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RESEARCH ARTICLE

Morpho-physiological changes in five varieties of maize (*Zea mays* L.) grown under different levels of water stresses leading to drought

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ABSTRACT : Drought is a complex syndrome involving timing, intensity, and duration of water deficit the high variability of these factors makes it difficult to define plant traits required for improved performance under all possible drought situations. With the unpredictability of drought, geographical and seasonal, including ongoing climate changes, the destructive impact of drought is likely to further increase. Drought causes numerous physiological changes in plants like plant height, membrane injury and relative water content. Keeping these views in mind an experiment was conducted to study the physiological changes among water stressed maize varieties. For the present study, five maize varieties were treated with different water doses (T_0, T_1, T_2 and T_3). Treatment T_0 showed maximum plant height and Treatment T_3 showed minimum plant height. In these stages variety Varun showed maximum membrane injury and variety Ashwini showed minimum injury. Maize variety Ashwini showed maximum relative water content while AAIMS2 variety showed minimum relative water content under drought stress.

Key Words :
Drought, Intensity, Deficit, Climate change, Maize

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Drought is a worldwide problem and dangerous for arable field crops growth and subsequently for food security (Jallel *et al.*, 2009). Drought, flooding, heat, wind and cold are the abiotic stresses. Drought is the major abiotic stress factor limiting crop productivity worldwide. Agriculture scientists are facing the challenge of drought in the current situation of water shortage. As water resources for agricultural uses become more limiting, the development of drought-tolerant lines will become increasingly important (Robert *et al.*, 2004). The severity of drought is unpredictable as it depends on many factors such as occurrence and distribution of rainfall, evaporative demands and moisture storing capacity of soils (Wery *et al*., 1994). During the drought conditions water potential and turgor are decreased and this situation disturbs the normal functioning of plant body (Hsiao, 1973). Water is an integral part of plant body plays an important role in growth initiation, maintenance of developmental process of plant life and hence has pivotal function in crop production (Grzesiak, 2001).

Maize is one of the earning grain crops and in the world it is perhaps the most versatile. It is used in the human diet in both fresh and processed forms. (Hallauer and Miranda, 2000). Maize grain is extensively used for the preparation of corn starch, corn oil dextrose, corn flakes, gluten, grain cake, lactic acid and acetone which are used by various industries such as textile, foundry, fermentation and food industries (Hussain, 2010). Thus, the development and spread of this exceptional product is very important. Maize, however, is highly sensitive to drought, specifically two weeks prior- and post-silking (Bänziger *et al.*, 2000 and Tollenaar and Lee, 2011). Maize requires 500-800 mm of water during life cycle of 80 to 110 days (Critchley and Klaus, 1991). Water requirement of maize at the time of tesseling is 135 mm/month (4.5 mm/day) and this requirement may increase up to 195 mm/month (6.5 mm/ day) during hot windy conditions (Anonymous, 2001). Maize is cultivated in both spring and autumn seasons and it is best suited in existing cropping scheme. However, yield potential of maize is highly prone to abiotic stresses (Drought, salinity, extreme temperatures, flooding, pollutants and poor or excessive irradiation) which are important factors towards limiting the crop productivity (Lawlor and Cornic, 2002).

To a careful estimate, only drought reasons for 50 per cent or more reduction in average yields worldwide (Wang *et al.*, 2003). In maize, drought reduces leaf area, leaf chlorophyll contents, photosynthesis and ultimately lowers the grain yield (Athar and Ashraf, 2005). Drought affected 20-25 per cent of the global maize area each year. Maize is quite drought susceptible compared to other cereals with the exception of rice; this has considerable consequences as most of the maize producing areas are under rainfed conditions (Banziger and Araus, 2007). The objective of this study is to evaluate the effect of water stress on different Morpho-Physiological changes in maize (*Zea mays* L.).

Experimental Methodology

The experimental material of the study comprised five varieties of maize Ludhiana J 1006, AAIMS 2, DHM 117, Varun and Ashwini, were collected from the Department of Genetic and Plant Breeding Sam Higginbottom Institute of Agricultural, Technology and Sciences, Allahabad. The experiment was laid out in Randomized Complete Block Design with three replications. Four levels of irrigation were randomized in plots as follows: 1. (T_0) Control where maize plants received daily watering, (T_1) where maize plants received irrigation after 5 days interval, (T_2) where maize plants received irrigation after 10 days and (T_3) where maize plants received irrigation after 15 days interval.

Plant height :

Plant height was measured manually using a meter scale from ground level to the topmost part of the plant in centimeter after 15 day of treatment.

Membrane thermostability test :

10 cm part of each flag leaf was taken, midrib was removed and cut into 2 equal halves, lengthwise. Cut each leaf again into 2 pieces.1 piece to use as control and the other for giving treatment. Wash the leaf pieces with deionized water and put into thoroughly washed glass test tubes. Covers the mouth of test tube with Al foil and incubate in the water bath at 52^0C for 15 min. After the treatment add 10 ml deionized water to each test tube including controlled one. Leave the test tube at 10^0C overnight to allow diffusion of electrolytes from plant material to water. Record the electrical conductivity of control and treated test tubes. Then autoclave the test tubes at 15 Ps pressure for 2 min to allow complete electrolyte leakage. Cool the test tube at room temperature and final EC should be recorded (Rehman *et al.*, 2004). The membrane injury was calculated using the formula given by Blum (1988).

$$\text{Relative injury (\%)} = 1-[\{1-(T_1/T_2)\}/\{1-(C_1/C_2)\}]\times 100$$

where,
T_1 = Conductivity of treatment before autoclaving.
T_2 = Conductivity of treatment after autoclaving.
C_1 = Conductivity of control before autoclaving.
C_2 = Conductivity of control after autoclaving.

Relative water content (RWC) :

0.5 g of leaf (FW) was taken and soaked in distilled water overnight to get them saturated. Then the leaf samples were weighed again to get the turgid weight (TW). The samples were then dried in an oven at 80°C for 24 h and weighed (DW) (Ali *et al.*, 2011). The relative water contents were measured as following:

$$RWC = (FW-DW)/(TW-DW) \times 100$$

where,
FW - Fresh weight
DW – Dry weight
TW – Turgid weight

EXPERIMENTAL FINDINGS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Morpho-physiological characteristics :

Plant height :

The data in Fig. 1 showed that there was a significant difference in plant height among the varieties. The plant height was maximum for variety Varun and the minimum for variety Ashwini under all the treatments whereas treatment T_0 showed the highest and treatment T_3 the lowest plant height for all the varieties but among all the varieties it was found that variety Varun showed the maximum height of plant under treatment T_0 and variety Ludhiana J 1006 the minimum plant height in T_3 treatment. The plant height differed significantly among the treatment. The treatment followed the increasing order $T_0 > T_1 > T_2 > T_3$.

Membrane injury and relative water content :

The data in table showed that there was a significant difference in membrane injury (%) among the varieties. The membrane injury (%) was found to be the maximum for variety Varun and the minimum for variety Ashwini under all the treatments whereas treatment T_3 showed the highest and treatment T_0 the lowest Membrane injury (%) for all the varieties but among all the varieties it was found that variety Varun showed the maximum membrane

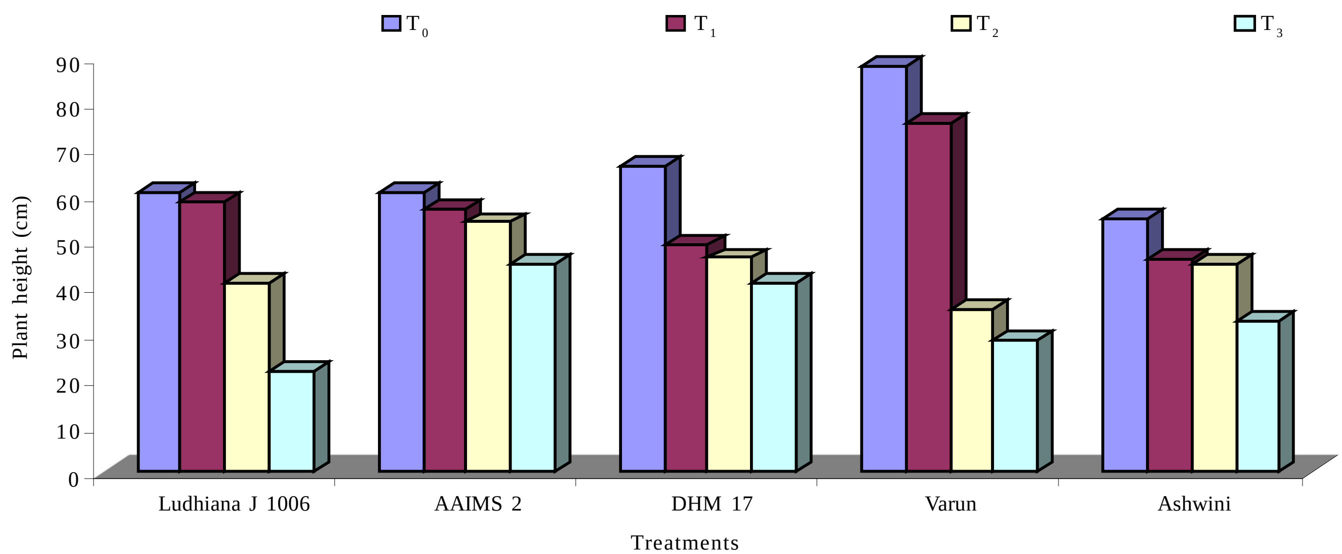

Fig. 1 : Effect of different treatments t (T_0 = Indigenous soil+ daily watering, T_1 = Indigenous soil + watering after 5 days interval, T_2 = indigeneous soil + watering after 10 days interval, T_3 = indigeneous soil + watering after 15 days interval) on plant height (cm) in different varieties of maize

Table 1: Effect of different treatments (T_0 = indigeneous soil+daily watering, T_1 = indigeneous soil+ watering after 5 days interval, T_2= indigeneous soil+ watering after 10 days interval, T_3= indigeneous soil+ watering after 15 days interval) on Membrane injury (%) and relative water content in different varieties of maize.

Varieties	Membrane injury (%)					Relative water content (%)				
	T_0	T_1	T_2	T_3	Var.mean	T_0	T_1	T_2	T_3	Var.mean
Ludhiana J 1006	16.000	20.667	51.333	64.333	38.083	87.743	62.863	55.520	44.670	62.699
AAI MS 2	12.667	22.000	55.667	67.667	39.500	89.473	57.253	42.640	40.447	57.453
DHM 117	16.667	28.667	33.667	71.333	37.583	88.040	56.117	55.970	35.973	59.025
Varun	15.667	26.667	51.667	72.333	41.583	88.160	59.143	51.923	49.490	62.179
Ashwini	17.667	25.000	50.667	65.667	39.750	87.423	89.847	62.660	55.327	73.814
Treatment mean	15.733	24.600	48.600	68.266	G.M.= 36.800	88.168	65.045	53.743	45.181	G.M.= 63.034
S.E. (±)	0.746	1.202	2.315	5.799		0.188	3.370	1.749	1.809	
C.D (P=0.05)	2.0843	2.3303	4.6607	4.6607		0.0218	0.0244	0.0488	0.0488	
C.V.			7.662					0.047		

injury (%) under treatment T_3 and variety AAI MS2 the minimum Membrane injury (%) in T_0 treatment. The minimum Membrane injury (%) differed significantly among the treatment. The treatment followed the increasing order $T_3>T_2>T_1>T_0$.

The data in table showed that there was a significant difference in relative water content among the varieties The relative water content was found to be the maximum for variety Aswini and the minimum for variety AAI MS2 under all the treatments whereas treatment T_0 showed the highest and treatment T_3 the lowest Membrane injury (%) for all the varieties but among all the varieties it was found that variety AAI MS2 showed the maximum relative water content under treatment T_0 and variety DHM 117 the minimum in relative water content T_3 treatment. The relative water content differed significantly among the treatment. The treatment followed the increasing order $T_0>T_1>T_2>T_3$.

In maize plant the inhibition of plant growth observed in the experiment was due to the drought stress. Plant height was maximum in varun while the minimum in Ashwini. Increase in drought intensity resulted in reduced plant height (Fig. 1). It was in accordance with the earlier findings. The reduction in plant height was associated with a decline in the cell enlargement and more leaf senescence in *A. esculentus* under water stress (Liu *et al.*, 2004). Membrane injury (%) was increased due to drought stress. Membrane injury (%) was found the maximum in Varun while the minimum in Ashwini. A decreasing trend in Membrane injury (%) was observed in maize plants in response to increasing drought levels (Table 1). This is due to damage to membrane structure caused by drought stress, which resulted in solutes leakage from cell hence cell membrane thermostability was reduced. Cytokinins are well recognized for enhancing the antioxidant activities, which scavenge the ROS production and ultimately reduce the membrane damage and improved the cell membrane thermostability (Sayd *et al.*, 2010). Relative water content decreased due to drought stress. Relative water content was maximum in Ashwini and the minimum in AAIMS2 . Under severe drought stress less negative osmotic potential than mild stressed, whereas lesser turgor potential than mild stressed plant leaves (Table 1). Similar results were observed when triticale varieties were exposed to drought stress plants exhibited the more negative osmotic potential and maintained the turgor potential, indicating better osmotic adjustment (Hura *et al.*, 2007). In another study, leaf relative water content (RWC) was significantly decreased under severe drought stress due to the excessive water loss (Machado and Paulsen, 2001).

Conclusion :

From the present study and on the basis of observations it was concluded that the varun variety of maize (*Zea mays* L.) was drought tolerant among all the variety. The morpho-physiological parameters in 5 maize varieties such as height of plant, membrane injury (%), relative water content, showed a significant decrease with the increase in treatment of drought stress. The antioxidant activity increased due to the drought stress.

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