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Determination of Yield Enhancing Traits in Maize (*Zea mays* L.) under Water Limited and Normal Irrigated Conditions

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ABSTRACT: Maize (*Zea mays.* L) is the most important food crop in the world for food security following rice and wheat. Drought is the most vulnerable sector affected by the rapid climate changes. The yield loss in maize is influenced by the crop stage at which drought occurs and the duration of exposure. In order to select genotypes for advanced stress breeding programs, it is important to screen them for the ability to cope with drought, particularly in rainfed environments. The current need of the drought breeding program is the screening of genotypes for its inherent capacity to with stand drought particularly under rainfed conditions. Most of the area under maize is in rainfed conditions and the identification of best genotype for rainfed conditions will meet out the current requirement. Twenty two maize hybrids were used to study the relationship of the yield associated traits under normal and rainfed conditions. Correlation study was performed among ten traits in the maize hybrids to see if there is any interdependence among the traits. The genotypes were raised in irrigated and rainfed conditions simultaneously. Plant height, cob length, number of rows per cob exhibited positive association with yield at 1% significance level. Anthesis Silking Interval showed negative association with yield at 1% significance level. The present study showed that cob characters *viz*., cob length, number of rows per cob, number of kernels per row, shelling percentage and early maturing genotypes with low ASI can be given more importance in selection criteria under rainfed conditions.

Key words: Correlation, anthesis silking interval, cob length, number of rows per cob, PCA.

INTRODUCTION

Maize called as queen of cereals is having diversified uses as food for mankind, livestock feed besides its utility as a source for large number of industrial products. It is grown over a wider geographical range of environment than any other cereal crop. Due to unpredictable climate changes and rise in global temperature there is an urgent need for the development of crop varieties suitable for drought. In South Asia, 1.5 to 1.7 billion people are expected to be affected by water scarcity by 2050 (World Bank Group 2021). Drought stress is found to affect maize production in future due to unpredictable climatic changes and it will be a great challenge for maize cultivation (Sheoran *et al.*, 2022). In Maize, drought occurrence at flowering stage is found critical for the crop and it is found to be the major limiting factor influencing production and productivity in India (Raza *et al.*, 2019). Development of broadly adapted material with maximum genetic potential as well as enhanced stability of yield when grown under water stress conditions is the current need. Incorporation of considerable level of drought tolerance in the germplasm will facilitate in the development of hybrids for drought. The unpredictable climatic changes will make it impossible to forecast when drought stress will affect the crop. Hence, the study of the critical stage of the crop for water stress is essential at present. In maize, the dissection and identification of yield association traits is more important for implication of indirect selection under drought conditions. Maize is a cross pollinated crop and development of high yielding hybrids with adaptation to drought situations is easier. Evolving new hybrids with better yield potential and improved yield stability under water limited environments will pave way to meet the future challenges in breeding for drought stress adaptability (Wesley *et al.*, 2002). With this idea, the current study was conducted with an objective to analyse the inter-relation of the yield associated traits in maize to dissect the major trait associated with yield under rainfed conditions. This will improve the selection efficiency of the breeding for drought conditions.

MATERIALS AND METHODS

The study was experimented in Maize Research Station, Tamil Nadu Agricultural University, Vagarai during rainfed conditions in 2021.The station is located at latitude of 10º57′N, longitude of 77 º56′E and altitude of 254 m MSL. The average rainfall in this area is around 500 mm. The farm has both red soil and black soil. The field study was conducted at both normal irrigated conditions and rainfed conditions during October 2021 – January 2022. The study was conducted with twenty two hybrids raised in Randomized block design in two replications. Irrigation was given to the control experiment once in 7-9 days depending on the environmental conditions and the same set was evaluated under rainfed conditions simultaneously. Sowing was taken in two rows of 4 m length adopting a spacing of 60 cm × 25 cm. All the recommended management practices were adopted for the crop. The biometrical traits *viz*., plant height, ear height, days to 50 % tasselling, days to 50 % silking, ASI, cob length, number of rows per cob, hundred seed weight, shelling percentage and yield were recorded. Correlation study was done using TNAU Stat statistical package.

Observations recorded

Plant height. The plant height was measured from the main stalk to the tassel base and expressed in centimeter.

Ear height. The measurement was made uniformly from the ground to the upper most ear in the main stalk and expressed in centimeter

Days to 50 % tasseling. The days from the sowing to the day when 50 % of plants in the plot shed pollen is recorded

Days to 50 % silking. It is the number of days from sowing to the day when fifty per cent of the plants had started silk emergence.

Anthesis Silking Interval (ASI). The difference in the days to 50 % silking and days to 50 % tasselling is represented in number of days.

Cob length. Cob length is measured as the length of the uppermost cob from the base to the tip and expressed in centimeter.

Kernel rows per cob. The kernels rows in each cob was counted and expressed in numbers.

Hundred grain weight. Hundred randomly selected grains from the cob were weighed in grams at 12 per cent moisture content.

Shelling percentage. The ratio of unshelled harvest weights to shelled weights is calculated from the five cobs taken from each genotype and expressed as percentage.

Shelling percentage = (weight shelled (kg)) / weight unshelled (kg)) × 100

Grain yield/hectare. All the grains obtained from single cob were weighed at 12 per cent moisture content and expressed in kg/hectare

RESULTS AND DISCUSSION

In maize, production and productivity gets affected by the occurrence of drought at flowering stage. In maize, comparison study of the association of secondary traits with yield under both normal irrigated and rainfed conditions will help in dissection of the best trait that will contribute to yield under water limited conditions. With this objective, twenty two hybrids were used for evaluation under irrigated and drought conditions. The data of the hybrids for the grain yield per hectare is represented in Table 1.

The mean of the hybrids under irrigated conditions was 8097 kg per hectare. The minimum and maximum yield were 6521 kg/ha and 9604 kg/ha respectively. But under rainfed conditions, mean, minimum and maximum yield were 6442 kg/ ha, 5167 kg/ha and 7450 kg/ha respectively. The data on yield shows that the hybrids exhibit considerable variation under irrigated and rainfed conditions. Under irrigated conditions, the hybrid VaMH 21007 (9604 kg/ha) followed by VaMH 21019 (9208 kg/ha) were found to be best performing. But under rainfed conditions, the hybrid VaMH 21007 (7450 kg/ha followed by VaMH 21019 (7300 kg/ha) excelled for grainyield. According to the findings of Adnan *et al.* (2020); Premalatha *et al.* (2010), grain yield is the result of the interaction of the environment and management with the growth and development processes that happens during the crop's maturation cycle. Under different environmental and agronomic conditions, yield component traits adjust their expressions to determine grain yield. This makes the selection process better in identification of the best hybrid suitable for rainfed conditions. Detection of candidate genes for the drought remains a challenge (Zhu *et al*., 2016). Plant growth parameters, flowering traits, yield attributes and yield were subjected to analysis for correlation for both irrigated and rainfed conditions. The association of the yield component traits under both irrigated and rainfed were presented in the Table 2.

In the correlation study under normal irrigated conditions, shelling percentage (0.409) exhibited positive association with yield. Cob length had positive association with number of rows per cob (0.401), hundred seed weight (0.523) and shelling percentage (0.495) at 1% significance level. Number of rows per cob showed positive association with hundred seed weight (0.343) and shelling percentage (0.282) at 1% significance level. Under rainfed conditions, plant height (0.398), cob length (0.437), number of rows per cob (0.455) and hundred seed weight (0.282) exhibited positive association with yield at 1% significance level. Anthesis Silking interval showed negative association with cob length (-0.286), number of cobs (-0.361) and yield (-0.286). Cob length showed positive association with number of rows per cob (0.780), hundred seed weight (0.496), shelling percentage (0.553) and grain yield (0.437) at 1% significance level. Number of kernel rows per cob showed positive association with number of rows per cob, hundred seed weight, shelling percentage and yield at 1% significance level. Hundred seed weight and shelling percentage exhibited positive association with yield at 1% significant level. Flowering stage in maize is found be more vulnerable to drought (Anjum *et al*., 2011). The goal of maize breeders is to develop maize hybrids that are resistant to the effects of water limited conditions.

In the study, correlations between grain yield and ASI was weak under normal irrigated conditions, but under rainfed conditions, it had significant negative association with yield. The result of low correlation of ASI with grain yield under irrigated conditions indicates that there is no significant variation in the trait for grain yield. But under moisture stress ASI is dominated by variation in ear-setting processes related to biomass partitioning at flowering and much less by factors putatively linked to crop water status. This clearly indicates that selection programs for drought tolerance under field conditions should consider these results. Drought stress affects maize productivity especially during flowering and pollination. Prolonged ASI period is an indication of poor tolerance to drought stress. In severe water deficit conditions, synthesis and translocation of carbohydrates to the reproductive parts is reduced and ASI gets prolonged and the final grain yield is drastically reduced. Shortening of ASI is highly correlated with grain yield and has a high heritability under drought.

Table 1: Comparison of grain yield of the maize hybrids in irrigated and rainfed conditions.

Sr. No.	Name of the Hybrid	Grain yield Kg/ha (I)	Grain yield Kg/ha (R)
1.	VAH 21001	7688	6083
2.	VAH 21002	8646	6850
3.	VAH 21003	8813	6817
4.	VAH 21004	7688	6083
5.	VAH 21005	8813	6817
6.	VAH 21006	8938	6583
7.	VAH 21007	9604	7450
8.	VAH 21008	7438	5883
9.	VAH 21036	8250	6500
10.	VAH 21010	6521	7017
11.	VAH 21012	7417	5867
12.	VAH 21013	7875	6233
13.	VAH 21014	8000	6333
14.	CO6	8333	6583
15.	VAH 21016	8729	6750
16.	VAH 21017	7708	6100
17.	VAH 21018	8417	6667
18.	VAH 21019	9208	7300
19.	VAH 21020	6625	5233
20.	VAH 21021	8708	6950
21.	VAH 21022	8167	6467
22.	VAH 21023	6542	5167
Mean		8097	6442
SD		845	583
Minimum		6521	5167
Maximum		9604	7450
CV		11.09	9.05

Table 2: Comparison of inter- association of yield and the associated traits under irrigated and rainfed conditions.

		Plant Height	Ear height	DAT	DAS	ASI	Cob length	NR/cob	HSW	Shelling %	Grain Yield
Plant Height	Irrigated	1									
	stress	1									
Ear height	Irrigated	-0.137	1								
	stress	0.738	1								
DAT	Irrigated	0.265	-0.291 *	1							
	stress	-0.410**	-0.193	1							
DAS	Irrigated	0.149	-0.434**	0.870**	1						
	stress	-0.521**	-0.502**	0.884**	1						
ASI	Irrigated	-0.124	-0.405**	0.148	0.616**	1					
	stress	-0.384**	-0.390**	0.136	0.582**	1					
Cob length	Irrigated	0.082	0.284*	-0.190	-0.255*	-0.208	1				
	stress	0.791**	0.641**	-0.244	-0.332**	-0.285*	1				
NR /cob	Irrigated	-0.0017	0.098	-0.451**	-0.447**	-0.176	0.401**	1			
	stress	0.662**	0.519**	-0.398	-0.496**	-0.361*	0.780**	1			
HSW	Irrigated	0.271	0.0972	-0.074	-0.172	-0.221	0.523**	0.343*	1		
	stress	0.539**	0.466**	-0.112	-0.180	-0.188	0.496**	0.465**	1		
Shelling %	Irrigated	0.056	0.106	-0.501**	-0.146	-0.213	0.495**	0.282*	0.534**	1	
	stress	0.595**	0.450**	-0.063	-0.165	-0.231	0.553**	0.547**	0.535**	1	
Grain Yield	Irrigated	-0.073	-0.108	-0.113	-0.186	-0.192	0.213	-0.161	0.178	0.409**	1
	stress	0.398**	0.217	-0.167	-0.257	-0.286*	0.437**	0.455**	0.248	0.505	1

* Significance at 1 % level; ** Significance at 1 % level

The studies conducted by Banziger *et al.* (2000); Kosova *et al.* (2014) showed that grain yield was found to be the positively associated with a short ASI and earlier flowering, leaf rolling and delayed leaf senescence under drought conditions. According to the studies of Wang *et al.* (2019); Dong *et al.* (2020), synthesis of protective proteins is induced by heat shock proteins during drought occurrence. Water stress during flowering will lead to delay in silking which will ultimately prolong the anthesis to silking interval and poor seed set in cob (Bharathi *et al.*, 2021). Drought stress encourages an assortment of morpho-physiological changes in plants. Drought tolerance in maize is the result of abundant morphological, anatomical and physiological parameters.

CONCLUSIONS

In maize breeding, knowledge on the relationships among yield components is of the great importance, because it is likely to facilitate breeders to choose the most efficient selection criteria. Selection of productive genotypes under water limited conditions based on grain yield alone has often been considered inefficient and the inter-association of secondary traits of adaptive value increase selection efficiency. Hence the cob characters *viz*., cob length, number of rows per cob, number of kernels per row, shelling percentage can be given more importance in selection criteria as they are contributing to yield. Under rainfed conditions where the crop faces water limitations, low ASI, reduced number of tassels and stay green trait with delayed senescence will lead to partitioning to early ear growth and achieve maximum yield potential under drought conditions. The results of the study concludes that better performance in water-limited environments will be successful through selection of early vigorous silking, reduced ASI, stay green trait and leaf rolling. This will give us opportunities for selection and faster development of improved hybrids for drought tolerance.

FUTURE SCOPE

The identified high yielding maize hybrids from the investigation can be cultivated under water limited conditions for getting maximum yield potential

Abbreviations: DAT – Days to 50% tasselling; DAS – Days to 50% silking; ASI – Anthesis Silking Interval; NR/cob – No of rows per cob; HSW – Hundred seed weight

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Conflict of Interest. None.

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