Short Communication

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

Evaluación de las características morfológicas de cinco genotipos de maíz (*Zea mays* L.) de Persia bajo condiciones de sequía

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ABSTRACT

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 research was established in a completely random design with five replications. 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 ($p \leq 0.05$). The data obtained allowed to identify SC 500 as a suitable genotype at low water supply. On the other hand, root dry weight was recognized as the best indicator and easiest typical to determine the drought- tolerance of maize.

Key words: *Zea mays*, leaf area, root length, plant height, root and shoot weight, polyethylene glycol.

RESUMEN

Se llevó a cabo un experimento de invernadero para evaluar la reacción de cinco genotipos de maíz (*Zea mays* L.) al estrés hídrico. Las semillas se sembraron en cápsulas de Petri. La investigación se estableció en un diseño completamente aleatorizado con cinco repeticiones. Las plantas se cosecharon 15 días despúes de la siembra y se determinaron los caracteres: área foliar por planta (AF), longitud de la raíz más larga (LR), altura de planta (AP), peso fresco de raíces (PFR), peso seco de raíces (PSR), peso seco de vástago (PSV), relación PSR/PSV y la materia seca total (MST). Se encontraron diferencias varietales significativas para todos los caracteres ($p \leq 0,05$). Los datos obtenidos permitieron identificar a SC 500 como un genotipo adecuado en condiciones de bajo suministro de agua. Por otro lado, el peso seco de las raíces se reconoció como el mejor indicador para determinar la tolerancia a la sequía en maíz.

Palabras clave: *Zea mays*, área foliar, longitud de raíces, altura de planta, peso de raíces y vástago, polietilenglicol

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.

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)

The experiment was carried out to assess the reaction of five maize (*Zea mays* L.) genotypes under drought stress.

MATERIAL 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 hybrids, oriented from inbred lines and all bred, except for SC108, to obtain good yield in Karaj seedling breeding institution. They were hybrids of high height.

The experiment was carried out in greenhouse at West Azerbaijan Agriculture Research Center, Urmia, Iran, in 2010. Fifty petri dishes were filled with distilled water. Seven seeds were planted per petri and the seedlings thinned out to three plants, three days after germination. Stress was compelled by adding , Polyethyleneglycol 6000 (1%) following emergence.

A completely random design with five replications was used in this study. When the plants were 15 days after sowing, 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 stem base 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 multiple range test (DMRT) was used to compare the means at 5% of significance Data of the experiment was analyzed by Mstat-C software.

The mean day temperature in the greenhouse was 24.3 ˚C, with a maximum of 29 ˚C 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 DISCUSSION

Considerable differences exist among the corn genotypes studied in their ability to endure drought stress. Table 1 shows that all genotypes, except for SC108, had a consistently high leaf area growth under aridity conditions. A 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 Khan *et al.,* 2001).

There was no considerable significant variation in longest root length (Table 1), a result that could have been caused by using petri dishes insufficiently deep to allow full expression of roots, however, there was a 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 gives 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 (Table1). SC108, SC700 and SC704 performed better than SC500 and SC647. Cellular growth appears to be the most sensitive response to drought stress (Caker, 2004). In Squash (*Cucurbita 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).

Table 1. Mean for five maize (*Zea mays* L.) genotypes grown under drought stress.

Genotypes	LA (cm^2)	LRL (cm)	PH (cm)	RFW (g)	RDW (g)	SDW (g)	RDW/SDW ratio	TDM (g)
SC108	22.67 b	8.55 b	17.84 a	0.88 b	0.17 b	0.24 b	0.77 b	0.40 c
SC500	31.16 a	9.32 a	16.21 b	1.92 a	0.48 a	0.41 a	1.17 a	0.89 a
SC647	33.84 a	8.78 ab	16.41 ab	1.48 ab	0.37 ab	0.48 a	0.70 b	0.85 a
SC700	34.32 a	8.90 ab	18.10 a	1.39 ab	0.30 ab	0.51 a	0.58 b	0.81 a
SC704	33.72 a	8.84 ab	17.93 a	1.31 ab	0.21 b	0.32 b	0.65 b	0.63 b

LA, leaf area per plant; LRL, longest root length; PH, plant height; RFW, root fresh weight; RDW, root dry weight; SDW, shoot dry weight; TDM, total dry matter.
Means within each column followed by the same letter are not significantly different at the 0.05 level according to Duncan's multiple range test.

Under drought, there were little significant differences in root fresh weight among genotypes (Table1). 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 may be 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 (Table1). 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 1), 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. It thus appears that vigorous shoot growth corresponds to vigorous root growth under a wide range of environmental conditions (included drought) and that either variable can be used to select for seedling vigor. 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 SC 704 and SC108, showed a high ability to accumulate dry matter, with the means above 0.81 g per plant. No statistically significant difference observed. SC108 showed the lowest total dry matter with the means below 0.41 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. Doggett (1988) 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. 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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