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RESEARCH ARTICLE

Screening at an early seedling stage for identification of drought tolerant genotypes in maize

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Abstract

The research entitled screening at early seedling stage for identification of drought tolerant genotypes in maize was carried in agronomy lab of Prithu Technical College, Lamahi, Dang during 2018. The trial was conducted in completely randomized design (CRD), with three replication and ten treatments under two different environments. Ten different drought tolerant genotypes named as viz: Arun-2, BGBYPOP, Rampur Composite, Arun-6, ZM-401, TLBRSO7F16, Rampur-4, Arun-4, Farmer's Local and HG-AB were tested in 30 clay pots at irrigated condition, maintaining proper soil moisture throughout the critical growth states, while 30 other clay pots with same genotypes were tested under drought environment. Data were collected at 25 DAS and 50 DAS. All genotypes showed non-significant difference for all traits in non-stress condition. There was no significant difference among the genotypes for various traits under the study in irrigated condition, while significant difference was observed for the same traits under the drought condition indicating that these genotypes had variation in drought tolerant ability. Arun- 4 and Arun- 6 had higher mean for root moisture content, shoot moisture content, number of root and number of dried leaves traits. Correlation study showed that root moisture content and shoot moisture content traits have highly positive significant association and can be used as drought tolerant traits. The identified stress tolerant genotypes need to be evaluated in open environment for confirmation of the results.

Key words: *Zea mays*, drought, stress, non-stress, genotypes

Introduction

Maize (*Zea mays* L.) also known as corn belongs to family Poaceae and tribe Maydae It is widely grown throughout the world in a wide range of agro-ecological environments for the purpose food grain, feed and forage and it has highest productivity among cereals. Maize ranks second position in term of area and production (MoAD, 2018; Thapa *et. al.*, 2019). Plant growth and development are affected by several environmental stresses, which hamper the productivity of crop plants (Farooq, 2008).

Drought is one of the major constraints worldwide limiting crop productions. According to Lambers *et. al.,* (2008) drought is considered the single most devastating environmental stress that decreases crop productivity more than any other environmental stress. When drought occurs during the vegetative stage, it affects the length of the inter-nodes by influencing the cell size development and, thus, the capacity for storing assimilates (Denmead and Shaw, 1960). It has also been reported that pro-longed drought at seedling stage causes total crop failure (Edmeades *et. al.,* 1989). Drought tolerance is also an adaptive strategy that enables crop plants to maintain their normal physiological processes and deliver higher economical yield despite drought stress. Vigorous maize seedlings lead to healthy crop and ultimately good production under water-deficit conditions. Potential variations exist in maize genetic stocks for drought-tolerance. Identification and characterization of genotypes is the primary step in developing drought tolerant cultivars (Naveed *et. al.,* 2008). The main aim of this research was to identify drought tolerant genotype. Hence the present study was planned to screen the maize genotypes based on the seedling stage and associated traits and to correlation them with drought tolerance.

Materials and method

Ten maize genotypes were evaluated in Completely Randomized Design (CRD) in two different environments i.e. irrigated and drought condition. Maize genotype were planted in pot with three replication at IAAS, Prithu Technical College, Lamahi municipality, Dang during July to August, 2018.Geographically, it is located at 27.9904' N Latitude and 82.3018' E Longitudes at the elevation of 725 masl.

Preparation of soil mixture and seed sowing

The soil used for filling the pot was taken from the animal farm. The soil was sandy loam type. The soil was mixed with well decayed farm yard manure. Chemical fertilizer; urea, DAP and MOP were also added to the mixture @32gm of each fertilizer. Seed was sown in during *kharif* 2018. The pots were filled with 4 kg of soil each and five seeds of each seeds were sown per pot. Water was applied to each pot at the rate of 0.6 liter per pot at the interval of two days until the seed germinated and the plants of three replications were watered frequently while the plants of other three replications were left without watering for the rest of the experiment period. Hoeing was done at 15 days interval.

Data collection and analysis

Parameters observed were plant height, seedling height, number of dry leaves, leaf curvature of blade, leaf angle, plant vigor, root length, root moisture content, shoot moisture content, leaf area, number of root, fresh root weight and fresh shoot weight. Eight days were allowed for the germination of seed and data was collected from the 25 DAS and 50 DAS. All the collected data were entered in MS excel and analysis was carried out by statistical package R.

Table 1: List of maize genotypes

Entry	Treatment	Entry	Treatment
1.	Arun 2	6.	TLBRSO7F16
2.	BGBYPOP	7.	Rampur-4
3.	Rampur Composite	8.	Arun-4
4.	Arun 6	9.	Local
5.	ZM-401	10.	HG-AB

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Results and discussion

Comparative evaluation of effect of stress and non-stress environment on root length and number of roots

The ANOVA table for root length reveals that under non stress condition, root length is statistically non-significant with grand mean 33.8. Genotype TLBRSO7F16 was found to have the greatest root length followed by genotype Rampur Composite whereas genotype Arun 6 had the shortest root length. Under stress condition, root length was found to be highly significant with grand mean 19.7. Variety Rampur composite showed the greatest root length followed by genotype BGBYPOP whereas the genotype TLBRSO7F16 was found to have shortest root length. This shows that the root length is highly affected under stress condition as it cannot attain its maximum length in absence of water. Reduction in root growth and development in response to drought has also been reported by earlier researchers (Shiralipour and West, 1984; Ramadan *et. al.*, 1985). In contrary highest root length in stress condition was reported by Khan et al. 2004. Under drought conditions the increase in root weight could be attributed to the fact that roots are increased in search of water. Under non stress condition, numbers of roots were found to be statistically non-significant with grand mean 26. Genotype Rampur 4 had the highest number of roots. Under stress condition also it was found to be non-significant with grand mean 11. Genotype Arun 6 showed the greatest number of roots followed by genotype ZM401 whereas genotype TLBRSO7F16 showed least number of roots. Hence, from our results we infer that there is observable reduction in the root length under stress condition when compared with non stress condition. Also we report that number of reduction in roots under stress condition.

Comparative evaluation of effect of stress and non-stress environment on plant height and number of dried leaves

The table for plant height shows that under non stress condition, it is found to be statistically non-significant with grand mean 135. Genotype TLBRSO7F16 showed the greatest height followed by genotype Arun 4 whereas the least height was seen on genotype Rampur Composite. Under stress condition also, it was found to be statistically non-significant with grand mean 59.6. The greatest height under stress condition was shown by genotype BGBYPOP followed by genotype Arun 2 whereas the least height was shown by the genotype TLBRSO7F16. Under non stress condition number of dried leaves was found to be statistically non-significant with grand mean 4. Whereas under stress condition, it was found to be highly significant with grand mean 7. Non significant different of plant height in both stress as well as non stress condition are reported by Abrowkach *et. al.*, 2017 which is accordance to our finding. Whereas under stress condition, it was found to be highly significant with grand mean 7.The lowest number of dried leaves was seen on genotypes ZM401 and Rampur Composite followed by genotype Arun 6 whereas genotype HG-AB showed the greatest number of dried leaves. Hence, from our results we conclude that there is observable reduction in the plant height under stress condition when compared with non stress condition. Also we report that number dried leaves are more under stress condition.

Table 2: Comparative evaluation of effect of stress and non-stress environment on root length and number of roots on 50DAS at Deukhuri Dang Nepal

S.N.	Genotypes	Root length (cm)		No. of roots	
		Non stress	Stress	Non stress	Stress
1	Arun 2	31.7	16.0	21	9.3
2	BGBYPOP	34.7	27.3	23	11.7
3	Rampur composite	34.8	27.4	27	10.3
4	Arun 6	30.5	23.7	26	14.7
5	ZM 401	31.2	20.5	31	13.7
6	TLBRSO7F16	48.4	4.3	30	7.7
7	Rampur 4	31.4	23.4	32	10.0
8	Arun4	30.7	11.5	22	11.0
9	Local	31.1	26.0	22	12.0
10	HG-AB	34.0	16.8	26	10.3
	Grand Mean	33.8	19.7	26.0	11.1
	5%LSD		10.2		
	CV%	18	22	19	25
	P-value	non significant	**	non significant	non significant

Comparative evaluation of effect of stress and non-stress environment on root moisture content and shoot moisture content

Root moisture content was found to be statistically non-significant under non stress condition with grand mean 17.1. The genotype Rampur 4 showed the higher moisture content followed by the genotype Arun 4 whereas, the least moisture content was shown by the genotype TLBRSO7F16 .Under stress condition, root moisture content was found to be statistically highly significant with grand mean 0.8. Arun 4 showed the greatest moisture content followed by genotype Arun 6 whereas genotype Rampur Composite showed the least moisture content. The shoot moisture content under non stress condition was found to be statistically non-significant with grand mean 75.6. Genotype Rampur Composite showed the greatest moisture content followed by Farmers' local whereas lowest moisture content was shown by genotype Arun 2. Under stress condition, shoot moisture was found to be statistically highly significant with grand mean 2.9. Genotype Arun 4 showed the higher moisture content followed by Arun 6 whereas Rampur Composite showed the least moisture content. Both RMC and SMC are higher in non stress condition as compared to stress condition because of longer root length in non stress condition. Similiar result was reported by Qayyum *et. al.*, (2012) reported higher root moisture content in non stress condition as compared to stress condition.

Comparative evaluation of effect of stress and non-stress environment on seedling height and leaf area

Seedling height under non stress condition was found to be statistically non- significant with grand mean 79.3. Highest length was seen on genotype HG-AB followed by genotype TLBRSO7F16 whereas Rampur composite was found to be shortest. Under stress condition, it was found to be statistically highly significant with grand mean 37.3. The greatest height was seen on HG-AB followed by genotype Arun 2 whereas genotype TLBRSO7F16 showed the shortest height. Under non stress condition, leaf area was found to be statistically non- significant with grand mean 269.2 where the genotype Rampur 4 showed the greatest leaf area. The smallest leaf area was seen on genotype Arun 6. Under stress condition also leaf area was found to be statistically non-significant with grand mean 77.8. The greatest leaf area was seen on genotype HG-AB followed by genotype Rampur Composite whereas the smallest area was seen on genotype TLBRSO7F16.

Abrowkach *et. al.*, (2017) reported that plant height of maize genotypes in non stress condition is higher than stress condition which is lined with our finding. It was also reported by Abo-El-Kheir and Mekki, (2007) that the plant height of single cross maize hybrid was affected when deficit water was applied at different growth stages. Prabhu and Shivaji (2000) reported that the main effect of drought in the vegetative period is to reduce leaf area so the crop intercepts less sunlight, which is also lined with our findings. Hence, we can conclude that at seedling stage the plant height was near about half of the non stress condition. Also it can be seen that in order to understand the stress visually plant height may prove indicator in the identification of the stressed plant. But is always better to confirm the observation under filed condition for sound conclusion.

Table 3: Comparative evaluation of effect of stress and non-stress environment on plant height and number of dried leaves on 50DAS

S.N.	Genotypes	Plant height (cm)		Number of dried leaves	
		Non stress	Stress	Non stress	Stress
1	Arun 2	144	65.3	3	8
2	BGBYPOP	132	66.0	3	8
3	Rampur composite	107	64.7	3	5
4	Arun 6	133	61.0	3	6
5	ZM401	142	58.3	4	5
6	TLBRSO7F16	151	40.3	4	7
7	Rampur 4	132	59.3	4	9
8	Arun 4	150	56.3	4	5
9	Local	114	59.7	4	8
10	HG-AB	143	64.7	3	9
	Grand Mean	135	59.6	3.6	7
	5%LSD				0.9
	CV%	14	20	17	7
	P-value	non significant	non significant	non significant	**

Table 4: Comparative evaluation of effect of stress and non-stress environment on root moisture content and shoot moisture content on 50DAS

S.N.	Genotypes	RMC(gm)		SMC(gm)	
		Non stress	Stress	Non stress	Stress
1	Arun 2	17.1	0.7	74.0	2.1
2	BGBYPOP	16.1	0.9	75.3	2.9
3	Rampur composite	17.8	0.3	79.3	1.6
4	Arun 6	17.1	1.2	76.3	4.4
5	ZM 401	16.2	1.1	75.3	4.0
6	TLBRSO7F16	15.4	0.8	74.3	2.5
7	Rampur 4	18.2	0.4	77.3	1.7
8	Arun 4	17.9	1.4	72.0	4.9
9	Local	17.7	0.5	78.0	1.9
10	HG-AB	17.7	1.0	74.3	3.3
	Grand Mean	17.1	0.8	75.6	2.9
	5% LSD		0.1		0.3
	CV%	6	4	4	6
	P-value	non significant	**	non significant	**

Table 5: Comparative evaluation of effect of stress and non-stress environment on seedling height and leaf area on 25DAS and 50DAS

S.N.	Genotypes	Seedling height		Leaf Area	
		Non stress	Stress	Non stress	Stress
1	Arun 2	81	46	298	68.0
2	BGBYPOP	76	41	306	86.1
3	Rampur composite	71	33	240	93.0
4	Arun 6	72	35	204	78.2
5	ZM 401	74	42	247	74.2
6	TLBRSO7F16	87	24	311	51.5
7	Rampur 4	82	41	315	72.3
8	Arun 4	79	37	244	75.2
9	Local	79	27	235	79.8
10	HG-AB	92	47	291	99.6
	Grand Mean	79.3	37.3	269.2	77.8
	5% LSD		6.5		
	CV%	15	10.2	23	20
	P-value	non significant	**	non significant	non significant

Comparative evaluation of effect of stress and non-stress environment on leaf curvature, leaf angle and plant vigor

The leaf curvature under non stress condition was found to be statistically non- significant with grand mean 4. Under stress condition, it was found to be statistically significant with grand mean 8. Genotypes ZAM401 and BGBYPOP were seen to have least curved leaves. The leaf angle under non stress condition was found to be statistically non-significant with the grand mean 3. Under non stress condition also the leaf angle was found to be statistically non-significant with grand mean 6. Genotypes BGBYPOP, TLBRSO7F6 AND Rampur 4 were seen to have least bent leaves. The plant vigor was found to be statistically highly significant in both stress and non-stress condition. Leaf rolling in maize crops is main plant reactions to water stress which can be visually scored. The relationship between leaf-rolling scores and changes in canopy structure can be determined by high-throughput remote-sensing techniques (Baret *et. al.*,2018). They scored leaf-rolling visually over the whole day around the flowering stage.

Correlation analysis of different traits recorded under non- stress condition

The traits shoot moisture content and root moisture content are strongly and positively correlated with each other with very high level of significance. The plant height showed positive and strong correlation with root length, seedling height and leaf area with highly significant, significant and highly significant level respectively. Similarly number of dry leaves and leaf curvature showed strong and positive correlation. Leaf curvature and number of roots showed negative correlation. Root length and leaf angle and plant vigor and root moisture content were also found to be positively correlated. Similarly, number of roots was found to be positively correlated with fresh root weight. Fresh shoot weight showed the positive correlation with leaf area. This result was lined with earlier report of Ali *et. al.*, (2016). Fresh root weight showed positive and significant correlation with root whereas it had negative and non-significant correlation with leaf curvature and number of roots. They also reported that plant height had positive significant correlation with leaf number which is lined with our findings.

Table 7: Correlation analysis of different traits recorded under non- stress condition at Deukhuri Dang Nepal

	PH	NDL	LCUV	RL	RMC	SMC	NOR	FRW	FSW	SH	LA
NDL	0.19										
LCUV	-0.13	0.71*									
RL	0.74**	0.02	-0.28								
RMC	-0.13	-0.32	-0.48	-0.4							
SMC	-0.09	-0.45	-0.57	-0.28	0.97***						
NOR	0.39	-0.36	-0.64*	0.56	0.41	0.54					
FRW	0.34	-0.37	-0.28	0.41	0.14	0.26	0.75**				
FSW	0.41	0.29	-0.36	0.47	0.05	0.03	0.31	-0.14			
SH	0.67*	0.28	-0.03	0.17	0.22	0.18	0.14	0.11	0.18		
LA	0.77**	0.10	-0.25	0.62*	-0.05	0.02	0.34	0.07	0.65*	0.42	
PVG	-0.19	-0.18	-0.26	-0.46	0.87**	0.81*	0.27	0.14	0.04	-0.01	-0.17

Where, *= significant, **= highly significant , NDL=No. of dried leaves , LCUV= leaf curvature, RL=root length , RMC=root moisture content , SMC=shoot moisture content , NOR= No. of roots, FRW= fresh root weight FSW= fresh shoot weight, SH= seedling height , LA= leaf area, PVG=plant vigor

We conclude that good amount of variability was observed in the response of the genotypes for tolerance to drought at seedling stage. We proved that the differential association among traits under drought condition. Arun- 4 and Arun- 6 considered as stress tolerant genotype as they were superior for root moisture content, shoot moisture content, number of root and number of dried leaves traits where as TLBRSO7F16 was susceptible genotypes to drought. In the present study root moisture content and shoot moisture content traits have highly positive significant association and can be used as drought tolerant traits. The identified stress tolerant genotypes need to be evaluated in open environment for confirmation of the results.

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References

1. Abrokwah, O. A., Antwi-Boasiako, A. and Effah, Z.2017. Effects of drought stress on maize genotypes (*Zea mays* L.) using some plant parameters. J. Sci. Res. Allied Sci., 6 (3): 481-490.
2. Ali, Q., Ahsan, M., Saif-ul-Malook, Kanwal, N., Ali, F., Ali, A., Ahmed,W., Ishfaq, M. and Saleem, M. 2016. Screening for drought tolerance: comparison of maize hybrids under water deficit condition. Advancements Life Sci., 3(2): 51 -58.
3. Abo-El-Kheir, M. S. A. and Mekki, B. B. 2007. The response of maize single cross to water deficits during silking and grain filling stages. World J. Agric. Sci., 3: 269–272.
4. Baret, F., Madec, S.; Irfan, K., Lopez, J., Comar, A., Hemmerle, M., Dutartre, D., Praud, S., Tixier, M.H., Leaf-rolling in maize crops: From leaf scoring to canopy-level measurements for phenotyping. J. Exp. Bot. 69: 2705–2716.
5. Denmead, O. T. and Shaw, R. H. 1960. The effects of soil moisture stress at different stages of growth on the development and yield of corn. Agron J., 52: 272-274.
6. Edmeades, G. O., Bolaños, J., Lafitte, H. R., Rajaram, S., Pfeiffer, W. and Fischer, R. A. 1989. Traditional approaches to breeding for drought resistance in cereals, pp. 27-52. In: Drought Resistance in Cereals. Baker FWG Ed. Wallingford, ICSU and CAB.
7. Farooq, A. 2008. Analysis of some physio-genetic parameters related to drought tolerance in maize. M Sc thesis Department of Plant

Breeding and Genetics University of Agriculture, Faisalabad.

8. Khan, I. A., Habib, S., Sadaqat, H. A. and Tahir. M. H. N.2004. Comparative Evaluation and Analysis of Seedling Traits for Drought Tolerance in Maize. Int. J. Agri. Biol., 6 (2) : 246-251.
9. Lambers, H., Chapin, F. S. and Pons, T .L. 2008. Plant physiological ecology, 2nd ed. Springer,New York.
10. MoAD . 2018. Stastical information of Nepalese Agriculture. Ministry of agriculture and development, Agriculture information and training centre, Hariharbhawan, Lalitpur.
11. Naveed, A., Khan, A. A. and Rauf, S. 2008. The potential of breeding okra (*Abelmoschus esculentus* L.) for water stress tolerance. Handbook Plant Biol.
12. Prabhu, L. P. and Shivaji, P. 2000. Meeting world maize needs: Technological opportunities and priorities for the public sector. CIMMYT World Maize Facts and Trends.
13. Qayyum, A. Ahmad, S., Liaqat, S., Malik, W., Noor, E., Saeed, H. M., and Memoona Hanif, M. 2012. Screening for drought tolerance in maize (*Zea mays* L.) hybrids at an early seedling stage African J. Agril. Res., 7(24): 3594-3604.
14. Ramadan, H. A., A-Niemi, S. N. and Hamdan, T.T. 1985. Water stress, soil type and phosphorus effects on corn and soybean, I. Effect on growth. Iraqi J. Agric. Sci. 3: 137–144.
15. Shiralipour, A. and West, S. H. 1984. Inhibition of specific protein synthesis in maize seedlings during water stress. Proc. Soil Crop Sci. Soc. Florida., 43: 102-106.
16. Thapa, S.B., Shrestha, P., Sah, S.K,. Karki, T.B., Shrestha, J., Aryal, K. and Kandel, B.P. 2019. Effect of different genotype, tillage method and plant population on dry matter, grain yield, stover yield and harvest index of hybrid maize. Int. J. Global Sci. Res.,6,(1):723-736.
17. Thakur, P. S. and Rai, V. K. 1984. Water stress effect on maize cultivars during early stage of growth. Indian J. Ecol., 11: 92-98.