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Short Communication

Evaluation of morphological characteristics in five Persian maize (*Zea mays* L.) under drought stress

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A greenhouse experiment was carried out to assess the reaction of five maize (*Zea mays* L.) genotypes under drought stress. Seeds were planted in Petri dishes. The study was established in a completely randomized design with five replications. The plants were harvested 15 days after sowing, and leaf area per plant (LA), longest root length (LRL), plant height (PH), root fresh weight (RFW), root dry weight (RDW), shoot dry weight (SDW), RDW/SDW ratio, and total dry matter (TDM) were determined. Significant varietal differences for all characters were found. The data obtained allowed to identify SC 500 as a suitable genotype at low water supply.

Key words: *Zea mays*, leaf area, root length, plant height, root weight, shoot weight, total dry matter, poly ethylene glycol.

INTRODUCTION

Corn (*Zea mays* L.) is the foremost cereal in the world following wheat and rice (Lerner and Dona, 2005). Maize grown under semiarid climate of Iran requires supplementary irrigation application to maximize the grain yield. The crop is adapted to tropical, sub-tropical and temperate areas, but little is known about drought stress response within tropical maize cultivars.

Drought or continuous water deficit is one of the most important factors affecting plant growth, development, survival and crop productivity (Seo, 2009; Ramı´rez et al., 2009; Ning et al., 2010). Over the years, physiological and morphological characteristics, such as osmotic adjustment, stomatal behavior, chloroplast activity, leaf water potential, root volume, root weight, leaf area, dry matter production, have been studied in several maize cultivars grown under limited water supply (Andrade et al., 2002; Hugh and Davis, 2003; Lerner and Dona, 2005; Osborne et al., 2002; Otegui and Andrade, 2000; Stone et al., 2001). Furthermore, an increase in drought resistance by the use of transgenic technology for gene transfer is a realistic strategy (Li et al., 2008). This study aims to investigate the morphological responses to drought stress of five corn cultivars, and their portion in the total dry matter production.

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Abbreviations: LA, Leaf area per plant; **LRL,** longest root length; **PH,** plant height; **RFW,** root fresh weight; **RDW,** root dry weight; **SDW,** shoot dry weight; **PEG,** poly ethylene glycol; **TDM,** total dry matter.

MATERIALS AND METHODS

Five genotypes of maize were studied: SC108, SC500, CS647, SC700 and SC704. The seeds of the five genotypes were treated with fungicides to avoid the activity of pathogens. The genotypes used were high yield hybrids, oriented from inbred lines and all bred, except for SC108, prepared from Karaj seed and plant improvement institute. Some traits of the seeds used are given in Table 1.

The experiment was carried out in greenhouse at West Azerbaijan Agricultural Research Center, Urmia, Iran, in 2010. Fifty Petri dishes were moistened with distilled water. Seven seeds were planted per 10 cm-diameter Petri and the seedlings thinned out to three plants, three days after germination. Stress was compelled by adding PEG6000 (1%) following emergence.

A completely random design with five replications was used in this study. When the plants were four weeks old, the two plants of each Petri harvested and carefully separated into roots and shoots. The roots washed with a 1% sodium hydroxide, to free them from particles. The harvested material then washed with distilled water, wrapped in wet paper towels, and brought to the laboratory where the following data were recorded: leaf area (area in cm^2, measured with LI-300. LI-COR, portable area meter), longest root length (mean length in cm), plant height (cm, from soil surface to insertion point of flag leaf), root wet weight (g), root dry weight (g), shoot dry weight (g) and total dry matter production (g). The Duncan`s

Table 1. Some traits of cultivars used.

Cultivars	Traits			
	Type of cultivar	Number of ear	Type of corn	Day to maturity
SC108	Early mature	1-2	Flint	90-100
SC500	Semi-late	1	Flint	95-115
SC647	Semi-late	1	Flint	95-115
SC700	Delay mature	1	Flint	125-140
SC704	Delay mature	1	Flint	125-140

Table 2. Mean for five maize genotypes grown under drought stress.

Genotypes	LA (cm^2)	LRL (cm)	PH (cm)	RFW (g)	RDW (g)	SDW (g)	RDW/SDW	TDM (g)
SC108	22.67^{b}	8.55^{ab}	17.84^{a}	0.88^{b}	0.17^{b}	0.24^{b}	0.77^{b}	0.38^{c}
SC500	31.16^{a}	9.32^{a}	16.21^{ab}	1.92^{a}	0.48^{a}	0.41^{a}	1.17^{a}	0.56^{ab}
SC647	33.84^{a}	8.78^{ab}	16.41^{ab}	1.48^{ab}	0.37^{ab}	0.48^{a}	0.70^{b}	0.48^{ab}
SC700	34.32^{a}	8.9^{ab}	18.10^{a}	1.39^{ab}	0.30^{ab}	0.51^{a}	0.58^{b}	0.49^{ab}
SC704	33.72^{a}	8.84^{ab}	17.93^{a}	1.31^{ab}	0.21^{b}	0.32^{b}	0.65^{b}	0.46^{ab}

Means within each column followed by the same letter are not significantly different at the 0.05 level.

multiple range tests (DMRT) was used to compare the means at 5% of significant.

The mean day temperature in the greenhouse was 24.3°□, with a maximum of 29°□ at 7:00 am. The mean relative humidity was 79.8% with a maximum of 82.9%, measured at 1:00 pm. The diurnal variations of temperature and relative humidity in the greenhouse were monitored with a thermo-hygrometer.

RESULTS AND DSISCUSSION

Considerable differences exist among the corn genotypes studied in their ability to endure drought stress. Data in Table 2 showed that all genotypes, except for SC108, had a consistently high leaf area growth under aridity conditions. Drought stress during the vegetative stage provokes diminution of the growth in maize crop leaves (Istanbulluoglu et al., 2002). SC108 showed the lowest total leaf area, (less than 23 cm^2) among all the genotypes. Growth and photosynthesis in young leaves frequently do not reach the original rates for several days, and old leaves are often shed. Furthermore, cells are smaller and leaves develop less during water shortage stress, resulting in reduced area for photosynthesis (Bismillah et al., 2001).

There was no considerable significant variation in longest root length (Table 2), a result which could have been caused by using Petri dishes insufficiently deep to allow full expression of roots; however, there was 1.09 fold difference between the smallest (SC108) and largest (SC500) root length. Fair decreased root length was because of low photosynthetic assimilates devoted to parts of plant due to diminished photosynthesis. Measurement of roots in greenhouse may give an approximation of root growth in the field, and that corn root growth at the seedling stage may therefore be useful in predicting root growth under drought stress at later growth stages.

Differences in plant height as the response to drought was found among the genotypes studied (Table 2). SC108, SC700 and SC704 performed better than SC500 and SC647. Cellular growth appears to be the most sensitive response to drought stress (Boyer, 1970). In Squash (*Cusurbita maxima*), reducing the external water potential by only - 0.1 Mpa (sometimes less) results in a perceptible decrease in cellular growth (irreversible cell enlargement) and thus in root growth (Sakurai and Kuraishi, 1988). Several investigations have reported that drought stress imposed during the vegetative growth phase lessens the plant height referring to Dek (1986).

Under drought, there were little significant differences in root fresh weight among genotypes (Table 2). SC108 exhibited the lowest RFW (0.88 g), while the other four varieties presented higher amounts, with no noticeable statistical differences among them. Drought drastically declined RFW in winter wheat genotypes grown in greenhouse container culture for three weeks (Mian et al., 1993). The trend demonstrated by SC108 maybe indicative of sensitivity to drought stress. When screening the corn genotypes responses for root dry weight under drought stress, it was found that all hybrids, except for SC108 andSC704, performed well. Hughes et al. (1984) reported that corn genotypes with low root dry weight are less tolerant to drought stress.

As was the case with RDW and RFW, SC108 again showed a low SDW (Table 2). With mean below 0.3 g, while the other four genotypes presented the best behavior in relation to this characteristic, with means between 0.32 g (SC704) and 0.51 g (SC700). Water stress during the vegetative growth stage lowers SDW in corn genotypes (Vianello, 1988) and consequently the yield (Vianello and Sobrado, 1991).

As to the RDW/SDW ratio (Table 2), one homogeneous group of genotypes included the following cultivars: SC700 (0.58), SC704 (0.65), SC647 (0.7) and SC108 (0.77). The other genotype presenting the higher value was SC500 (1.17). Genotypic ability for high RDW/SDW ratio contributes to drought tolerance. It seems that maize crops are less tolerant to drought due to their high shoot dry weight and low root dry weight.

SC108 demonstrated a different trend to the other characteristics studied, its RDW/SDW ratio was fair high under drought, whereas this genotype showed lower RDW (0.17 g) and SDW (0.24 g) than other four genotypes. Nour et al. (1987) correlated high RDW/SDW ratio of young plants with superior drought resistance in sorghum genotypes. However, it is not possibly indicative of better tolerance of SC108 to drought compared with other four genotypes. Such results raise doubts about the relevance of studies on the evaluation of genotypic responses using RDW/SDW ratio under drought stress.

Little genotypic variability was found for total dry matter production. All genotypes, except for SC108, showed a high ability to accumulate dry matter, with the means above 0.46 g per plant. No statistically significant difference observed. SC108 showed the lowest total dry matter with the means below 0.4 g. It is most likely that any factor which affects the photosynthetic process will influence the total dry matter (Vianello and Sobrado, 1991). Thus, drought can be causing strong inhibition of the photosynthetic activity in SC108. Leave precocious wilting phenomenon was observed in this hybrid. Boyer (1970) cited that maize leaves subjected to drought for a week or more suffered permanent damage to the stomata and in all cases, the stomatal behavior was parallel to the photosynthetic activity.

The data obtained allowed to identify SC108 to be the most undesirable genotype under conditions where water constitute a limiting factor. On the other hand, SC500 could be utilized in a breeding program considering its response to drought. This genotype showed consistently higher values of root volume and RDW/SDW ratio when grown under limited water supply.

Conclusion

The evaluation technique employed in this work was found to have merit as an inexpensive and simple method of screening genotypes for drought tolerance and predicting the response of whole plant in the field. In this study, SC108 was a poor genotype at low water supply, however, SC500 showed the best behavior under drought stress. Root dry weight was identified as the major criterion for selection of maize genotypes under drought conditions.

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