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Effect of Pre-treatment of Barley Grain on Germination and Seedling Growth Under Drought Stress

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Abstract: Seed priming is currently a wide used commercial process that accelerates the germination rate and improves seedling uniformity in several crops. A laboratory study was conducted to evaluate the effect of grain priming treatments on barley grain germination and seedling growth under drought stress imposed by PEG-6000. The experiment was performed employing a factorial completely randomized block design with four levels of drought stress (0,10,20 and 30% PEG6000) and 14 priming treatments (dry, hydropriming, 5, 10, 15% PEG-6000; 500, 1000, 1500 mg/l KNO_3; 25, 50, 75 mg/l thiamin; 50, 100, 150 mg/l sodium metasilicate) with five replications for each treatment. Germination percentage, germination index, energy of germination, mean germination time, seedling vigor, seedling length, 10 seedling fresh and dry weights were measured below the experimental conditions. Variance analysis results (ANOVA) showed extremely significant ($p<0.05$) variations between treatments in all traits. It had been discovered that increasing PEG concentrations up to 30% significantly decrease germination criteria and seedling growth traits and that priming treatments in most cases significantly increased all germination and seedling parameter. The most effective in this regard was 1000 mg/l potassium nitrate as compared with untreated control treatment. Priming treatments in most cases mitigates PEG effects as a major increase, particularly with 1000 mg/l potassium nitrate. It is concluded that potassium nitrate at 1000 mg/l is helpful to enhance drought tolerance of barley grain germination and seedling growth.

Keywords: Barley, Drought, Grain Priming, Hydropriming, Osmopriming, Potassium Nitrate, Silicon, Thiamin

1. Introduction

Barley (*Hordeum vulgare* sbsp. Vulgare L.) belongs to family Poaceae (Graminae) is widely grown fourth most important world cereal following maize, wheat and rice. It is the main cereal in several dry areas of the Middle East and North Africa and is important for the livelihood of the many poor farmers. It is a very important supply of feed and forage for livestock, and of food for humans. Barley is comparable to different cereal grains in terms of caloric worth and protein content, however, contains higher levels of strong nutritional interest: tocols (vitamin E) and a water soluble fiber β-glucans [1,2]. There's strong proof that barley β-glucans will lower blood cholesterol levels, thereby reducing the danger of coronary heart and cancer diseases [3]. Besides grain, barley straw is additionally fed to animals for stall feeding, particularly throughout winter months once different feed resources are either scarce or in accessible.

Germination and seedling stablishment are critical stages within the plant life cycle, in special beneath a biotic stress condition like drought [4, 5]. Under a biotic stress cereal production is wide restricted by poor stand establishment and germination tends to be irregular and might extend over long periods as well as inhibited seedling growth [4, 6]. The ensuing poor crop stands leave gaps within the canopy, which are rapidly filling with vigorously growing weeds. These weeds vie with the crop plants for light, water and nutrients [7]. Observations in several semi-arid areas counsel that stand establishment, notably of cereals like as barley, is commonly very poor. Water stress not solely affects seed germination however additionally will increase the mean germination time in crop plants [8, 9]. It's well established that speedy and uniform field emergence is two essential

conditions to increase yield, quality and ultimately profits in crops.

There are several methods to beat the negative effects of drought stress. An excellent strategy is that the selection of cultivars and species for drought condition [10]. However another strategy for the chances to overcome drought stresses is by seed pre-treatments. One pragmatic approach to increment crop production is seed invigoration or seed priming [11]. Seed priming could be a low cost and low risk intervention wont to overcome poor stand establishment [12]. Seed priming could be a controlled hydration method followed by re-drying that permits the seeds to imbibe water and start internal biological processes necessary for germination, however that doesn't enable the seed to really germinate [13]. Seed priming is reportable as an efficient method for increasing seed vigor and improvement germination and seedling growth. A sturdy seedling establishment enhances aggressiveness against weeds, improves tolerance to environmental stresses and maximizes biological and grain yield [14, 15, 16, 17, 18].

The helpful effects of seed priming technique have already been successfully expressed in several crop plants, i.e., wheat [19], andrice [20]. Seed priming improve germination uniformity and seedling establishment [11, 21], additionally to attenuate abiotic stresses throughout germination in barley [22]; wheat [23], and rice [24].

Common priming techniques include osmopriming, halo-priming, hormonal priming, vitamin priming, hydropriming and others [16, 17, 25, 26]. Harrisetal. [27] introduced an occasional value, low risk technology referred to as 'on-farm seed priming' that will be acceptable for all farmers, no matter their socioeconomic standing. However, the manner the priming is finished could well influence the results. The principle is that sowing soaked seed decreases the time required for germination and should permit the seedling to escape deteriorating soil physical conditions. Besides higher establishment, farmers have reportable that primed crops grew a lot of vigorously, flowered earlier and yielded higher [16].

It was discovered that hydropriming much ensured speedy and uniform germination accompanied with low abnormal seedling percentage under control and/or drought conditions [17, 28, 29, 30]. Application of potassium nitrate as a priming treatment resulted in higher seed germination and stand establishment [16, 17, 31]. Several investigators have reported that silicon enhanced the drought tolerance in wheat [32], maize [33] and sorghum [34]. Recently silicon (Si) priming is one amongst the most important strategies, which might improve a biotic stress tolerance [35].

Osmopriming was found to establish deep roots more rapidly than untreated seed, in this concern, El-Saidy et al. [16] and Farouk and El-Saidy [17] reportable that primed sunflower achens emerged 1-3 days earlier than non-treated ones, and early seedling gemergence junction rectifier to a variety of advantages later. Thiamin needs for growth and differentiation of some plant species are reportable [36, 37]. But there is a little information about its role in improving drought tolerance of plants. Though the results of priming treatments on germination of some seed crops has been studied, however very little information is available on the invigorating of barley grain under drought stress. With these facts in mind, the present study was undertaken to evaluate the effect of grain priming in order to achieve an effective solution for optimizing the plant seedling growth and establishment under drought stress.

2. Subjects and Methods

This experiment was carried out within the Agricultural Botany Department lab. , Fac. Of Agriculture, Mansoura University, Egypt throughout the period of 2015/2016 to study the ameliorating effect of priming treatments on grain germination and seedling growth of barely under drought stress (PEG-6000). The experiment design was factorial (4x14) organized in a completely randomized block design, with 5 replications and thiry grains per replicate. The main factor was PEG-induced drought stress at 10, 20 and 30%, and the sub-factor represent priming agent in 14 sets (13 priming agent i.e., hydropriming, osmopriming with 5, 10, and 15% PEG-6000; vitamin priming with 25, 50, and 75 mg/l thiamin; nutria-priming with 500, 1000 and 1500 mg/l potassium nitrate (KNO_3) as well as 50, 100 and 150 mg/l sodium metasilicate (Na_2SiO_3); plus non-primed (dry grains) as control).

The grains of barley (*Hordium vulgare* L.) cv Giza129 used in the present investigations were secured from the Field Crop Res. Inst., ARC, Giza, Egypt. Before the experiment begin, grains were sterilized in 70% ethanol for 5 min, then rinsed with distilled water and surface dried by placing them between paper towels for 30 min. at room temperature [38]. The sterilized grains were divided into 14 sets. The first set was non-primed (dry grain) to serve as control; the remaining set of grain was separately soaked for 24 h in distilled water or aqueous solutions of priming agents as mentioned above. The subsequent standard priming treatment was adopted altogether experiments; one layer of barley grains was submerged in every priming solution or distilled water, to a depth of one cm on top of the highest of the seeds for twenty-four hr at room temperature within the dark [26]. The ratio of seed weight to solution volume was1:5 (g/ml) [11]. The treated grains were rinsed totally with tap water 3 times for about 2 minutes, and re-dried well with regards to their original weight in the shade [39]. Once drying, all the treated and non-treated grains were sealed in polyethylene bag until more use [39].

Every set was divided into four groups each one composed of 600 grains. The groups transferred to a sterile germination plate containing two layers of filter paper. The first group was wetness with twenty cubic centimeter of distilled water (control). The other three groups were wetness severally with 20 ml of PEG solution concentration at 10; 20 and 30% that were prepared in 1/10 strength Hogland solution for fulfillment of nutrient necessities. Thirty grains were placed on every germination plate. Germination plate was inspected

daily and distilled water was added as required to compensate for evaporation loss. Grains are considered physiologically germinated when the radical reach approximately 2-3 mm long [40]. The germinated grains were counted and first count defined as the number of germinated grains at the 2nd days from planting. Then, each twenty four hours the number of germinated grains was counted till the end of germination test (8days).The experiment was repeated two times and therefore the following data was recorded:

2.1.Germination Parameters

Germination percentage (G%) was defined as the production of normal seedling [41] and therefore the initiation of germination was thought of to possess occurred whenever the emergent radical was visible. The daily record of germinated seed was taken up to eight days from setting up of the test. Data were counted daily and the sum of the data after fourteen days was calculated by using the following formula:G%= (number of normal seedlings / Total number of grains) x 100.The germination index(GI) has been calculated by the formula as represented within the Association of Official Seed Analysis [42]: GI = (Germination percentage in each treatment/ Germination percentage in control treatment). Mean germination time(MGT) has been calculated supported the subsequent equation of Alvardo and Bradford [43]: MGT = ($\sum$Dn / $\sum$n), where n is the number of grains that germinated on the day (D); D is the number of days counted from the beginning of germination. Energy of germination (EG) had been determined from the percentage of germinating grain at the first count (2 days once planting) relative to the whole number of tested grains [44].

2.2. Seedling Parameters

Seedling length (cm) was recorded at eight days after planting. Ten seedlings were carefully uprooted randomly out of all the seedlings. The uprooted seedlings were washed with tap water and excess water was soaked with tissue paper. Seedling length was measured with a ruler. Ten seedling fresh weight (mg): Ten seedling samples of the above samples were packed separately in paper bags and 10 seedling fresh weights were recorded by an electronic balance (Model: Satorious, a200S). Ten seedling dry weight (mg): After taking fresh weight those ten seedling sample packages were dried in an electric oven maintaining 72°C temperature for 48 hours. After drying, the seedling dry weights were weighed by an electronic balance (Model: Satorious, a200S) and they were recorded accordingly. Seedling vigor index (SVI): it was calculated according to the formula suggested by Vashisth and Nagarajan, [45], SVI = (Seedlings Length x Germination Percentage)/100.

2.3. Statistical Analysis

Data were analyzed by analysis of variance (ANOVA) technique using computer software MSTATC and significant treatment means were compared using least significance difference (LSD) test at 0.05 probability level according to Gomez and Gomez [46].

3. Results and Discussion

3.1. Grain Germination Parameters

Analysis of variance indicated that grain priming and drought stress had a significant effect on grain germination parameters of barley alone or incombinations (Tables1, 2). Data presented in tables (1, 2) revealed that increasing drought stress up to 30% PEG-6000 significantly decreased the germination parameters. The maximum reduction was obtained due to 30% PEG-6000 which decreased germination percentage "G%", germination index "GI", mean germination time "MGT", the energy of germination "EG" and seedling vigor index "SVI". On the other hand, grain priming in various agents had significant effects on germination parameters of barley. Potassium nitrate at 1000 mg/l was the best given the highest G%, GI, EG and SVI as compared with other priming agents or non-primed dry grain. As regards to mean germination time, application of 500 mg/l potassium nitrate gave the highest value compared with untreated control plant, meanwhile, grain osmopriming in 15% PEG gave the lowest mean germination time. Moreover, it is obvious from the present table (2) indicated that in most cases the application of grain priming with 15% PEG generally gave the lowest values of germination parameters.

Table 1. *Effect of drought (D), grain priming agent (P) and their combinations on germination percentage and germination index of barley seedlings.*

Priming Agent(P)	Germination Percentage					Germination Index				
	Drought (PEG%,D)					Drought (PEG%,D)				
	0	10	20	30	Mean	0	10	20	30	Mean
Dry	91.99	91.99	87.99	74.66	86.66	1.000	1.000	0.657	0.812	0.942
Hydropriming	95.99	96.00	94.66	94.66	95.33	1.044	1.044	1.029	1.029	1.036
Potassium nitrateat500mg/l	98.66	98.66	97.33	95.99	97.66	1.073	1.073	1.058	1.044	1.062
Potassium nitrateat1000mg/l	98.66	100.0	98.66	95.99	98.33	1.073	1.087	1.073	1.044	1.069
Potassium nitrateat1500mg/l	95.99	95.99	94.66	93.33	94.99	1.044	1.044	1.029	1.015	1.033
Thiaminat25mg/l	95.99	94.66	93.33	91.99	93.99	1.044	1.029	1.015	1.000	1.022
Thiaminat50mg/l	95.99	95.99	94.66	93.33	94.99	1.044	1.044	1.029	1.015	1.033
Thiaminat75mg/l	93.33	93.33	89.99	89.33	91.49	1.015	1.015	0.978	0.971	0.995
Polyethyleneglycolat5%	94.66	93.33	90.66	93.33	92.99	1.029	1.015	0.986	1.015	1.011
Polyethyleneglycolat10%	91.99	91.99	89.32	79.99	88.33	1.000	1.000	0.971	0.870	0.960

Priming Agent(P)	Germination Percentage					Germination Index				
	Drought (PEG%,D)					Drought (PEG%,D)				
	0	10	20	30	Mean	0	10	20	30	Mean
Polyethyleneglycolat15%	90.66	90.66	83.99	58.66	80.99	0.986	0.986	0.913	0.638	0.881
Sodium metasilicateat50mg/l	94.66	94.66	93.33	91.99	93.66	1.029	1.029	1.015	1.000	1.015
Sodium metasilicateat100mg/l	97.33	97.33	95.99	94.66	96.33	1.058	1.058	1.050	1.029	1.049
Sodium metasilicateat150mg/l	98.66	97.33	95.99	95.99	96.99	1.073	1.058	1.044	1.044	1.055
Mean	95.33	95.14	92.90	88.85	===	1.036	1.034	1.010	0.966	===
LSD0.05	D2.123	P3.971	DP7.943			D0.023	P0.0431	DP0.0861		

Table2. *Effect of drought (D), grain priming agent (P) and their combinations on germination energy, mean germination time and seedling vigor index of barley seedlings.*

Priming Agent(P)	Germination Energy					Mean Germination Time				
	Drought (PEG%)					Drought (PEG%)				
	0	10	20	30	Mean	0	10	20	30	Mean
Dry	92.00	90.66	88.00	53.33	81.00	3.160	2.760	2.640	2.240	2.700
Hydropriming	92.00	93.33	94.66	94.66	93.66	2.880	2.880	2.840	2.840	2.860
Potassium nitrateat500mg/l	93.33	96.00	95.99	94.66	94.99	2.960	2.960	2.920	2.880	2.930
Potassium nitrateat1000mg/l	98.66	98.66	95.99	94.66	96.99	2.960	2.840	2.960	2.880	2.910
Potassium nitrateat1500mg/l	95.99	96.00	91.99	93.33	94.33	2.880	2.880	2.840	2.800	2.850
Thiaminat25mg/l	94.66	94.66	84.00	92.00	91.33	2.880	2.840	2.720	2.760	2.800
Thiaminat50mg/l	95.99	95.99	92.00	92.00	93.99	2.880	2.880	2.840	2.800	2.850
Thiaminat75mg/l	91.99	93.33	90.66	87.99	90.99	2.800	2.800	2.760	2.680	2.760
Polyethyleneglycolat5%	94.66	90.66	88.00	92.00	91.33	2.840	2.800	2.720	2.800	2.790
Polyethyleneglycolat10%	89.33	87.33	89.33	78.66	86.16	2.760	2.760	2.680	2.440	2.660
Polyethyleneglycolat15%	86.66	90.66	82.66	48.00	77.00	2.720	2.720	2.520	1.760	2.430
Sodium metasilicateat50mg/l	91.99	94.66	97.33	92.00	94.00	2.840	2.840	3.120	2.760	2.890
Sodium metasilicateat100mg/l	97.33	97.33	96.00	94.66	96.33	2.920	2.920	2.880	2.840	2.890
Sodium metasilicateat150mg/l	94.66	97.33	96.00	86.66	93.66	2.960	2.920	2.880	2.680	2.860
Mean	93.52	94.04	91.61	85.33		2.889	2.843	2.809	2.654	===
LSD0.05	D2.769	P5.182	DP1.364			D0.077	P0.145	DP0.291		

Table 2. *Continue.*

PrimingAgent(P)	SeedlingVigorIndex				
	Drought (PEG%)				
	0	10	20	30	Mean
Dry	13.898	12.884	9.156	4.002	9.985
Hydropriming	19.202	15.940	13.364	9.622	14.532
Potassium nitrateat500mg/l	21.170	18.666	15.652	11.802	16.823
Potassium nitrateat1000mg/l	21.974	20.140	16.390	12.750	17.814
Potassium nitrateat1500mg/l	18.854	15.786	12.626	9.084	14.088
Thiaminat25mg/l	17.496	14.918	12.346	8.902	13.416
Thiaminat50mg/l	18..58	15.944	13.672	8.830	14.351
Thiaminat75mg/l	15.310	13.858	10.216	6.696	11.520
Polyethyleneglycolat5%	16.942	14.216	10.994	7.424	12.394
Polyethyleneglycolat10%	14.594	13.204	10.592	5.548	10.985
Polyethyleneglycolat15%	13.500	12.808	8.688	3.514	9.628
Sodium metasilicateat50mg/l	16.980	14.206	11.416	7.618	12.555
Sodium metasilicateat100mg/l	20.234	17.546	14.516	10.224	15.630
Sodium metasilicateat150mg/l	20.398	17.528	15.148	10.574	15.912
Mean	17.822	15.546	12.484	8.328	
LSD0.05	D0.6426	P1.2026	DPNS		

Regarding to the interaction between drought stress and grain priming agents, the data in Tables (1,2) indicate that in most cases all interactions significantly increased grain germination percentage and germination index except the grain priming with 75 mg/l thiamin and 10% PEG under moderate or severe drought stress potential; with 5% PEG under moderate drought stress, as well as PEG at 15% under all drought potential stress. The highest germination percentage was obtained due to grain priming in 1000mg/l potassium nitrate under low drought stress potential as compared with control or normal conditions.

The data in the same tables proved that speed germination index markedly increased in most cases by grain priming in all agent under all drought stress as compared with untreated control plants, except 75mg/l thiamin and 10% PEG under moderate and severe water stress; and 5% PEG under moderate water stress as well as 15% PEG under all water stress. Grain priming in 1000mg/l potassium nitrate gave the highest value of germination index compared with other priming treatments or untreated control. Also, application of priming agent counteracts the harmful effect of drought stress as compared with un-priming plants under such drought

potential.

Regarding mean germination time, the data in the same table indicate that, grain priming in 50 and 75mg/l thiamin, 5, 10, 15% PEG, and 50 mg/l Si significantly decreased mean germination time. The lower MGT was obtained due to 15% PEG under severe water stress. Moreover, potassium nitrate at 1000 mg/l and 100 mg/l silicon significantly increased the germination energy under control or drought stress. Also hydropriming, 500 mg/l potassium nitrate, 150mg/l Si under water stress gave a significant increase as compared with untreated control plants. Meanwhile potassium nitrate at 1500 mg/l, and thiamin at 25 and 50 mg/l gave a significant increase under control or low water stress.The greatest germination energy was obtained due to 1000 mg/l potassium nitrate as compared with untreated control plant.

All priming treatment markedly increased seedling vigor index and counteracted the harmful effects of drought as compared with untreated treatment under drought stress.The highest SVI was obtained due to application of 1000mg/l potassium nitrate under control treatment.

Germination and establishment are critical phases within the life time of aplant when they are the foremost liable to injury, disease, and water stress [47]. Germination is one amongst the foremost drought-sensitive plant growth stages and severely inhibited with increasing drought stress potential. Drought stress during the initial stage of crop hampered germination characteristics, resulted in delaying and erratic seedling emergence and stand establishment in many crops. In the present investigation, increasing drought stress induced a significant and prominent reduction in barley germination criteria. Similar results were reported [4, 6, 29, 32], on a range of plant species. It can be proposed that under water restriction the velocity of water absorption is affected, where the absorption and consequently the hydrolysis and mobilization of carbohydrates are slower [48]. Drought also disturbs the plant growth owing to loss of turgor, as water supply from the xylem to the surrounding elon gating cells is interrupted [49]. The reduction in germination percentage under drought stress could be as a result of declining within the cellular enlargement and reduced water potential, and causing a complete inhibition of seed germination [50].The first physiological disorder, which takes place during germination, is the reduction in imbibitions of water by seeds which leads to a series of metabolic changes, including a general reduction in hydrolysis and utilization of the seed reserve [51].

Priming treatment is a successful practice for improving seed germination criteria performance and/or counteracted the harmful effect of drought stress. These results corroborate with the finding of Jalilian et al. [52]; Rouhi et al. [53] for hydropriming; and Ansari et al. [4]; Rouhi et al. [6]; Espanany et al. [54] for potassium nitrate priming; and Afef et al. [32], Hameed et al. [35]; Ghajari et al. [55] for silicon priming as well as Rouhi et al. [53]; Aghbolaghi and Sedghi [56] for polyethyleneglycol, and Hamada and Khulaef [57]; Sayed and Gadalla [58] for thiamin they found that germination parameter were significantly increased by seed priming treatment under normal or drought stress conditions. Moreover, primed seedlings are known to emerge additional quickly and grow additional vigorously than those from non-primed seeds [59].

One of the positive and effective reasons of priming treatment on the seed germination probably due to hormonal imbalance and reduced the proportion of growth inhibiting substances such as abscisic acid [60]. In this concern Hopkins [61] found that priming strategies cause ABA hydrolysis and increasing the phenolic compounds leaching to the aqueous solution, which might act as germination inhibitors.The positive effect of priming technology was most likely as a result of the stimulatory effects of priming on the early stage of germination processes by the mediation of cell division in germinating seeds. Furthermore, the literature indicates beneficial effects of priming related to repair and build-up of nucleic acids, inducing protein synthesis and repair of membranes [62]. Finally, priming treatment enhances the activity of antioxidant enzymes in treated plants which helping in alleviated the oxidative stress induced by drought on seed germination criteria [63].

Recently, numerous hypotheses have been proposed to account for the action of nitrate in seed germination, including, action of the Pentose Phosphate Pathway [64], stimulation of oxygen uptake [65] and action as a co-factor of phytochrome [66]. The greater efficiency of potassium nitrate priming is probably associated with the osmotic advantage that K^+ have in improving cell water standing, and additionally in this they act as cofactors within the activities of various enzymes, most of which are active once reserve mobilization and radical protrusion are in progress [49]. Moreover Khan et al. [67] revealed that the presence of nitrate during imbibitions could offer a further substrate for amino acid and protein synthesis for the enhancement of germination throughout priming and time to emergence of seedlings.

There is terribly rare data concerning the influences of thiamin priming treatment on seed germination and seedling growth and vigor and need more and more experiments. In accordance with the results of the current investigation, seed dressing with thiamin increased germination rate of bean seedlings [37]. Thiamin molecules, consisting of a pyrimidine and a thiazole moiety are an incipient thiol. Thiol compounds like glutathione have vital functions as constituents of free radical scavenging systems. Impairment of those defense mechanisms throughout prolonged periods of oxygen deprivation is taken into account as a serious cause for post-anoxic injuries of plant tissues under stress conditions. It has been reported from the current study and by alternative investigators that osmopriming may be a less effective technique than hydropriming for improving seed germination and MGT [16, 17].This dangerous impact could be as a result of the high concentration of PEG has some disadvantages like the reduction of oxygen concentration within the solution due to the viscous nature of PEG successively could have negative effects on each protein synthesis and degradation and hamper respiration

processes throughout seed germination. Also, the dangerous impact of high PEG solution could also be as a result of its effect in reducing seed water imbibitions as compared with distilled water [68] as a result of its osmoticeffect.

3.2. Seedling Growth

Data presented in Table 3 indicate the effects of drought levels, priming agents and their combinations on barley seedling growth. Analysis of variance indicates significant difference due to the effect of various levels of drought stress in respect ofs eedling growth parameters. The longest seedling length, high fresh and dry weights were found from the control treatment which was statistically different from other treatments. Likewise, Increasing drought level upto 30% PEG decreased seedling length, fresh and dry weights of seedling, particularly under high drought level "30%". Grain priming increased markedly seedling length, seedling fresh and dry weight. Among the seed priming treatments, the highest values of seedling length, seedling fresh weight, seedling dry weight were obtained as a result of grain priming in 1000 mg/l potassium nitrate as compared with control treatment. Additionally the data within the same table revealed that 15% PEG gave the lowest values followed by hydro–priming techniques. Correspondingly, non–priming noted the shortest shoot.

Table3. *Effect of drought (D), grain priming agent (P) and their combinations on seedling length and 10 seedling fresh and dry weights of barley seedlings.*

Priming Agent(P)	Seedling Length(cm)					10 Seedling Fresh Weight (mg)					10 Seedling Dry Weight (mg)				
	Drought (PEG %, D)					Drought (PEG% ,D)					Drought (PEG%,D)				
	0	10	20	30	Mean	0	10	20	30	Mean	0	10	20	30	Mean
Dry	15.0	14.0	10.3	5.38	11.2	2358	2158	1645	1131	1823	329	306	250	215	275
Hydropriming	20.0	16.6	14.1	10.1	15.2	3270	3174	2728	1438	2653	416	382	330	305	358
Potassium nitrateat500mg/l	21.5	18.9	16.0	12.3	17.2	3707	3347	2900	1806	2940	463	411	348	314	384
Potassium nitrateat1000mg/l	22.3	20.1	16.6	13.2	18.0	3747	3440	2901	1821	2977	487	424	354	327	398
Potassium nitrateat1500mg/l	19.6	16.4	13.3	9.84	14.8	2902	2994	2492	1372	2440	410	374	314	288	347
Thiaminat25mg/l	18.1	15.8	13.2	9.64	14.2	2804	2894	2427	1351	2369	392	373	311	280	339
Thiaminat50mg/l	19.7	16.6	14.4	9.66	15.1	3159	3079	2541	1427	2551	408	375	324	295	350
Thiaminat75mg/l	16.4	14.9	11.3	7.56	12.5	2633	2458	1933	1215	2059	354	345	267	258	306
Polyethyleneglycolat5%	17.8	15.2	12.1	7.92	13.2	2712	2515	2003	1236	2116	363	357	280	267	316
Polyethyleneglycolat10%	15.7	14.3	11.8	6.92	12.2	2493	2427	1900	1127	1987	345	341	258	253	299
Polyethyleneglycolat15%	14.8	14.0	10.3	6.10	11.3	2274	2092	1467	1084	1729	308	307	235	208	264
Sodium metasilicateat50mg/l	17.9	15.0	12.2	8.32	13.3	2755	2722	2394	1362	2308	433	366	296	272	342
Sodium metasilicateat100mg/l	20.7	17.9	15.0	10.7	16.1	3557	3226	2854	1656	2823	424	392	335	311	365
Sodium metasilicateat150mg/l	20.7	17.9	15.7	11.0	16.3	3670	3334	2854	1792	2912	433	405	341	315	373
Mean	18.6	16.2	13.3	9.20	===	3003	2847	2360	1415	===	397	368	303	279	===
LSD0.05	D 0.620	P 1.160	DP NS			D 51.35	P 96.07	DP19 2.15			D 4.870	P 9.112	D P1822		

As regards to interactions between priming treatments, moderate and high drought levels, data in Table 3 show that priming agent partially counteracted the harmful effects of drought especially at severe drought stress potential.

The negative effects of drought on the growth of early seedling were much more than on the germination of barley grains. The present results showed that, drought stress brought by PEG-6000 inhibited seedling growth parameters and seedling vigor index. The findings are in accordance with other researchers [53, 69].The observed reduction in seedling growth under drought stress could also be as a result of cell expansion suppression and cell growth that's in response to low turgor pressure [70] and will be attributed to the repressive impact of ABA that was induced by drought on cell division and/or cell enlargement [71]. Also, the inhibition effects of drought stress on growth parameters of plants might be due to inhibits the growth through reduced water absorption, changes in water relations of tissues exposed to low water potential, accumulation of ions in tissues and stomata conductance of leaves [72]. Moreover, Soltani et al. [8] found that wheat seedling dry weight reduction in response to environmental stresses may be a consequence of the decrease in mobilized seed reserve as a result of low water uptake by the germinating seeds.

The experimental results showed that grain priming showed significant response in terms of seedling length, seedling fresh and dry weight as well as seedling vigor index. These findings are in accordance with the results reported by Jalilian et al [52] in barley, Golizadeh et al. [73] in Cannabis seed; and Kalpana et al [74] in wheat. Faster emergence rate after priming may be due to increased rate of cell division in the root tips of seedlings from primed seeds as reported in wheat [28] and sunflower [29].

Potassium application increased drought tolerance in plants by regulation a spread of processes, like osmoregulation, charge balance, energy status, and proteins ynthesis [75]. Many studies, typically underneath short durations of drought stress, have provided proof of the role of K in mitigating drought stress by enhancement of NRA and accumulation of K^+ and glycinebetaine [75, 76]. It is well known that application of silicon inducing growth and development of plants under drought stress [34, 77]. The present investigation revealed that grain priming with sodium silicate improved the seedlings growth under drought. Similarly, Afef et al., [32] has

additionally been indicated the improved emergence and better seedling stand establishment afters eed priming. Also, Si decreased significantly the level of jasmonic acid and ABA, which play a key role in regulation physiological processes related to plant resistance to biotic and a biotic stresses, thereby protective the plant metabolism from ROS [78]. Kim et al. [79] ascribed the Si-mediated reduction within the levels of those plant hormones in rice plants exposed to environmental stress to the ameliorative effect of silicon on the stress intensity by regulation the expression of genes responsible for the synthesis of ABA and JA.

Generally, it was found that the applied vitamins like thiamin could stimulate the growth of seedlings. In accordance with this, El-Zawahry and Hamada [80] recorded that, soaking of *Solanum melanogena* seeds, in thiamin increased shoot and root fresh and dry weights compared with those of the control. It is known that thiamin, as a functional coenzyme thiamin pyrophosphate, plays an integral role within the regulation of the carbon metabolism in plants. Bender [81] mentioned that pyridoxine having the pyridine ring represents a precursor for the essential enzyme pyridoxal-phosphate, which is utilized in all phases of amino acid metabolism.

The useful effects of hydropriming are attributed to the mobilization in embryonic tissues of enzyme activities needed for fast seed germination and of compounds like free amino acids, proteins, and soluble sugars from storage organs [21]. The improved seedling fresh and dry weight of barley could also be attributed to optimum availability of nutrients to seedling soon after their emergence, which enhanced the early grow thand thus resulted in improved barley fresh and dry weight within the nutrient primed seed treatments.These results are in accordance with the findings of Yari et al. [82], who observed maximum seedling growth rate for each wheat cultivars in seeds treated with distilled water. These findings are in agreement with previous reports [68]. Many researchers reported the positive impact of hydropriming on seedling emergence rate, seedling establishment, and early vigor.

Generally, It's over that 1000 mg/l potassium nitrate is beneficial to boost barley grain germination and seedling growth under control or drought conditions.

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