



Studies on Screening of Maize (*Zea mays* L.) Hybrids under Drought Stress Conditions

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ABSTRACT

Drought is one of the most serious problems posing a grave threat to cereals production including maize. Two experiments (lab and wire house) were conducted to screen out the most tolerant and most sensitive maize hybrids (7386, 6525, Hycorn, 9696, 32B33, 3672, MMRI and 31P41) under artificial imposing drought stress by PEG-6000 and under water stress applied after seedling emergence. In first experiment five water stress levels such as zero (control), -0.2 MPa, -0.4 MPa, -0.6 MPa, and -0.8 MPa were developed using polyethyleneglycol-6000 (PEG-6000) while in second experiment water stress applied after seedling emergence. Complete randomized design with three replications was used for both experiments at stress Physiological Lab, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan. Promptness index, germination stress tolerance index (GSI), plant height stress index (PHSI), root length stress index (RLSI) and dry matter stress index (DMSI) were used to evaluate the genotypic response to PEG-induced water stress. In first experiment germination percentage, promptness index and germination stress tolerance index for all maize hybrids decreased with increasing artificial imposed water stress by PEG-6000. In second experiment on the basis of ranking the RLSI, PHSI and DMSI was observed in all maize hybrids. In both experiments the two maize hybrids 6525 and 32B33 showed that these are most tolerant against drought than all others maize hybrids while Hycorn and 31P41 maize hybrid showed that these are most sensitive against drought stress. The variation among hybrids for germination stress index (GSI) was found to be a reliable indicator of drought tolerance in maize.

Keyword: Polyethyleneglycol-6000 (PEG-6000), Water stress, Physiological indices, Maize

INTRODUCTION

The water and nutrients are the most important factors which are essential for the growth of plant and ultimately enhanced the yield of crops. Water is basic requirement for all the growth stages of plant and it also limited in some area such as arid and semi-arid region of the world. Water is required for plant for its growth and development. Without water the plant goes under drought condition and severally affects its growth stages and ultimately yield of crops is reduced. The most important stage of crop is seed germination in the presence of water [1] and the growing of seed under drought condition, it effect the seedling growth of plant [2]. The polyethylene glycol (PEG) having high molecular weight and important for controlling germination of seed by creating osmotic stress in plants. The PEG inhibits the seed germination by creating stress in plants [3, 4, and 5]. Several physiological characteristics have been reported as being reliable indicators for the selection of germplasm possessing drought tolerance. These characteristics include seed germination and seedling growth in nutrient solutions with low osmotic potential [6, 7, 8, 9, 10, and 11]. The success of these approaches requires evidence that the drought tolerance of cultivars tested under laboratory and greenhouse conditions also reflects this character under field conditions [12]. Maize is an important cereal crop grown all over the world [13]. Also, it is a stable food and commercial crop [14] which is sensitive to

drought [15]. Seed germination and seedling emergence and establishment are most important stages of plant life cycle for plant growth and its survival [16]. Germination is regulated by duration of wetting and the amount of moisture in the growth medium [17, 18]. The seed germination and its growth were limited under water deficit condition [19]. Water stress not only affects seed germination but also increases mean germination time in maize plants [20]. The water stress effect the plant growth and development especially at germination and seedling stages of growth of different crops such as corn [21, 22, 23, 24 and 25].

The aim of this study was to investigate the effects of osmotic stress generated by PEG-6000 on germination stage and water stress at seedling growth of maize hybrids. The primary objective of the present study was to screen out the most tolerant and most sensitive maize hybrids under drought stress.

MATERIAL AND METHODS

Two experiments (lab and wire house) were carried out at Stress Physiology Laboratory, Department of Agronomy, University of Agriculture Faisalabad, Pakistan. Eight maize (*Zea mays* L.) hybrids viz., 7386, 6525, 3672, 9696, Hycorn, 32B33, MMRI hybrid and 31P41 that are widely grown in the region were tested the under artificial imposing drought stress by PEG-6000 and under water stress applied after seedling

emergence. The drought stress imposed by PEG was checked at germination stage of maize while water stress at seedling growth stage was investigated in a laboratory experiment ($25\pm 3^{\circ}\text{C}$). In first experiment PEG with a molecular weight of 6000 (PEG-6000) was used as a drought stimulator and five water stress levels of zero (control), -0.2 MPa, -0.4 MPa, -0.6 MPa and -0.8 MPa were developed by dissolving 10, 20, 30, and 40 g of PEG per 50 mL distilled water. Ten seeds of each maize hybrid were planted in each petri plate containing filter papers. But in second experiment was conducted in pot and water stress applied after seedling emergence by using sand as media. In each pot 500g sand is added and five seed in each pot was sown. Both experiments were laid out in a completely randomized design with 3 replicates for each experimental unit. In first experiment ten mL of designated treatment solution was applied on daily basis in each and every petri dish after thoroughly washing and draining out the previous left solution. 14 DAS (Days after sowing) the number of germinated seeds was manually counted on each day. A seed was considered to be germinated when the emergence of both axis (plumule and radicle) had become visible to the range of 5 mm. The germination percentage, Promptness index (PI), germination stress tolerance index (GSI) were calculated using the following formulae given by Ashraf *et al* [26].

i. $P.I = nd_2 (1.00) + nd_4 (0.75) + nd_6 (0.5) + nd_8 (0.25)$ where n is the number of seeds germinated at day (George, 1967)

ii. $G.S.I. (\%) = [P.I \text{ of stressed seeds} / P.I \text{ control seeds}] \times 100$

While in second experiment the fresh and dry weights of root and shoot length were recorded after 25 days of germination at seedling stage when plant leaf are start wilting. Plant dry weights were recorded after drying at 70°C to a constant weight. From these measurements the plant height stress tolerance index (PHSI), root length stress tolerance index (RLSI) and dry matter stress tolerance index (DMSI) were calculated using the following formulae given by Ashraf *et al*. [26].

i. $PHSI = (\text{Plant height of stressed plant} / \text{Plant height of control plants}) \times 100$

ii. $RLSI = (\text{Root length stressed plant} / \text{Root length of control plants}) \times 100$

iii. $DMSI = (\text{Dry matter of stressed plant} / \text{Dry matter of control plants}) \times 100$

The data so collected was analyzed statistically using analysis of variance technique and the STATISTICA Computer Program was used for this purpose.

RESULT AND DISCUSSION

RESULTS

The data regarding, the germination percentage showed that the different levels of PEG-6000 such as control, -0.2 MPa, -0.4 MPa, -0.6 MPa and -0.8 MPa significantly ($P \leq 0.01$) effect on the germination of maize hybrids (7386, 6525, 3672, 9696, Hycorn, 32B33, MMRI hybrid and 31P41). The value of germination was same recorded in all maize hybrids in the control treatment (Fig. 1) and showed that the all maize hybrids were non-significant in control treatment. While in treatment where water stress applied @ -0.6 MPa showed that the two maize hybrids such as 6525 (3%) and 32B33 (2%) gave maximum germination and tolerant against artificial induced water stress (Fig. 1).

The data regarding, the promptness index showed that the different levels of PEG-6000 such as control, -0.2 MPa, -0.4 MPa, -0.6 MPa and -0.8 MPa significantly ($P \leq 0.01$) effect on the promptness index of maize hybrids (7386, 6525, 3672, 9696, Hycorn, 32B33, MMRI hybrid and 31P41). We calculate the most sensitive and most tolerant maize hybrids by using promptness index. The recorded showed that the promptness index of two maize hybrids Hycorn (5%) and 31P41 (5%) performed better than others in control treatment where only distil water was applied and these are most sensitive hybrids as show in Fig. 2. While the two maize hybrids 6525 (1.5%) and 32B33 (1.75%) gave maximum promptness index and performed better than all others maize hybrids where treatment applied @ -0.6 MPa and also showed that the these maize hybrids are most tolerant presented in Fig. 2

The water stress induced by the PEG-6000 showed that the germination stress index (GSI) decreased with the increased concentration of water stress. The data regarding, the GSI showed that the different levels of water stress induced by the PEG-6000 such as control (distil water), -0.2 MPa, -0.4 MPa, -0.6 MPa and -0.8 MPa significantly ($P \leq 0.01$) effect on the GSI of maize hybrids (7386, 6525, 3672, 9696, Hycorn, 32B33, MMRI hybrid and 31P41). The recorded data showed that the GSI of two maize hybrids Hycorn and 31P41 performed better than all others maize hybrids in control treatment where only distil water was applied and these are most sensitive hybrids as show in Fig. 3. While the two maize hybrids 6525 and 32B33 gave maximum GSI and performed better than all others maize hybrids where treatment was applied @ -0.6 MPa and also showed that these maize hybrids are most tolerant presented in Fig. 3.

In the second experiment the physiological indices such as plant height stress index (PHSI), root length stress index (RLSI) and dry matter stress index (DMSI) were calculated from all maize hybrids (7386, 6525, 3672, 9696, Hycorn, 32B33 MMRI hybrid and 31P41). The data recorded showed that the maximum value of PHSI, RLSI and DMSI was observed in two maize hybrids such as 33B33 (109.28, 122.51 and 106.33) and 6525 (102.84, 121.06 and 105.93) which are statically at par (Table 1). While the minimum value of PHSI, RLSI and DMSI was observed in two maize hybrids such as 31P41 (79.63, 83.79 and 64.20) and Hycorn (90.98, 87.84 and 78.93) presented in Table 1. The two maize hybrids 32B33 and 6525 showed that these are most tolerant against drought than all others maize hybrids while maize hybrids such as Hycorn and 31P41 showed that these are most sensitive against drought stress.

DISCUSSION

Polyethylene glycol (PEG) is an important which is responsible for creating water stress in plants and act as simulant [27]. In this current study the PEG-6000 was used for creating osmotic stress in plants. The most of the researchers used it in lab experiment for creating artificial drought and check the response of plant [28, 29].

The study regarding the effect of water stress created by PEG-6000 indicated that germination percentage; promptness and germination stress indices (GSI) were limited by enhancing the levels of PEG-6000. The germination stress tolerance index of different maize hybrids were also affected by increasing

concentration of PEG-6000. However 6525 and 3672 maize hybrid performed better than others. Many reports indicated that GSI can be utilized as screening criteria for stress tolerance. However, many are of the view that germination criteria did not seem to reflect stress tolerance in different plants, but rather to indicate seed quality differences, nor did this procedure reflect the yield stability of genotypes [27]. This agreed with the results of Khayatnezhad *et al.* [23], Khodarahmpour [25] and Mostafavi *et al.* [24]. According to Ayaz *et al.* [30], the germination of the seed was limited under water deficit condition. The seed germination was also limited due to the imbibition of seed with water because the see not absorbed water [31].

The results of present study showed that the PHSI and DMSI are non-significantly affected but RLSI significantly effected under drought stress. Ranking showed that the two maize hybrids such as 6525 and 3672 were performed better than all others maize hybrids. Water stress acts by decreasing the percent and rate of germination and seedling growth [22, 23]. There are reports in the literature of potential drought resistance traits like extensive viable radicle system that could explore deeper soil layers for water [32, 33]. Maize plants with more radicles at seedling stage subsequently developed stronger radicle system, produce more green matter and had higher values for most characters determining seed yield [33].

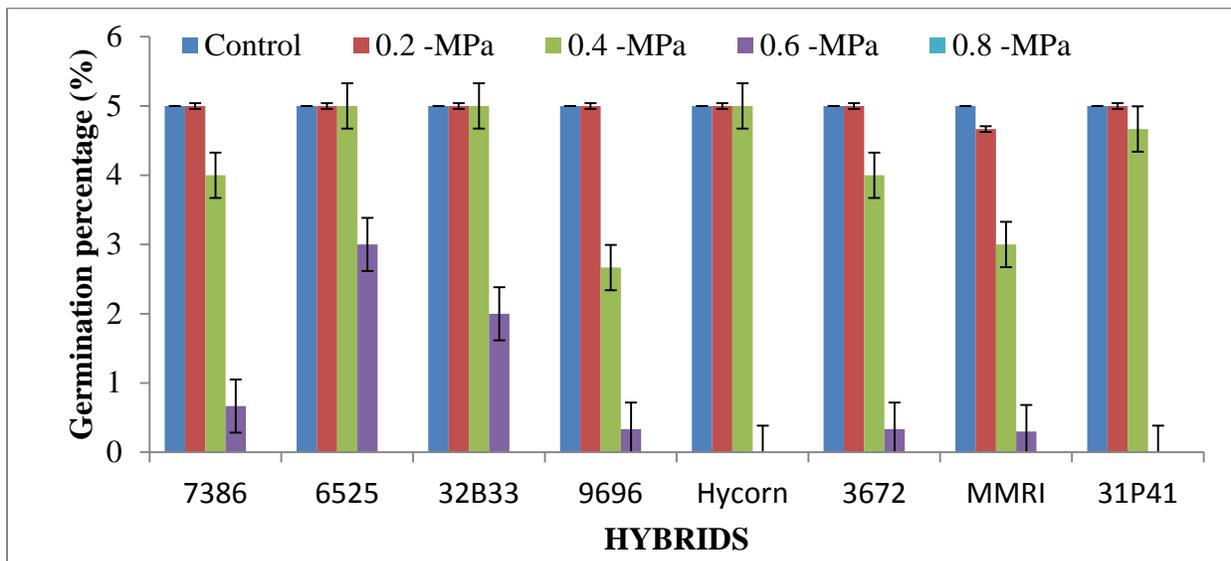


Fig. 1: Germination percentage (%) of eight maize hybrids subjected to PEG-6000 induced osmotic stress (-MPa)

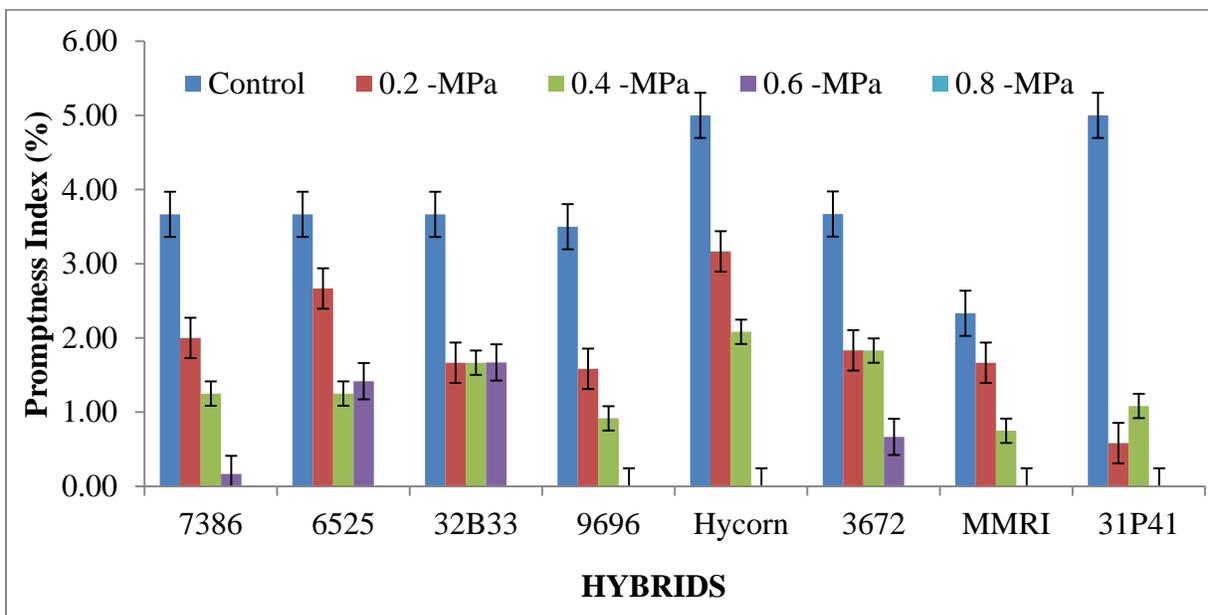


Fig. 2: Promptness index (%) of eight maize cultivars subjected to PEG-6000 induced osmotic stress (-MPa)

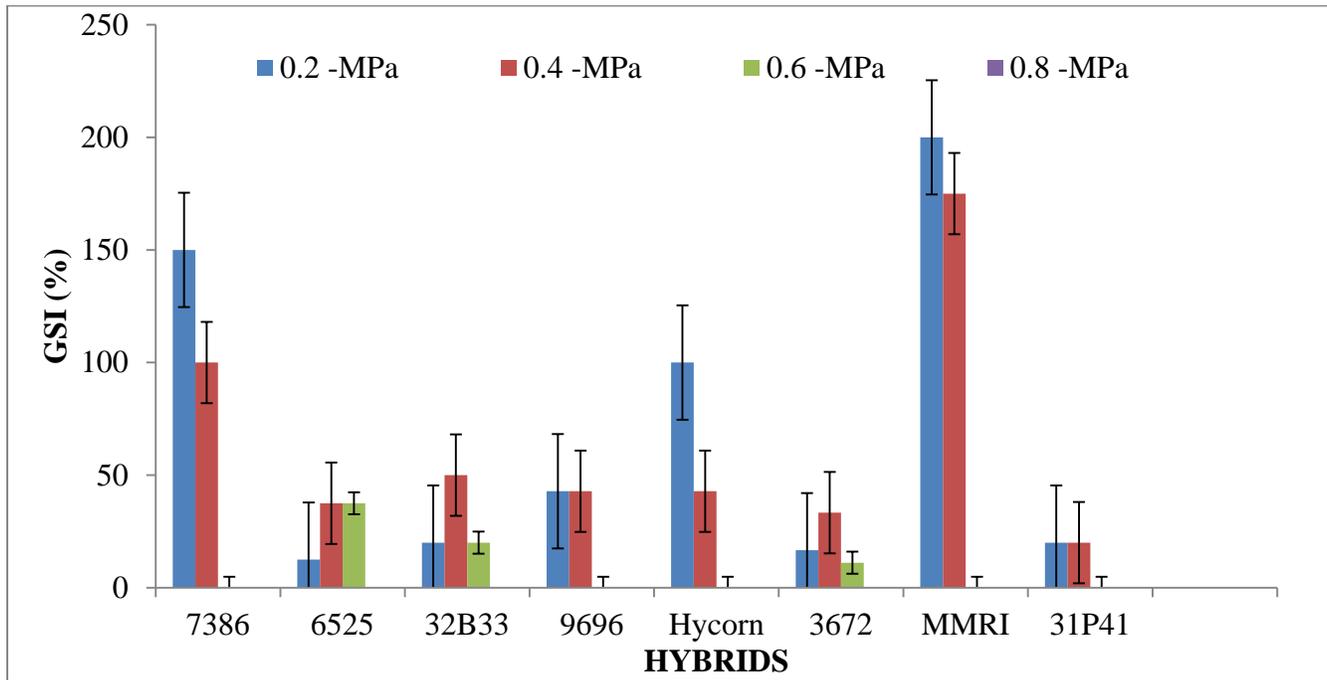


Fig. 3: Germination stress index (%) of eight maize hybrids subjected to PEG-6000 induced osmotic stress (-MPa)

Table No. 1: Effect of water stress on plant height stress index, root length stress index and dry matter stress index of maize

Varieties	Physiological Indices					
	PHSI	Ranking	RLSI	Ranking	DMSI	Ranking
7386	97.89 ab	4	88.74 b	6	102.78 a	3
6525	102.84 ab	2	121.06 a	2	105.93 a	2
32B33	109.28 a	1	122.51 a	1	106.33 a	1
9696	100.30 ab	3	96.78 ab	5	83.57 a	6
Hycorn	90.98 ab	7	87.84 b	7	78.93 a	7
3672	91.36 b	6	110.83 ab	3	86.54 a	4
MMRI	94.29 ab	5	109.84 ab	4	84.81 a	5
31P41	79.63 b	8	83.79 b	8	64.20 a	8

CONCLUSION

Keeping in view the above stated research finding it can be concluded that the two maize hybrids 6525 and 32B33 are the best performing under drought conditions and hence can be declared drought tolerant and Hycorn and 31P41 hybrids of maize are called the most drought sensitive. It was also revealed that variation among hybrids for germination stress index (GSI) was found to be a reliable indicator of drought tolerance in maize and here in lies the novelty of this research.

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