Journal of AgriSearch 5(1):13-18
An Open Access International Peer Reviewed Quarterly
ISSN : 2348-8808 (Print), 2348-8867 (Online)
https://doi.org/10.21921/jas.v5i01.11126

Evaluation of rice genotypes for its response to added fertility levels and induced drought tolerance during reproductive phase

LAXMI KHAREL*, SURYA KANT GHIMIRE, JIBAN SHRESTHA[1], CHITRA BAHADUR KUNWAR[1] AND SUBARNA SHARMA[2]

Tribhuvan University, Institute of Agriculture and Animal Sciences, Rampur, Chitwan, Nepal

ARTICLE INFO

Received on	:	06/11/2017
Accepted on	:	16/02/2018
Published online	:	27/02/2018

ABSTRACT

A field research was carried out at agronomy field at Regional Agricultural Research Station, Khajura, Banke, Nepal from June to November 2012-2013 in order to evaluate drought tolerant rice genotypes under different nutrient levels in artificially created stress condition during reproductive stages. The field experiment was conducted in strip plot design with three replications. Three main-plots contain three different levels of fertilizers, each consisting of 14 sub-plots of genotypes. The result revealed that the rice genotypes showed the significant differences for days to flowering, days to maturity and grain yield. Genotype IR83381-B-B-137-1 produced the highest grain yield (3851 kg ha^{-1}), followed by IR83383-B-B-141-2 (3130 kg ha^{-1}). The differences was significant for no. of tillers hill^{-1}, no. of panicles hill^{-1} and biomass yield kg ha^{-1}. In terms of level of fertilizers; rice genotypes showed significant differences for days to maturity. Interaction effect was observed significant for days to maturity and no. of panicles. The correlation between tillers number hill^{-1} and panicle number hill^{-1} was the highest (0.994**) and in path analysis for grain yield; direct effect of biomass yield was the highest (0.58134).

Keywords: Correlation, Genotypes, Path Analysis, Reproductive stress.

INTRODUCTION

Rice is the staple food and a mainstay of Asian countries including (Singh *et al.*, 2012). Rice is miracle crop can sustain and produced economically in any environment and climatic situation (Singh *et al.*, 2007). Rice only accounts for more than 50% of the total calories of Nepalese people. Rice accounts for 51.82% of total cereal crop production, while occupying 43.78% of the total agricultural area of India. It is worth to mention here that in Nepal, during the year 2012-13, 4.50 Mt rice was produced in from 1.42 Mha, with an average productivity of 3171 kg ha^{-1} (MoAD, 2013). To feed ever increasing population, rice production in Nepal has to be increased over 6.0 million tons by 2020 to meet the growing demand of ever increasing population. Rice has the evolutionary nature of semi-aquatic. As a result, there is little adaptation to drought stress (Lafitte *et al.*, 2004). Uneven distribution of unreliable monsoons and precipitation causes annual changes in crop yields. Therefore, drought can be regarded as a major constraint on rice production and productivity in a rainy environment. The occurrence of drought is likely to affect rice production in Nepal as most of the area under rice production lack irrigation facility. The variation in spatial and temporal rainfall patterns negatively affected the summer rice crop in Nepal, particularly crops that are 100% dependent on rainfall for irrigation (Regmi, 2007). Work in drought tolerant rice is in infant stage in Nepal. Farmers in the rainfed areas of hill have not benefitted from the technologies developed for the irrigated condition. Further, purchasing capacity of the Nepalese farmers for fertilizers is very poor (Singh and Kumar, 2009). Due to resource poor condition, low accessibility and untimely availability of fertilizers; famer's inability to purchase in time as per recommendation dose, farmers are in sought of varieties that can perform well even in sub-optimized input condition.

Rice cultivars can perform well in low input condition accompanied by drought tolerance are, hence, the most promising and deliverable technology for increasing productivity in sub-optimal lowland stressed areas of our country (Abarshahr *et al.*,2011). It needs to enhance the livelihoods of farmers with rainfed farming while conserving fragile natural resources through identifying, validating and disseminating of drought tolerance varieties. Trait correlation is crucial to achieving the goal in the breeding program. Correlation analysis measures the correlation between a few variables that are independent of some other considered variables (Owen and Jones, 1977). Path coefficient analysis provides more information between variables than correlation coefficients because this analysis has a direct effect on yield and indirect effects of different yield components on specific yield components (Garcia Del Moral *et al.*, 2003). This study was aimed at improving the livelihood of resource slums in drought-affected areas by reducing fertilizers that require rice varieties vulnerable to drought. Keeping view food security issues of poor, marginalized and vulnerable farmers of Nepal in the imminent climate change scenario, there is an urgent need to develop rice varieties that respond to drought resistant and less fertilizer responsive.

[1]Nepal Agricultural Research Council, National Maize Research Program, Rampur, Chitwan, Nepal
[2]Tribhuvan University, Institute of Agriculture and Animal Sciences, Lamjung Campus, Sundar Bazar, Lamjung, Nepal
*Corresponding Author Email: 9laxsu9@gmail.com

MATERIALS AND METHODS

Research site, soil properties and agro-meteorological condition

The field experiment was conducted on rice research field at NARC, Regional Agricultural Research Station, Khajura, Nepal, from June to November during 2012 and 2013. The precise location of experimental site was 80^{0}6'N, 81^{0}37'E and at an altitude of 181meters above mean sea level. The soil of the experimental plot was sandy to silty loam with pH 7.2-7.5 and poor in organic carbon and total N content but medium in soil available P_2O_5 and K_2O. The climate of research location is tropical to sub-tropical. The maximum temperature recorded was 45.5^{0}C in the month of June while the minimum temperature recorded was 1.2 ^{0}C during winter peak. Average rainfall of region is 1000-1500 mm per annum and relative humidity ranges from 27-96.1 %. During the experiment period, the field received average cumulative rainfall 1177 mm with maximum of 344 mm in August. The meteorological data were obtained from meteorological station, RARS Khajura, Banke.

Plant materials and raising of seedlings

The plant materials tested in the research were 14 elite rice genotypes for drought tolerance under three different levels of fertilizers. Dry nursery beds were established for each genotype on 15th July during both the years *i.e.* 2012 and 2013. Late seeding was done in order to coincide the flowering with drought period. Each nursery row was 1 m in length and supplied with equal amount of farmyard manure. No chemical fertilizers were applied on nursery beds. The seed rate applied was 50 kg ha^{-1}. The age of seedlings was 23 days during transplanting.

Experimental field layout and transplanting

The field experiment was conducted in strip-plot design. The trial was replicated thrice. There were 3 main-plots each consisting of 14 sub-plots in each replication. Main-plots contain three different levels of fertilizers i.e. F_1- 0:0:0 NPK kg ha^{-1}, F_2- 45:25:25 NPK kg ha^{-1} and F_3- 90:50:50 NPK kg ha^{-1}. Half dose of urea and full dose of DAP and MOP were applied as basal while remaining half dose of urea was top dressed in split at 30 DAT in two main plots except control. Each sub-plot within main plots contains 6 rows of a genotype of 5m length. Each sub-plot was 5m in length and 1.2 m in width. Transplanting of 2-3 seedlings per hill was done on 25th November with a spacing of 20cm between rows and 20cm between hills in each plot. There was a gap of 0.5m between sub-plots and 1.5 m between main-plots within a replication. There was 2.0 m gap between the replication. Bunds were constructed in between main plots and replications.

Creation of drought, stress characterization, sampling and observation

Late seeding was done so that flowering coincides with drought period. The drought condition was artificially created during reproductive stage. As per IRRI drought rice research protocol, stress was initiated one month after transplanting. Existing water was drained and the field was exposed to reproductive stress by ceasing irrigation completely from one month of transplanting to harvest. A provision for immediate drainage was made in case of rainfall during stress period. Meteorological data, field water status, and ground water table were recorded carefully on daily basis during stress period.

Meteorological Observations

Data pertaining to average temperature and rainfall during stress period (Fig. 1), month wise average rainfall pattern during experimentation period of 2012 and 2013 (Fig. 2), Average number of rainy days per month during cropping season during experimentation period of 2012 and 2013 (Fig. 3), as well as average water table (Pyzometer) reading during stress period was also recorded and presented in Fig. 4.

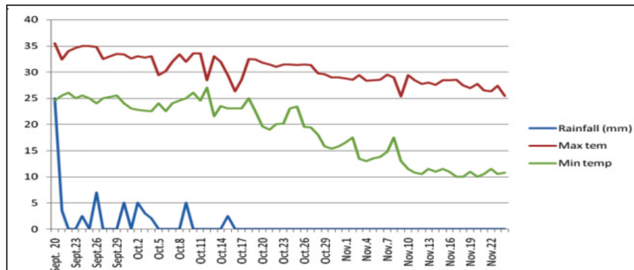

Fig. 1: Meteorological Data (Average Temperature & Rainfall during stress period)

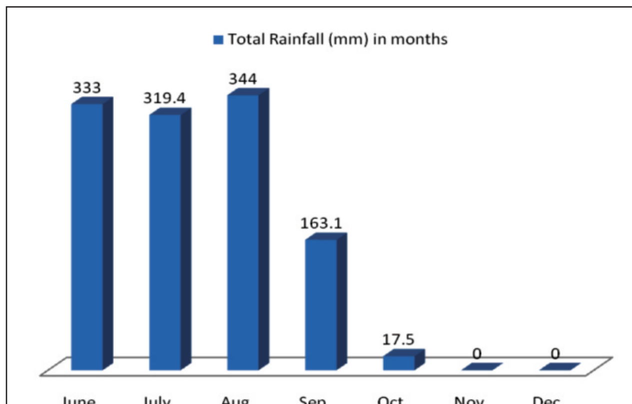

Fig.2: Month wise average rainfall pattern during experimentation period of 2012 and 2013

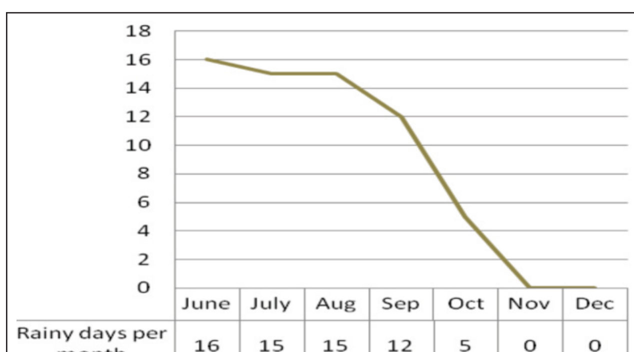

Fig. 3: Rainy days (No) per month during cropping season during experimentation period of 2012 and 2013

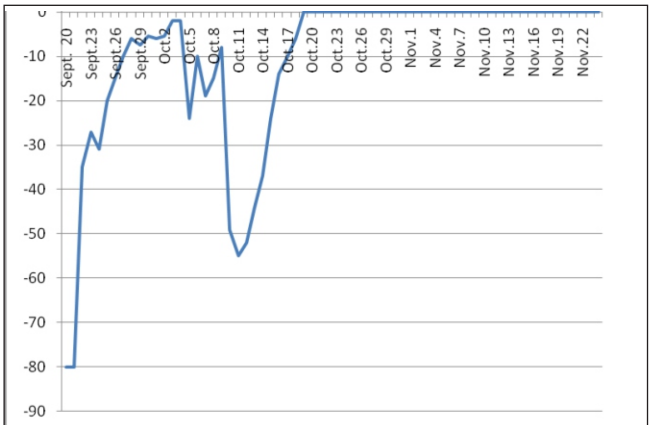

Fig 4: Average Water table (Pyzometer) reading during stress period

Recording observation and data analysis

The observations for quantitative traits were taken from randomly sampled five plants from each of the treatments. Observations were taken for the different parameters like days to flowering, plant height, days to maturity, number of tillers $hill^{-1}$, number of panicles $hill^{-1}$, panicle length, grain yield $plot^{-1}$ and biomass yield $plot^{-1}$. MSTAT, SPSS 16, and MS-Excel computer software were applied in data analysis. Correlation computation and path analysis were also carried out. The results were used to screen low nutrient input requiring drought tolerant rice genotypes.

Table 1: Performance of rice genotypes under different fertilizer levels in terms of days to flowering, days to maturity and plant height

Treatments	Days to flowering	Days to maturity	Plant height (cm)
	Level of fertilizers NPK kg ha^{-1}(F)		
1. F 1- 0:0:0	89.262	121.7b	95.924
2. F2- 45:25:25	89.095	121.6b	96.148
3. F3- 90:50:50	90.238	122.8a	95.876
LSD (0.05)	NS	0.9152	NS
	Genotypes (G)		
1. IR 83388-B-B-108-3	92.67	124.2a	97.911
2. IR 83381-B-B-137-1	88.44	121.3 de	98.733
3. IR 83377-B-B-48-3	90.00	123.0ab	95.178
4. IR 83383-B-B-129-3	90.00	122.1bcd	93.711
5. IR 83383-B-B-141-2	90.11	122.2bcd	94.622
6. IR 83376-B-B-71-1	88.67	121.3de	94.867
7. IR 82870-48	86.67	119.9f	96.222
8. IR 83383-B-B-129-4	91.22	123.4ab	94.133
9. IR 83873-B-B-47-4	87.22	119.9f	98.956
10. IR 83376-B-B-130-2	88.67	121.7cd	96.889
11. IR 83377-B-B-93-3	90.11	122.8bc	97.133
12. IR87707-446-B-B-B	91.11	123.2ab	95.333
13. RADHA-4	87.33	120.2ef	94.800
14. SUKHADHAN-3	91.22	123.2ab	95.267
LSD (0.05)	1.062	1.186	NS
Interaction effect (F×G)	NS	*	NS

NS = Non significant, * = significant at 0.05

RESULTS AND DISCUSSIONS

Days to flowering, days to maturity and plant height

Details of the results on days to flowering, days to maturity and pant height is given in Table 1. Among the genotypes highly significant differences were observed in days to flowering. Genotype IR83388-B-B-108-3 recorded 92.67 days to flower while Sukhadhan-3 took 91.22 days to get 75% flowering.

In contrast, genotype IR82870-48 was the earliest (86.67 days) in flowering. Level of fertilizers and genotype interaction showed non-significant differences in terms of days to flowering. Similarly, there were highly significant differences among the genotypes in terms of days to maturity. Genotype IR82870-48 and IR 83873- B-B- 47-4 took the minimum days (119.9) to reach to maturity days. In contrast, genotype IR83388-B-B-108-3 took the maximum days (124.2) to reach 75% maturity followed by IR83383-B-B-129-4 (123.4 days). Level of fertilizers and interaction also showed significant differences in terms of days to maturity. Genotypes and level

Table 2: Performance of genotypes under different fertilizers level in terms of no. of tillers $hill^{-1}$, no. of panicles $hill^{-1}$ and panicle length (cm)

Treatments	No. of tillers $hill^{-1}$	No. of panicles $hill^{-1}$	Panicle length (cm)
	Level of fertilizers NPK kg ha (F)		
1. F 1 - 0:0:0	13.062	12.517	23.195
2. F2- 45:25:25	14.443	13.767	22.671
3. F3- 90:50:50	14.895	14.255	23.524
LSD (0.05)	NS	NS	NS
	Genotypes (G)		
1. IR 83388 -B-B-108-3	16.53	15.58 a	22.889
2. IR 83381 -B-B-137-1	15.78	15.09ab	22.333
3. IR 83377 -B-B-48-3	12.42	11.67 c	22.889
4. IR 83383 -B-B-129-3	14.69	14.09 abc	21.044
5. IR 83383 -B-B-141-2	13.47	12.78 abc	22.289
6. IR 83376 -B-B-71-1	12.98	12.56 bc	22.467
7. IR 82870 -48	13.60	13.11 abc	22.733
8. IR 83383 -B-B-129-4	16.02	15.53 a	23.156
9. IR 83873 -B-B-47-4	13.64	13.09abc	22.956
10. IR 83376 -B-B-130-2	13.84	12.98 abc	23.356
11. IR 83377 -B-B-93-3	13.40	12.84 abc	25.244
12. IR87707 -446-B-B-B	13.13	12.53 bc	27.400
13. RADHA -4	13.67	13.22 abc	22.489
14. SUKHADHAN -3	14.69	14.11abc	22.578
LSD (0.05)	2.491	2.435	NS
Interaction effect (F×G)	NS	4.217	NS

NS = Non significant

of fertilizers interaction revealed non-significant differences in terms of Plant height. Selection based on flowering time is effective for improving drought tolerance (Lafitte *et al*., 2003). The duration of rice maturity is under genetic control and low water availability during vegetative phase decreases growth duration. The delay in maturity under water stress condition is related to corresponding delay in flowering (Abarshahr *et al*., 2011).

No. of tillers hill^{-1}, no. of panicles hill^{-1} and panicle length (cm)

Details of the result regarding no. of tillers hill^{-1}, no. of panicles hill^{-1} and panicle length (cm) are presented in Table 2. Significant differences among the genotypes were observed in terms of no. of tillers per hill. Genotype IR83388-B-B-108-3 had the highest number of tillers hill^{-1} (16.53) followed by IR83383-B-B-129-4 (16.02).

In contrast, genotype IR83377-B-B-48-3 had the least number of average tillers hill^{-1} (12.42). Level of fertilizers and interaction showed non-significant differences in terms of average no. of tillers hill^{-1}. Similarly, there were significant differences among the genotypes in terms of no. of panicles per hill. Genotype IR83388-B-B-108-3 had the highest (15.58) number of panicles hill^{-1} followed by IR83383-B-B-129-4 (15.53). In contrast, genotype IR83377-B-B-48-3 has the least number of average panicles hill^{-1} (11.67). Level of fertilizers showed non-significant differences in terms of no. of panicles hill^{-1}. Genotypes and level of fertilizers interaction revealed non-significant differences in panicle length. Decline in number of tillers under water stressed condition have been reported by Mostajeran and Rahimi-Eichi (2009). Decline in number of panicles under water stressed condition have been reported by Lafitte *et al.* (2006).

Table 3: Performance of genotypes under different fertilizers level on grain yield (kg ha^{-1}) and biomass yield (kg ha^{-1})

	Treatments	Grain yield (kg ha^{-1})	Biomass yield (kg ha^{-1})
		Level of fertilizers NPK kg ha^{-1} (F)	
1.	F 1 - 0:0:0	2587.810	3297.571
2.	F2- 45:25:25	2969.429	4059.452
3.	F3- 90:50:50	3031.833	4115.024
	LSD (0.05)	NS	NS
		Genotypes (G)	
1.	IR 83388-B-B-108-3	2902	3778
2.	IR 83381-B-B-137-1	3851	4666
3.	IR 83377-B-B-48-3	2773	3833
4.	IR 83383-B-B-129-3	2702	3704
5.	IR 83383-B-B-141-2	3130	4167
6.	IR 83376-B-B-71-1	2887	3518
7.	IR 82870-48	2592	3333
8.	IR 83383-B-B-129-4	3104	4296
9.	IR 83873-B-B-47-4	2577	3333
10.	IR 83376-B-B-130-2	2903	3870
11.	IR 83377-B-B-93-3	3073	3926
12.	IR87707-446-B-B-B	2108	2593
13.	RADHA-4	2705	411
14.	SUKHADHAN-3	2777	3481
	LSD (0.05)	550.6	793.9
	Interaction effect (F×G)	NS	NS

NS = Non significant

Grain and biomass yields (kg ha^{-1})

The genotypes were highly significant for grain yield. The highest grain yield (3851 kg ha^{-1}) was produced by the genotype IR83381-B-B-137-1 followed by IR83383-B-B-141-2 (3130 kg ha^{-1}) and IR83383-B-B-129-4 (3104 kg ha^{-1}), respectively. In contrast, genotype IR87707-446-B-B-B produced the least grain yield (2108 kg ha^{-1}). Level of fertilizers and interaction showed non-significant differences in terms of grain yield. Similarly, the genotypes were significant differences for biomass yield. Genotype IR83381-B-B-137-1 produced the highest biomass yield (4666 kg ha^{-1}) followed by IR83383-B-B-129-4 (4296 kg ha^{-1}) and IR83383-B-B-141-2 (4167 kg ha^{-1}), respectively. In contrast, genotype IR 82870-48 and IR 83873-B-B-47-4 produced the least biomass yield (3333 kg ha^{-1}).

Under water stresses condition straw yield reduction has been reported by Lafitte *et al.* (2006). The overall decrease in plant size, tiller number, assimilation because of water shortages may be the cause of reduced yields. Significant changes in straw yield under water stress conditions were observed by Gomez *et al.* (2006). Under drought stress, high harvest potential is the goal of plant breeding. In many cases, high-performance potentials can contribute to output in moderate stress environments (Abarshahr *et al*., 2011). It was noted that drought-tolerant genotypes have higher yields as compare to others tested lines. Details of the results for grain yields and biomass yields are given in Table 3.

Correlation coefficient analysis

The detail correlation coefficients among recorded traits are shown in Table 4. Based on correlation coefficient of yield components and grain yield, number of tillers hill^{-1} had positively high and highly significant correlation (0.994**) with panicle numbers hill^{-1}. This value is followed by correlation between days to flowering and days to maturity (0.883**) and that between grain yield and biomass yield (0.579**), respectively. The negative and least correlation was obtained between tillers hill^{-1} and panicle length (-0.193*) and that between panicle no. and panicle length (-0.189*), respectively.

The correlation between days to flowering and days to maturity, tillers hill^{-1} and panicles hill^{-1}, tillers hill^{-1} and grain yield, tillers hill^{-1} and biomass yield, panicle number and grain yield, panicle number and biomass yield, plant height and panicle length as well as that between grain yield and biomass yield is positive and highly significant. Similarly, the correlation between days to flowering and tillers hill^{-1}, days to maturity and tillers hill^{-1}, and that between days to maturity and panicles hill^{-1} was found to be positive and significant.

Table 4: Simple correlation coefficient of yield components and grain yield kg ha^{-1} and inter se association of components

	DTF	DTM	Tillers no	Panicle no	Plant ht	Panicle length	Grain yield	Biomass yield
DTF	1							
DTM	.883**	1						
Tillers no	.178*	.204*	1					
Panicle no	.163	.187*	.994**	1				
Plant ht	-.096	-.137	.043	.023	1			
Panicle length	.125	.073	-.193*	-.189*	.365**	1		
Grain yield	-.052	-.026	.259**	.262**	.104	-.002	1	
Biomass Yield	.138	.112	.290**	.294**	-.088	-.021	.579**	1

** Correlation is significant at 0.01 level (2-Tailed).
* Correlation is significant at 0.05 level (2-Tailed).
DTF- Days to flowering, DTM- Days to maturity, Tillers no - Number of tillers per hill, Panicle no- No. of Panicles $hill^{-1}$

Path coefficient analysis of grain yield

Grain yield is the major economic character in rice that depends on several component traits, which are mutually related. The analysis of the path coefficient is developed if the association of grain yield with its component characters is due to the direct effects of the component characters on grain yield or is a consequence of its indirect effect through some other traits. The direct effects and indirect effects of various yield components on grain yield (kg ha^{-1}) have been given in Table 5. Direct effects of biomass yield (kg ha^{-1}) on grain yield had the highest positive value (0.581) followed by that of panicle no. (0.239) as compared to all other traits has been taken into consideration. Plant height ranked third important yield component (0.151) based on direct effect in path analysis. Though, negative correlation was observed between days to maturity and grain yield (-0.026); the direct effect through days to maturity on grain yield is found to be positive (0.1340). Among indirect effects, effect of tillers number through panicle number was found to be the highest (0.2378).

Table 5: Direct effects and indirect effects of yield components on grain yield

Variables	DTF	DTM	Tillersno	Panicleno	Plantht	Pan length	Bioyld
Via DTF	**-0.24983**	-0.2206	-0.04447	-0.04072	0.023984	-0.03123	-0.03448
Via DTM	0.118361	**0.134044**	0.027345	0.025066	-0.01836	0.009785	0.015013
Via Tillers no	-0.02454	-0.02813	**-0.13788**	-0.13705	-0.00593	0.026611	-0.03999
Via Panicle no	0.039011	0.044755	0.237896	**0.239332**	0.005505	-0.04523	0.070364
Via Plant ht	-0.01458	-0.0208	0.006529	0.003492	**0.151841**	0.055422	-0.01336
Via Panicle length	-0.00064	-0.00038	0.000993	0.000973	-0.00188	**-0.00515**	0.000108
Via Biomass yield	0.080225	0.06511	0.168589	0.170914	-0.05116	-0.01221	**0.58134**
Total	**-0.052**	**-0.026**	**0.259**	**0.262**	**0.104**	**-0.002**	**0.579**

DTF- Days to flowering, DTM- Days to maturity, Tillersno- Number of tillers per hill, Panicleno- No. of panicles $hill^{-1}$, Plantht- Plant height(cm), Panicle length- Panicle length (cm), Grainyld- Grain yield kg ha^{-1}, Bioyld- Biomass yield kg ha^{-1}.

CONCLUSION

Form above study it is concluded that the occurrence of drought is likely to affect rice production in Nepal as most of the area under rice production lack irrigation facility. Considering the food security issues of the poor, marginalized and vulnerable farmers it has been extremely urgent to develop drought resistant less fertilizer requiring rice varieties and provide them with options of new rice varieties for stressed environments. From this experiment, some promising genotypes suited for low fertilizer input conditions were identified.

ACKNOWLEDGEMENTS

The authors want to give their sincere acknowledgement to NARC, RARS Khajura and IRRI for funding and creating the healthy environment for conducting this experiment.

REFERENCES

Abarshahr M, Rabiei B and Samizadeh Lahigi H. 2011. Assessing genetic diversity of rice varieties under drought stress conditions. *Notulae Scientia Biologicae* **3**(1):114-123.

Garcia del Moral LF, Rharrabti YD and Villegasroyo C. 2003. Evaluation of Grain Yield and Its Components in Durum Wheat under Mediterranean Conditions. An Ontogenic Approach. *Agronomy Journal* **95**:266–274.

Gomez SM, Kumar SS, Jeyaprakash P, Suresh R, Biji KR, Boopathi NM, Price AH and Babu RC. 2006. Mapping QTLs Linked to Physio-Morphological and Plant Production Traits under Drought Stress in Rice (*Oryza sativa* L.) in the Target Environment. *American Journal of Biochemistry and Biotechnology* **2** (4): 161-169.

Lafitte HR, Courtois B and Atlin G. 2003. The International Rice Research Institute's experience in field screening for drought tolerance and implications for breeding. In: NP Saxena and JC. O'Toole (eds.). Field Screening for Drought Tolerance in Crop Plants with Special Emphasis on Rice. Proceedings of an International Workshop on Field Screening for Drought Tolerance in Rice. December 11–14, 2000. International Crop Research Institute for Semi-arid Tropics, Patancheru, India; International Crop Research Institute for Semi-arid Tropics and Rockefeller Foundation, New York, USA. pp. 25–40.

Lafitte HR, Li ZK, Vijaya kumar CHM, Gao YM, Shi Y, Xu JL, Fu BY, Yu SB, Ali AJ, Domingo J, Maghirang R, Torres R and Mackill D. 2006. Improvement of rice drought tolerance through backcross breeding: Evaluation of donors and selection in drought nurseries. F*ield Crops Research* **97**:77–86.

Lafitte R, Blum A and Atlin G. 2004. Using secondary traits to help identify drought tolerant genotypes. In: KS Fischer, R Lafitte, S Fukai, G Atlin and B Hardy (eds.). Breeding Rice for Drought-prone Environments. International Rice Research Institute. Los Banos, Philippines. pp. 37–48.

MoAD. 2013. Statistical information on Nepalese agriculture 2012-13. Government of Nepal, Ministry of Agriculture Development. Agribusiness Promotion and Statistics Division, Singh Durbar, Kathmandu, Nepal. Tridevi Chhapakhana, Bagdol, Lalitpur, Nepal.

Mostajeran A and Rahimi-Eichi V. 2009. Effects of Drought Stress on Growth and Yield of Rice (*Oryza sativa* L.) Cultivars and Accumulation of Proline and Soluble Sugars in Sheath and Blades of Their Different Ages Leaves. *American-Eurasian Journal of Agriculture & Environmental Science* **5** (2): 264-272.

Owen E and Jones F. 1977. Statistics (3rd ed.) Renold Publishing Company. New York. 30p.

Regmi HR. 2007. Effect of unusual weather on cereal crops production and household food security. *The Journal of Agriculture and Environment* **43**: 20-29.

Singh AK and Kumar P. 2009. Nutrient management in rainfed dryland agro ecosystem in the impending climate change scenario. *Agril. Situ. in India*. **65**: 265-270

Singh AK and Singh Lal. 2007. Role of thermal time in rice phenology. *Envi. & Ecol.* **25** (1): 46-49.

Singh AK, Chandra N and Bharati RC. 2012. Effects of Genotype and Planting Time on Phenology and Performance of Rice (*Oryza sativa* L.). *Vegetos*. **25** (1): 151-156.

Citation:

Kharel L, Ghimire SK, Shrestha J, Kunwar CB and Sharma S. 2018. Evaluation of rice genotypes for its response to added fertility levels and induced drought tolerance during reproductive phase. *Journal of AgriSearch* **5** (1): 13-18