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RESEARCH PAPER

Efficacy of polyethylene glycol (PEG) induced drought on germination indices and photosynthetic pigments of sweet corn var. NSC-901B

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Germination of seed is considered as the first and most fundamental stage of a plant life cycle so that, the achievement in growth and yield production also depends on this stage. Drought stress is one of the most important environmental factors that limit the growth, development and production of plants. The influence of drought stress (0, -.6, -1.2 and -1.8 bar) by polyethylene glycol (PEG) 6000 on seed germination indices and photosynthetic pigments in sweet corn was examined under laboratory conditions with triplicates. Results indicated that drought stress significantly reduced germination per cent (76%), radicle length (71%), plumule length (65%), radicle fresh weight (76%), plumule fresh weight (68%), radicle dry weight (78%), plumule dry weight (56%), chlorophyll a (67%), chlorophyll b (75%), total chlorophyll (69%) and carotenoids (72%). Overall, drought stress had a negative effect on all the parameters.

Key words : Drought stress, PEG, Photosynthetic pigments, Seed germination, Seedling growth

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INTRODUCTION

Germination is a crucial step in the life cycle of plants, particularly in arid and semi-arid areas. The success of natural propagation mainly depends on the response of seed germination to a number of external factors (Krichen *et al.*, 2014). Seed germination, seedling emergence and seed establishment are the key processes in the survival and growth of plants (Hadas, 2004). Drought stress impairs the plant growth, development and productivity, especially in arid and semi-arid regions (Galle *et al.*, 2007). Seed germination and early seedling growth are the most critical stages of water stress (Ahmad *et al.*, 2009). Corn is one of the most important crop grown all over the world (Farhad *et al.*, 2009). Also, it is a staple and commercial crop as well (Tri-da *et al.*, 2006). Sweet corn is a variety of maize having very high sugar content. It also considered a powerhouse of antioxidants, rich source of beta-carotene, high vitamin and protein content, lycopene, bioflavonoids, omega 3 fatty acids shows tremendous health benefits. The present study was conducted to investigate the influence of PEG-induced drought stress on the germination indices of sweet corn (*Zea mays* L.).

RESEARCH METHODOLOGY

Seeds of sweet corn (*Zea mays* L.) var. NSC-901B were obtained from National Seed Centre, IARI, New

Delhi. Germination assays were performed at plant physiology Laboratory, Kurukshetra University, Kurukshetra by evenly distributing the seeds of sweet corn NSC-1901B in a 10-cm diameter sterile Petri dish with two layers of filter paper (Whatman No. 2) saturated with 10 ml of a treatment solution. PEG at different concentration was used to establish different osmotic potential: 0, 10, 20, and 30 g of PEG per 100 ml distilled water to generate three osmotic stress levels (0, -0.6, -1.2 and -1.8 bar, respectively). Broken, small and infected seeds were eliminated. Seeds were then sterilized with sodium hypochlorite (1%) and soaked in a 98 per cent sulfuric acid solution for10 minutes to break physical dormancy followed by washing with distilled water. Three replicates of 10 seeds of each osmotic potential were used to assess the germination percentage. The dishes were placed in a germinator at 25 °C/10 °C and a relative humidity of 60 per cent. When radical length reached 2 mm then seeds were considered germinated.

Germination indices :

After 10 days, germination per cent was measured by international seed testing association (ISTA) standard method. At the end of the tenth day, the germination per cent [(Germinated seed number/Test seed number) ×100%], length of radicle and plumule of seeds, fresh and dry matter weight of radicle and plumule and seed vigour index (SVI) was also measured. Seedling vigour index (SVI) was calculated by (Abdul-Baki and Anderson, 1970).

$$\text{Seed vigor index (SVI)} = \frac{\text{Germination \% x Seedling length}}{100}$$

Chlorophyll and carotenoid estimation:

Chlorophyll and carotenoids from the fresh leaves were extracted in 80 per cent acetone and the absorbance was read spectrophotometrically at 663 and 645 nm on double beam spectrophotometer 2203 systronics for chlorophylls and 480 and 510 nm. for carotenoids. Chlorophyll content was estimated by Arnon (1949) and carotenoid content by the method of Holden (1965).

Statistical analysis :

Data were analyzed to test for significant differences by one-way analysis of variance (ANOVA) using statistical package for social sciences (SPSS) version 16.0.

RESEARCH FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Germination per cent :

Germination was significantly affected by the drought stress. As shown in Table 1, an increase in PEG stress markedly decreased the germination percentage of sweet corn. A significant decline in the germination percentage was recorded at 20 per cent and 30 per cent PEG. The germination percentage at the 10 per cent, 20 per cent and 30 per cent PEG concentrations was 55 per cent, 21 per cent and 8 per cent, respectively.

Radicle and plumule length :

The radicle and plumule length decreased with increasing PEG concentration, with the greatest reductions occurring under the highest water stresses (Table 1). Radicle length decreased by 12 per cent, 32 per cent and 71 per cent at 10 per cent, 20 per cent and 30 per cent PEG, respectively over control. While plumule length decreased by 8 per cent, 26 per cent and 65 per

Table 1 : Effect of PEG (6000) on germination, radical length, plumule length, radical fresh weight, plumule fresh weight, radical dry weight, plumule dry weight and seed vigour index on sweet corn var. NSC-901B

Drought level (bar)	Germination %	Radicle length	Plumule length	Radicle fresh weight	Plumule fresh weight	Radicle dry weight	Plumule dry weight	Seed vigour index
0	84±0.45[a]	6.90±0.13[d]	5.40±0.25[a]	2.11±0.12[a]	1.76±0.14[b]	0.189±0.028[a]	0.208±0.034[a]	10.33±0.24[a]
-0.6	55±0.39[b]	5.97±0.16[c]	4.96±0.16[b]	1.73±0.08[b]	1.51±0.17[b]	0.160±0.021[b]	0.183±0.030[b]	06.01±0.29[b]
-1.2	21±0.41[c]	4.59±0.09[b]	3.99±0.09[c]	1.30±0.05[c]	1.19±0.09[c]	0.115±0.016[c]	0.139±0.019[c]	01.80±0.12[c]
-1.6	08±0.21[d]	1.90±0.11[a]	1.84±0.11[d]	0.54±0.04[d]	0.59±0.04[d]	0.068±0.010[d]	0.091±0.016[d]	00.30±0.08[d]
ANOVA $F_{(3,8)}$	37513.35	1971.03	434.72	2374.93	1998.77	867.24	3336.60	15081.27

Each value is mean of three replications (single replicate = single pot with three plants) ± standard error, P<0.05

cent at 10 per cent, 20 per cent and 30 per cent PEG, respectively than their control.

Radicle and plumule fresh weight :

Both radicle and plumule fresh weight decreased linearly with increased PEG concentration but radicle fresh weight was found to be more affected than plumule fresh weight (Table 1).

Drought decreased radical fresh weight by 18 per cent, 38 per cent and 76 per cent and plumule length by 14 per cent, 32 per cent and 68 per cent at 10 per cent, 20 per cent and 30 per cent PEG, respectively compared to their controls.

Radical and plumule dry weight :

Radicle and plumule dry weight decreased with increasing PEG concentration, the effects were much more pronounced under high PEG concentration (Table 1). Radicle and plumule dry weight decreased by 15 per cent, 39 per cent, 78 per cent and 12 per cent, 23 per cent, 56 per cent at 10 per cent, 20 per cent and 30 per cent PEG, respectively corresponding to their controls.

Seed vigour index:

Seed vigour index of sweet corn seedlings decreased with increasing PEG concentrations. Reduction in seed vigor was expected because the seedling length and germination per cent were decreased by salinity stress.

Photosynthetic pigments:

The results showed that as the PEG concentration was increased photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content) decreased (Table 2). Higher concentration of PEG (30%) exerted the maximum effect. Different PEG concentrations (10%, 20% and 30%) decreased chlorophyll a (16%, 40 and 67), chlorophyll b (25%, 27% and 75%), total chlorophyll (19%, 46% and 69%) and carotenoids (43%, 55% and 73%).

Seed germination and early seedling growth are crucial stages for plant establishment, growth and production (Li *et al*., 2011) and plants are more sensitive to drought during these stages. Drought is responsible for the decline in productivity of sweet corn in many areas of the world. Sweet corn is very sensitive to drought stress during seed germination and early seedling growth. In this experiment, we observed the effect of PEG-induced drought stress on germination indices and photosynthetic pigment of sweet corn. The germination rate of sweet corn declined obviously under drought stress.

Our results regarding the decrease in germination rate are consistent with Siahsar *et al*. (2010). Who reported that high concentrations of PEG reduce the final germination percentages of lentil. Ahmad *et al*. (2009) also reported that drought has an inhibitory effect on the seed germination sunflower. It seems that reduction in germination percentage is associated with the decrease in water absorption into the seeds (Hadas, 1977).

In the present study, seedling growth was found to be maximum in un-stressed condition and minimum in high water stress. Thus, as the water stress increased seedling growth was decreased. Similar observations were made by Nejad (2011) who reported that major parameters in drought conditions such as root length, number, decreased under water stress. Reduction in seedling growth was also reported in *Pisum sativum* (Gamze *et al*.,2005) and *Sesamum indicum* (Keshavarzi, 2012) by PEG-induced drought stress.

Photosynthetic pigments (chlorophyll a, chlorophyll b, total chlorophyll and carotenoids) under PEG-induced drought stress were less than the control, each parameter decreased gradually with increasing PEG concentration. Under drought stress, photosynthetic pigments decreased slightly at first but then decreased more sharply at the higher PEG concentration (Liu *et al.*, 2007 and Ashraf, 2010).

Table 2 : Effect of PEG (6000) chlorophyll a, chlorophyll b, total chlorophyll and carotenoids on sweet corn var. NSC-901B

Drought level (bar)	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoids
0	0.144 ± 0.08^{a}	0.068 ± 0.04^{a}	$0..212 \pm 0.025^{a}$	1.51 ± 0.130^{a}
-0.6	0.121 ± 0.07^{b}	0.051 ± 0.02^{b}	$0..172 \pm 0.018^{b}$	1.06 ± 0.080^{b}
-1.2	0.086 ± 0.05^{c}	0.029 ± 0.02^{c}	0.115 ± 0.028^{c}	0.68 ± 0.063^{c}
-1.6	0.048 ± 0.02^{d}	0.017 ± 0.02^{d}	0.065 ± 0.011^{d}	0.41 ± 0.031^{d}
ANOVA $F_{(3,8)}$	530.03	1266.68	722.62	974.81

Each value is mean of three replications (single replicate = single pot with three plants) ± standard error, $P<0.05$

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