability of crops such as rice (Oryza sativa L.), which is major staple food of Nepal. In Nepal, rice is traditionally cultivated in flooded irrigation system. Any shortfall in irrigation directly affects the crop yield. The increase in variability at the spatial scale and will lead to severe cases of water stress throughout (NCVST, 2009). Guma et al., also reported that about 30 percentage rice area is prone to drought in Nepal. Venuprasad et al., reported that grain yield decreases under drought stress conditions from 12 to 46 percent. Besides other solutions, development of drought resistant lines is the most economical and an enduring approach to reduce the drought effect.

2 Methodology

The trial comprised 39 inbred lines received from International Rice Research Institute, Philippine; with checks Sabitri, Radha 11, Swarna, Sukha Dhan 3, Radha 12, Radha 4, IR 64, Hardinath 1 and IR 36 of different genetic background. The genotypes were seeded in 3rd July of 2013 and transplanted in 23rd July, 2013 in both locations. The fertilizers of 100:30:30 N: P205: K20 kg/ha. The Nitrogen was applied in three split doses and hand weeding measure was followed. The crop was kept under well water conditions for a period of 45 days to establish good stand in each condition. Drought plot was in upland where trench around the main plot was maintained to control occasional moisture seepage. The crop observations on days to 50 percent heading, maturity, plant height, and panicle length, number of productive tillers per plant, Biomass and grain yield measured. The data were analyzed through computer's software Genestat -16 Discovery edition.

2.1 Study area and meteorology

The average monthly rainfall in Tarahara was highest in July i.e. 670mm, after that the rainfall had been decline drastically in proceeding month which suggested rice genotypes get stressed and produced less yield as compare to non-stress condition. The water table during flowering stage was less in Nepalgunj area than in Tarahara. The location of Tarahara station is in latitude of 26º42'16.85" North and 87º16'38.43" East with 152masl in sandy loam soil but slightly clay soil in Nepalgunj.

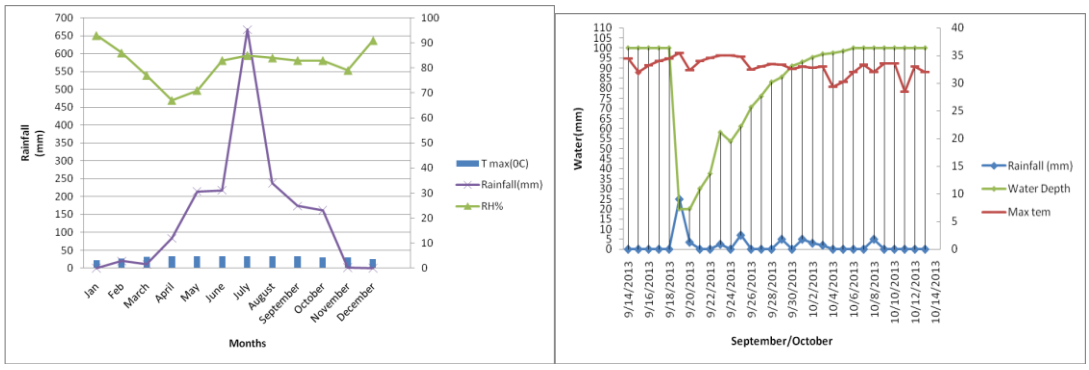

Figure 1. Relative humidity, moisture and maximum temperature (0C) in Tarahara (left) and Nepalgunj (right) during 2013.

3. Result and Discussion

The analysis of variance (Table 2) revealed that various rice genotypes had significant and highly significant differences for all studied traits under each water management conditions. The highest yielder with respect to the above mentioned traits were IR87751-20-4-4-2, IR87761-51-1-1-1-4, IR87759-22-1-1-2, IR88869-2-1-1-4, IR88965-36-1-2-2, IR88965-39-1-6-4, IR88968-2-1-1-2, IR88968-2-1-1-2 and IR70210-39-CPA-7-1. These genotypes were at par with check Sukha Dhan-3 with respect to all studied traits. The variability present in the genotypes could be utilized in breeding program as a parent in rice hybridization or they could be directly used as a variety for drought prone areas in Nepal.

3.1 Days to 50 percent flower

The lines IR 88963-31-6-1-1 and IR 88965-36-1-2-2 observed as the earliest of 84 days to flower, which is at par with the check variety Hardinath-1. Kumar et al., early flowering feature was a very important mechanism to escape drought stress. The genotypes IR 88880-23-2-1-4, IR 84859-B-86-3-1 and IR 88968-2-1-1-2 took 87 days exhibiting medium range to flower like another check Sukha dhan-3 and Radha-4. Earlier studies also revealed that medium maturing lines produced better yield as compared to late genotypes under drought conditions.

3.2 Plant height (cm)

The plant height significantly differed in rice genotypes. Wide ranges of plant height with medium and tall plants ranging from 89.68 to 111.57 cm were observed. Maximum reduction in height by stress had been found for IR 81896-B-B-68-B, IR 87760-15-2-3-4, IR 88836-4-1-4-2, IR 88963-31-6-1-1 and check SWARNA. Kumar et al.,(2008) majority of the rice lines evaluated had reduction in plant height in drought condition. The positive correlation of plant height with yield, biomass, number of effective tillers, days to flower and leaf rolling had been observed. Therefore, it would be effective while selecting for plant height for drought tolerance.

3.3 Number of productive tillers

The number of productive tillers also significantly differed among the genotypes in drought as well in irrigated normal sown condition which ranged from 8.10 to 14.57 per plant. Maximum productive tillers were produced by the lines IR88880-23-2-1-4 and IR88968-2-1-1-2 with 14.35 and 14.44 respectively in stress condition at par with check variety Sukha Dhan-3 with 14.48 numbers of effective tillers. Bernier et. al.,(2009) reported that higher yield was associated with traits like biomass yield and productive tillers per plant.

3.4 Plant biomass (kg)

IR 88966-2-1-1-4, IR 88965-39-1-1-3, IR 84859-B-86-3-1, IR 88793-2-2-1-2, IR 88880-23-2-1-4, IR 88963-31-6-1-1 and IR 88964-11-2-2-2 have least reduction for biomass in drought. Bernier et.al., (2009) observed that under stress condition, both biomass yield and harvest index were severely reduced.

3.5 Leaf rolling

IR 87761-51-1-1-4, IR 88880-23-2-1-4, IR 88963-31-6-1-1, IR 88964-11-2-2-2, IR 88965-39-1-1-3 and IR 88966-2-1-1-4 were selected as the higher leaf roll and yield advantage under drought. The higher leaf rolling was positively associated with higher yield and higher plant height (O"Toole et al., 1982).

3.6 Grain yield (kg/ha)

In drought condition, highest yield of (5383kg/ha) was harvested from genotypes IR88966-45-2-1-3 closely followed by lines IR87753-11-2-1-1 (5228kg/ha). The most stable entries with respect to a similar management in both location and condition were IR87753-11-2-1-1, IR88869-2-1-1-4, IR88880-23-2-1-4, IR88965-39-1-6-4 and IR88966-45-2-1-3 which were able to produce at par yield with check variety SUKHA DHAN-3 (Table 2). Grain yield under stress was suggested to be a desirable direct trait for selection in drought prone environments (Ceccarelli et al., 1991). Berner et. al., (2009) reported that under drought condition, tolerant cultivars had higher production and yield stability than drought susceptible cultivars.

3.7 Correlation

The plant height, numbers of panicles hill-1 and total biomass at maturity were lower under drought stress condition and their flowering was delayed compared to irrigated condition and majority of these traits were correlated with yield. The positive and significant correlation had been found between effective numbers of panicles with grain yield. Therefore selection based on plant height, less number of days to flower, number of effective panicles and biomass would be the most effective traits to be integrated during selection of varieties for drought prone area.

Table 1. Correlation among various traits of rice genotypes in two different environments of Tarahara and Nepalgunj in drought stress condition during 2013.

	Biomass(kg)	Days to flower	Harvest Index	Number of Panicles	Yield (kg/ha)	Plant height(cm)	Leaf rolling
Biomass(kg)	1						
Days to flower	0.079	1					
Harvest Index	-.875**	-0.228	1				
Number of Panicles	.336*	0.167	-0.229	1			
Yield(kg/ha)	.557**	-0.127	-0.187	.301*	1		
Plant height(cm)	.324*	0.107	-0.146	0.043	.479**	1	
Leaf rolling	-0.034	-.419**	0.215	-0.1	0.222	0.126	1

*.Correlation is significant at 5% level **.Correlation is significant at 1% level

Table 2: Comparison of yield and yield attributing traits of fourteen top rice genotypes under irrigated and drought condition at Tarahara and Nepalgunj during 2013.

Genotypes/Traits	Yield(kg/ha)		Biomass(kg)		Effective number of Panicles per hill		Plant Height(cm)		Leaf Rolling
	Irrigated	Drought	Irrigated	Drought	Irrigated	Drought	Irrigated	Drought	Drought
IR 88966-45-2-1-3	5003	5383	3472	2000	12.97	11.09	102	98	5
IR 87753-11-2-1-1	4658	5228	4661	1600	13.12	12.03	105	98	5
IR 88965-39-1-6-4	4897	4967	3514	2020	12.31	9.57	104	96	5
IR 87761-51-1-1-4	4448	4844	3694	2500	12.85	11.59	105	97	5
IR 70210-39-CPA-7-1	4026	4833	3692	2003	13.8	11.71	112	107	4
IR 87761-52-1-2-2	3726	4818	4067	1467	13.65	9.73	100	101	5
IR 87759-22-1-1-2	4777	4811	4125	2000	15.27	10.69	101	96	5
IR 88965-39-1-1-3	4104	4803	2289	1733	12.35	9.16	103	96	5
IR 88968-2-1-1-2	3716	4782	3422	2083	12.63	14.44	100	97	5
IR 88965-36-1-2-2	4382	4761	3594	1983	14.28	10.37	104	102	5
IR 87759-12-2-1-1	4834	4736	3872	1620	11.92	13.92	105	99	5
RADHA 12	4834	4720	3503	1590	11.9	12.13	102	102	3
IR 88966-2-1-1-4	4458	4704	2844	1667	11.37	7.91	97	92	5
SUKHA DHAN 3	5063	4664	4000	1200	17.15	14.48	103	98	5
G*E (p value)	0.049		<0.001		0.008		<0.001		
EMS	894002		312794		7.48		43.83		
SED	545.9		322.9		1.58		3.82		
CV%	22.3		22.2		23.4		6.7		

3.8. Variability study

3.8.1 Multivariate analysis: UPGMA Clustering

All genotypes were clustered using biomass, yield, number of productive tillers, days to flowering, harvest index, plant height and leaf roll score as a variable for variability study. Six clusters were seen with a minimum of 70 % similarity level in UPGMA clustering. In cluster I, genotypes IR 87759-12-2-1-1, IR 88968-2-1-1-2, SUKHA DHAN-3, IR87753-11-2-1-3,IR88966-45-2-1-3,IR87761-51-1-1-4, IR87759-22-1-1-2,IR87759-2-2-1-1,IR88965-39-1-1-3, IR88965-39-1-6-4, IRRI123 IR36 and RADHA 4 were defined as stable yield producer and seems to be drought tolerance than others. In cluster III, genotypes IR87761-52-1-2-2, IR87749-10-1-1-4, IR70210-39-CPA-7-1, IR81896-B-B-68-B and Radha-12 were characterized as minimal yield loss by stress and have longest plant height than others. In cluster IV and V, almost to the checks, some of them had enough drought tolerance. The tolerance checks were RADHA-11, SABITRI lies in cluster IV and susceptible was SWARNA which was found in cluster V. The rest of the genotypes had medium yield loss by stress and lies in Cluster II. In cluster VI, most susceptible genotype IR88836-4-1-4-2 was found.

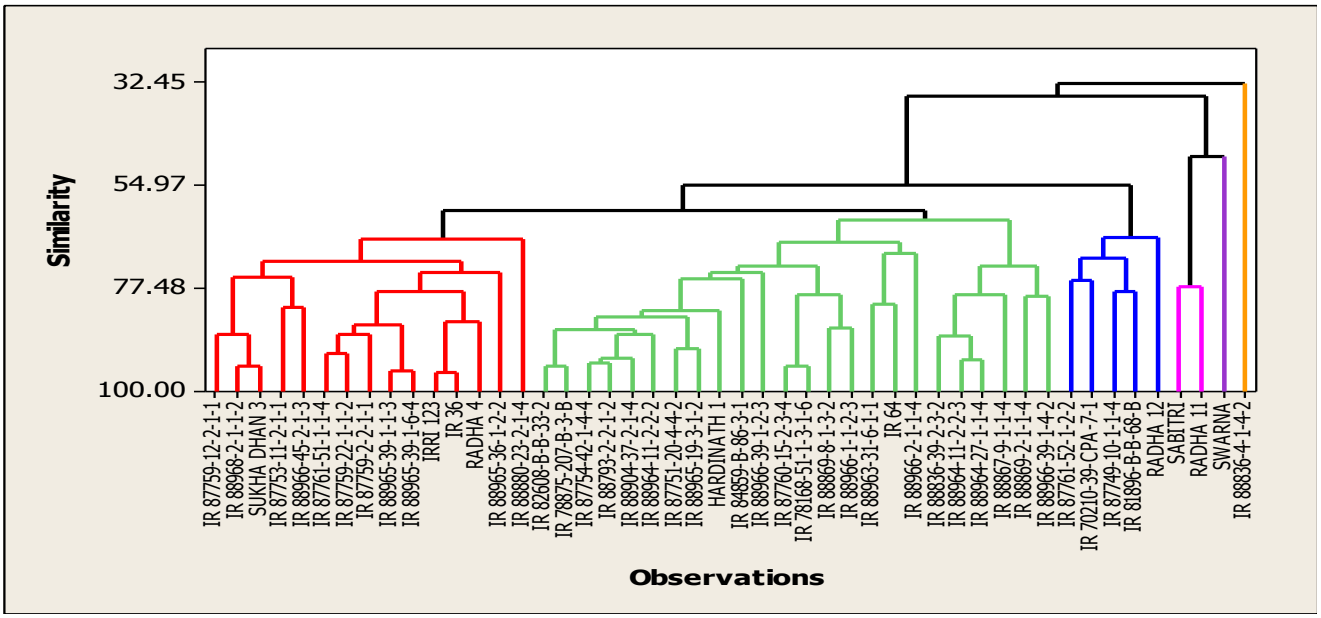

Figure 3: Variability of 48 rice genotypes characterized in to different group of clusters based on UPGMA clustering.

4. Conclusion

The study concludes the different genotypes performed differently under various conditions and location for each specific traits. The highest yielder were IR87751-20-4-4-2, IR87761-51-1-1-1-4, IR87759-22-1-1-2, IR88869-2-1-1-4, IR88965-36-1-2-2, IR88965-39-1-6-4, IR88968-2-1-1-2, IR88968-2-1-1-2 and IR70210-39-CPA-7-1. These genotypes were at par with check Sukha Dhan-3 with respect to all studied traits. The variability present in the genotypes could be utilized in breeding program as a parent in rice hybridization or they could be directly used as a variety for drought prone areas in Nepal.

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