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Germination Behaviour of BARI Gom 27 (*Triticum aestivum*) as Influenced by PEG-Induced Drought Stress

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Abstract: Drought is the natural stress in Bangladesh that influence on germination failure of wheat seed. But pre-sowing seed treated with Polyethylene Glycol (PEG) helps to enhance the germination behavior of seed. So, a lab experiment was conducted to find out the effect of different levels of drought stress on germination behaviour of BARI Gom 27. Non primed and primed seeds (osmoprimed and hydroprimed) were germinated under 0, 5, 10, 15 and 20% PEG solution induced drought stress conditions. Results showed that wheat seeds primed with 10% PEG and distilled water enhanced germination behavior and seedling growth over nonprimed seeds. The drought tolerant capability of nonprimed and hydroprimed seeds decreased drastically as drought stress increased, but osmoprimed seeds showed considerable tolerance capability upto stress level induced by 10% PEG then significantly decreased with increasing drought stress. Seeds pre-soaked with 10% PEG and distilled water showed better performance in terms of germination behavior and seedling growth compared to untreated control under drought stress. Therefore, seed priming helps to enhance the germination behavior of wheat seed.

Key words: Drought stress · Germination · Wheat · Polyethylene glycol

INTRODUCTION

Plants create some defense mechanism on itself during the stress condition as a result yield of crops reduce but helps to increase the seed quality [1]. Though stress has this positive impact on seed, but it is not good for seed germination especially for drought stress. And for this reason seed priming is considered as a promising approach to increase stress tolerance capacity of crop plants including drought. Seed priming is the induction of a particular physiological state in plants by the treatment of natural and synthetic compounds to the seeds before germination. The physiological state in which plants are able to faster or better activate defense responses or both is called the primed state of the plant [2]. Seed priming can be accomplished through different methods such as hydro-priming (soaking in DW), osmo-priming (soaking in osmotic solutions such as PEG, potassium salts, e.g., KCl, K_2SO_4) and plant growth inducers (CCC, Ethephon, IAA) [3-6].

Seed priming is also widely used to synchronize the germination of individual seeds [7]. Seed-priming technology has twofold benefits: enhanced, rapid and uniform emergence, with high vigor and better yields in vegetables and floriculture [8] and some field crops [9,10]. According to McDonald [11], primed seeds acquire the potential to rapidly imbibe and revive the seed metabolism thus enhancing the germination rate.

In many crops, seed germination and early seedling growth are the most sensitive stages of water limitation and the water deficit may delay the onset and reduce the rate and uniformity of germination, leading to poor crop performance and yield [12]. Therefore, the beneficial effects of priming may be more evident under unfavorable rather than favorable conditions [13]. Primed seeds usually exhibit an increased germination rate, greater germination uniformity and at times, greater total germination percentage [9]. These attributes have practical agronomic implications, notably under adverse germination conditions [11]. Therefore, there is a strong

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interest in the seed industry to find suitable priming agent(s) that might be used to increase the tolerance of plants under adverse field conditions [14].

MATERIALS AND METHODS

The experiment was conducted under the laboratory condition of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka from August 2013 to February 2014. Temperature range of the laboratory during the experiment was 26.2°C-33.4 °C and the relative humidity was 56-84%.

In this research work, seeds of the wheat variety BARI Gom 27 was collected from Bangladesh Agricultural Research Institute (BARI) were used as planting material. Different priming chemicals such as PEG and distilled water were utilized for osmo and hydro priming. Different equipments such as growth chamber, electric balance, Petri dish, filter paper, micro pipette etc. were used for this study.

All seeds were surface sterilized with 2% Safex solution for 5 minutes, then rinsed with sterilized water and air dried at room temperature. After that seeds were used for priming.

All priming media were prepared in distilled water and duration of soaking for hydro and osmopriming were 12 h. After soaking seeds were air dried and placed in Petridish. For each replicate 30 seeds were placed in 12.5 cm Petridish on a layer of filter paper no. 102 moistened with 8 ml of distilled water.

The experiment was conducted in Completely Randomized Design (CRD) with five replications. The first factor was the three levels of priming *viz.*, Non primed seed (dry seed) (T_0), Hydro prime for 12 h (T_W) and Prime with 10% PEG (osmo prime) for 12 h (T_P); second factor was the five levels of drought stress *viz.*, only water (P_0), 5% PEG solution (P_5), 10% PEG solution (P_{10}), 15% PEG solution (P_{15}) and 20% PEG solution (P_{20}). After that data collected on various parameters and mean data of germination percentage, plumule length, radical length, seedling length, vigour index, germination index and seedling dry weight were recorded and analyzed using statistical computer software MSTAT-C and mean were separated using least significance difference (LSD) at 5% level of probability.

RESULT AND DISCUSSION

Effect on Germination Percentage: Germination percentage of primed (hydroprimed and osmoprimed) and non primed wheat seed was influenced by different levels of drought stress (Figure 1). There was a significant difference between well watered and different level of drought stress levels. Germination percentage (GP) of osmoprimed and hydroprimed seeds was higher compared to nonprimed seeds at well watered and various levels of stress whereas osmoprimed seed gave best result. Germination percentage (GP) of nonprimed and hydroprimed seedsdecreases drastically as drought stress increases but osmoprimed seeds showed tolerance capacity upto stress level induced by 10% PEG then significantly decreased with increasing drought stress. The highest GP of osmo, hydro and non primed seeds were 85.55%, 84.44% and 65.55%, respectively in well watered condition. Whereas in drought stress level created by 10% PEG, GP of osmo, hydro and non primed seeds were 4.05%, 52.01% and 118.52% lower in respect of well watered condition, respectively.

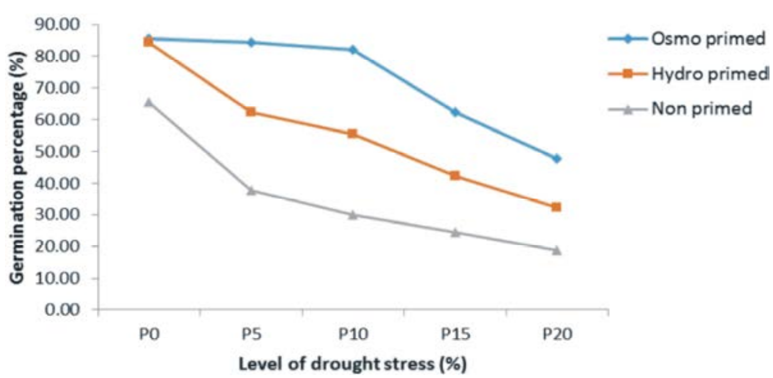

Fig. 1: Effect of different levels of drought stress on germination percentage of primed and non primed seeds ($LSD_{0.05}$ = 1.985, 3.797, 4.135)

Note: P_0: only water, P_5: 5% PEG solution, P_{10}: 10% PEG solution, P_{15}: 15% PEG solution, P_{20}: 20% PEG solution

Similar results were also represented by Yağmur and Kaydan [15], Abbasdokht *et al.* [16], Janmohammadi *et al.* [17], Zamirifar and Bakhtiari [18], Moghanibashi *et al.* [19], Moghanibashi *et al.* [20], Rouhi *et al.* [21], Razaji *et al.* [22], Ghiyasi and Tajbakhsh, [23], Sun *et al.* [24], Mohammadi and Amiri [25], Chen and Arora [26]. Osmopriming with PEG results in strengthening the antioxidant system and increasing the seed germination potential, finally resulting in an increased stress tolerance in germinating seeds of spinach [26]. Despite the negative effects of stress condition, the priming treatment was effective in improving germination percentage in Presto [15] and in *Nigella sativa* [18]. Hydroprimed seeds achieved maximum germination especially during the higher osmotic potentials compared to untreated seeds [16] and significantly improved germination under both stress and non-stress conditions [17]. Rouhi *et al.* [21] mentioned that germination of Tall Wheatgrass was delayed by drought stress simulated by PEG inprimed and nonprimed seeds. Osmopriming increased germination parameters under drought stress rather than hydropriming especially at lowest osmotic potentials. Razaji *et al.* [22] concluded that priming resulted improvement in germination components and enzymes activity of rapeseed on drought stress condition and boost the resistance of rapeseed to drought stress condition. Compared to hydro-priming, priming with PEG in a proper concentration had a better effect on seed germination under drought stress although such effects had limited capability and severe drought stress inhibited germination [24].

Effect on Plumule Length (mm): Plumule length (mm) of primed (hydroprime and osmoprime) and non primed wheat seed was influenced by different levels of drought stress (Fig. 2). Significant difference was observed between well watered and different drought stress levels. Plumule length of nonprimed seedsdecreases drastically as drought stress increases but osmoprimed and hydroprimed seeds showed tolerance capability upto stress level induced by 10% PEG then significantly decreased with increasing drought stress. The highest plumule length of osmo, hydro and non primed seeds were 94.67 mm, 90.67 mm and 70.33 mm, respectively in well watered condition. Whereas in drought stress level created by 10% PEG, plumule length of osmo, hydro and non primed seeds were 9.23%, 30.14% and 283.63% lower in respect of well watered condition, respectively.

The result of the present study corroborates with those obtained by Moghanibashi *et al.* [20] and Mohammadi and Amiri [25]. Mohammadi and Amiri [25] also reported that plumule length was reduced when drought stress level was increased. As drought and/or salinity levels increased, shoot length reduces but the priming treatments clearly improved the parameter under drought and salinity conditions so can be used to improve seed performance of sunflower under normal and stress conditions [20].

Effect on Radical Length (mm): Radical length (mm) of primed (hydroprime and osmoprime) and non primed wheat seed was influenced by different

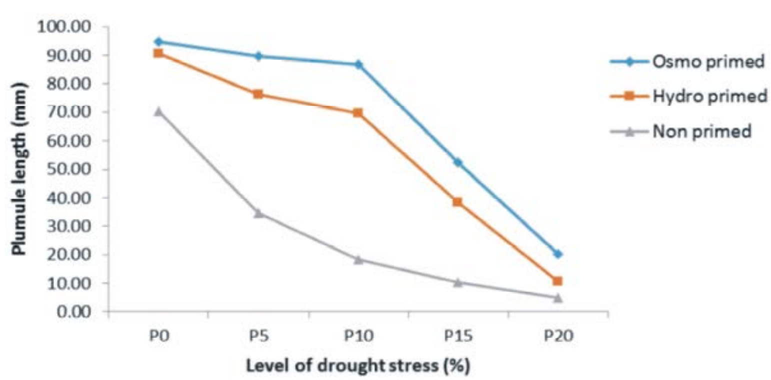

Fig. 2: Effect of different levels of drought stress on plumule length of primed and non primed seeds ($LSD_{0.05}$ = 1.191, 1.518, 1.354)

Note: P_0: only water, P_5: 5% PEG solution, P_{10}: 10% PEG solution, P_{15}: 15% PEG solution, P_{20}: 20% PEG solution

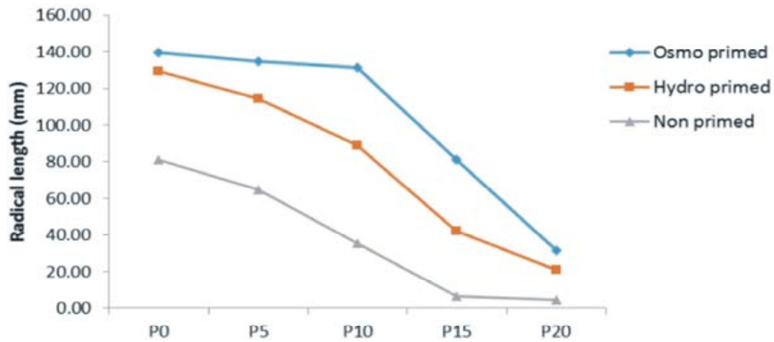

Fig. 3: Effect of different levels of drought stress on radical length of primed and non primed seeds ($LSD_{0.05}$ = 1.975, 1.141,1.479)

Note: P_0: only water, P_5: 5% PEG solution, P_{10}: 10% PEG solution, P_{15}: 15% PEG solution, P_{20}: 20% PEG solution

levels of drought stress (Fig.3). There was a significant difference was observed between well watered and different drought stress levels. Radical length of osmoprimed and hydroprimed seeds was higher compared to nonprimed seeds at well watered and various levels of stress whereas osmoprimed seed gave best result. Radical length of nonprimed seedsdecreases drastically as drought stress increases but osmoprimed seeds showed a considerable tolerance capability upto stress level induced by 10% PEG then significantly decreased with increasing drought stress. The highest radical length of osmo, hydro and non primed seeds were 139.67 mm, 129.67 mm and 81.33 mm, respectively which were obtained from well watered condition. Whereas in drought stress level created by 10% PEG, radical length of osmo, hydro and non primed seeds were 6.35%, 46.24% and 130.19% lower in respect of well watered condition, respectively.

This trend of the present results are in agreeemt with those obtained by Moghanibashi *et al.* [20], Mohammadi and Amiri [25]. Moghanibashi *et al.* [20] also reported that as drought and/or salinity levels increased, root length reduced but the priming treatments clearly improved the parameter of sunflower under normal and stress conditions. Mohammadi and Amiri [20] mentioned that radicle length was reduced when drought stress level was increased from 0 to 1.5 MPa.

Effect on Seedling Length (mm): Seedling length (mm) of primed (hydroprime and osmoprime) and non primed wheat seed was influenced by different levels of drought stress (Fig. 4). There was a significant difference observed between well watered and different drought stress levels. Seedling length of nonprimed seedsdecreases drastically as drought stress increases but osmoprimed and hydroprimed seeds showed a considerable tolerance capability upto stress level induced by 10% PEG then significantly decreased with increasing drought stress. The highest seedling length of osmo, hydro and non primed seeds were 234.33 mm, 220.33 mm and 151.67 mm, respectively which were obtained from well watered condition. Whereas in drought stress level created by

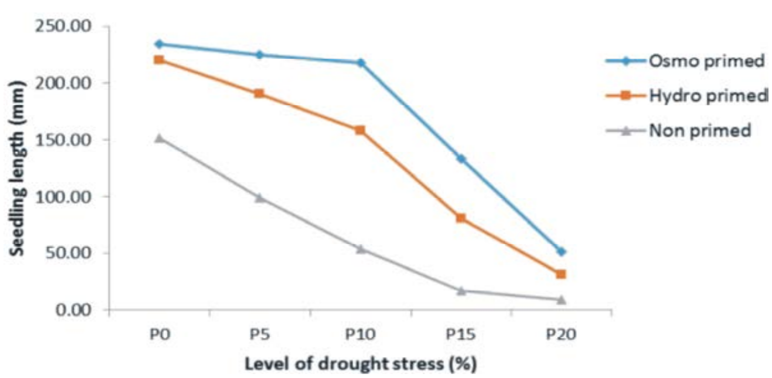

Fig. 4: Effect of different levels of drought stress on seedling length of primed and non primed seeds ($LSD_{0.05}$ = 1.899, 1.594, 2.344)

Note: P_0: only water, P_5: 5% PEG solution, P_{10}: 10% PEG solution, P_{15}: 15% PEG solution, P_{20}: 20% PEG solution

10% PEG, seedling length of osmo, hydro and non primed seeds were 7.49%, 39.16% and 182.61% lower in respect of well watered condition, respectively.

This result of the study is consistent with the findings of Yağmur and Kaydan [15], Kayaa *et al.* [27], Janmohammadi *et al.* [17], Ghiyasi and Tajbakhsh [23], Razaji *et al.* [22] and Sun *et al.* [24]. Hydropriming significantly improved length of seedling under both stress and non-stress conditions [17, 27]. Ghiyasi and Tajbakhsh [23] mentioned that inhibition of seedling growth due to drought stress should be overcome by using PEG 6000 as osmopriming agent in soybean. Razaji *et al.* [22] observed that increasing in drought stress catalase activity (CAT), peroxidase activity (POX) and Proline content increased as compared to control and concluded that priming resulted improvement in seedling growth and enzymes activity of rapeseed on drought stress condition and boost the resistance of rapeseed to drought stress condition. Sun *et al.* [24] reported that compared to hydro-priming, priming with PEG in a proper concentration had a better effect on seedling growth under drought stress although such effects had limited capability and severe drought stress inhibited germination and caused damages of rice seedlings

Effect on Vigour Index (VI): Vigour index (VI) of primed (hydroprime and osmoprime) and non primed wheat seed was influenced by different levels of drought stress (Fig. 5). There was a significant difference observed between well watered and different drought stress levels. Vigour index of nonprimed and hydroprimed seeds decreases significantly as drought stress increases but osmoprimed seeds showed a considerable tolerance capability upto certain level. The highest vigour index of osmo, hydro and non primed seeds were 200.47, 186.04 and 99.41, respectively which were obtained from well watered condition. Whereas in drought stress level created by 10% PEG, vigour index of osmo, hydro and non primed seeds were 11.85%, 111.54% and 518.11% lower in respect of well watered condition, respectively.

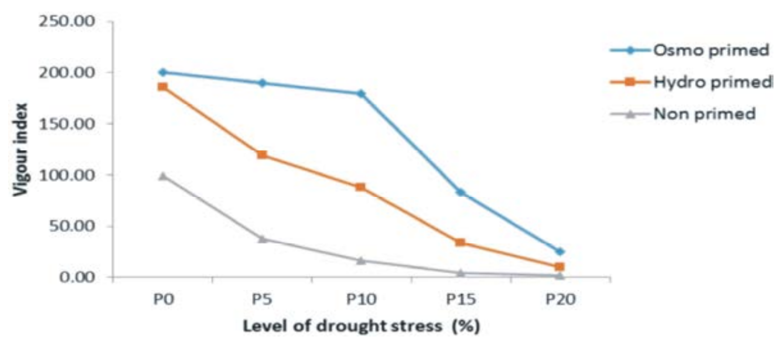

Fig. 5: Effect of different levels of drought stress on vigour index of primed and non primed seeds ($LSD_{0.05}$ = 4.73, 4.727, 3.227)

Note: P_0: only water, P_5: 5% PEG solution, P_{10}: 10% PEG solution, P_{15}: 15% PEG solution, P_{20}: 20% PEG solution

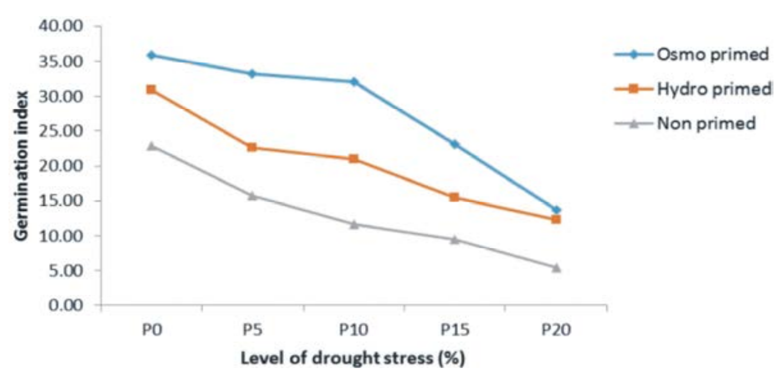

Fig. 6: Effect of different levels of drought stress on germination index of primed and non primed seeds ($LSD_{0.05}$ = 1.647, 0.7921, 1.461)

Note: P_0: only water, P_5: 5% PEG solution, P_{10}: 10% PEG solution, P_{15}: 15% PEG solution, P_{20}: 20% PEG solution

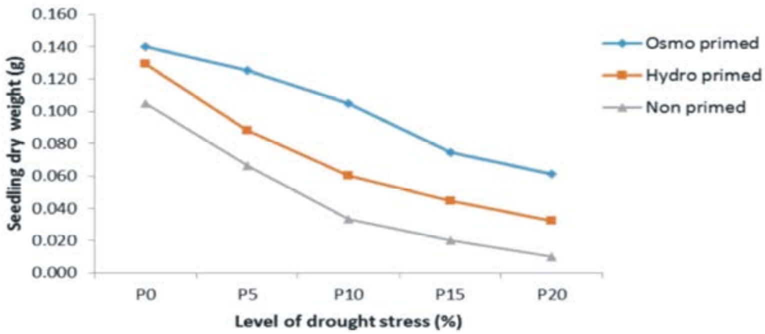

Fig. 7: Effect of different levels of drought stress on radical length of primed and non primed seeds ($LSD_{0.05}$ = 0.0188, 0.0179, 0.0172)

Note: P_0: only water, P_5: 5% PEG solution, P_{10}: 10% PEG solution, P_{15}: 15% PEG solution, P_{20}: 20% PEG solution

This result is in agreement with the findings of Abbasdokht *et al.* [16], Janmohammadi *et al.* [17], Moghanibashi *et al.* [20] and Ghiyasi and Tajbakhsh [23]. Janmohammadi *et al.* [17] reported that hydropriming significantly improved seedling vigour index under both stress and non-stress conditions. As drought and/or salinity levels increased, vigour reduced but the priming treatments clearly improved the parameter under drought and salinity conditions so these treatments can be used to improve seed performance of sunflower under normal and stress conditions [20]. Ghiyasi and Tajbakhsh [23] mentioned that inhibition of seedling vigor index due to drought stress should be overcome by using osmopriming treatments in soybean.

Effect on Germination Index (GI): Germination index (GI) of primed (hydroprime and osmoprime) and non primed wheat seed was influenced by different levels of drought stress (Figure 6). Significant difference was observed between well watered and different drought stress levels. Germination index of osmoprimed and hydroprimed seeds was higher compared to nonprimed seeds at well watered and various levels of stress whereas osmoprimed seed gave best result. Germination index of nonprimed and hydroprimed seeds decreases drastically as drought stress increases but osmoprimed seeds showed tolerance capability upto stress level induced by 10% PEG then significantly decreased with increasing drought stress. The highest germination index of osmo, hydro and non primed seeds were 35.92, 30.89 and 22.92, respectively which were obtained from well watered condition. Whereas in drought stress level created by 10% PEG, germination index of osmo, hydro and non primed seeds were 12.14%, 47.76% and 96.23% lower in respect of well watered condition, respectively.

The result of the present study is also supported by Abbasdokht *et al.* [16], Janmohammadi *et al.* [17], Moghanibashi *et al.* [19] and Ghiyasi and Tajbakhsh [23]. Under high osmotic potentials, hydroprimed seeds hadhigher GI as compared to untreated seeds [16, 17]. Moghanibashi *et al.* [19] reported that as salinity and/or drought level increased, all of these parameters reduced under both conditions. Primed seeds produced higher GI under all salinity and drought levels as compared with non-primed seeds. Inhibition of germination index due to drought stress should be overcome by using osmopriming treatments in soybean [23].

Effect on Seedling Dry Weight (g): Seedling dry weight (g) of primed (hydroprime and osmoprime) and non primed wheat seed was influenced by different levels of drought stress (Figure 7). There was a significant difference observed between well watered and different drought stress levels. Seedling dry weight of osmoprimed and hydroprimed seeds was higher compared to nonprimed seeds at well watered and various levels of stress whereas osmoprimed seed gave best result. Seedling dry weight of nonprimed and hydroprimed seeds decreases drastically as drought stress increases but osmoprimed seeds showed tolerance capability upto stress level induced by 10% PEG then significantly decreased with increasing drought stress.The highest seedling dry weight of osmo, hydro and non primed seeds were 0.140 g, 0.129 g and 0.105 g, respectively which were obtained from well watered condition. Whereas in drought stress level created by 10% PEG, seedling dry weight of osmo, hydro and non primed seeds were 33.50%, 115.19% and 217.10% lower in respect of well watered condition, respectively.

This r esult of the study is consistent with those reported by Abbasdokht *et al.* [16], Moghanibashi *et al.* [20], Ghiyasi and Tajbakhsh [23] and Mohammadi and Amiri [25]. Hydroprimed seeds achieved maximum seedling dry weight especially during the higher osmotic potentials compared to untreated seeds (Abbasdokht *et al.,* 2010) [16]. Ghiyasi and Tajbakhsh [23] mentioned that inhibition of seedling dry weight due to drought stress should be overcome by using PEG 6000 as osmopriming treatments in soybean. Mohammadi and Amiri [23] reported that seedling dry weight was reduced when drought stress level was increased from 0 to 1.5 MPa.

CONCLUSION

The present investigation showed that seed treated with Polyethylene Glycol (PEG) has a positive effect on germination behavior on wheat seed. Non primed and primed seeds (osmoprimed and hydroprimed) were germinated under 0, 5, 10, 15 and 20% PEG solution induced drought stress conditions. Results revealed that all the characters *viz.* germination percentage, plumule length, radical length, seedling length, vigor index, germination index and seedling dry weight was significantly influenced by different stress level. Osmoprimed and hydroprimed seeds gave better result over nonprimed seeds at well watered and at various levels of stress whereas osmoprimed seed gave best result. Results showed that germination behavior and seedling growth of nonprimed and hydroprimed seeds decreased drastically as drought stress increased but osmoprimed seeds showed considerable tolerance capability upto stress level induced by 10% PEG then significantly decreased with increasing drought stress. So, it can be concluded that seed treated with Polyethylene Glycol (PEG) helps to increase the germination behavior on wheat seed.

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