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Effect of seed priming on morpho-physiological traits of wheat in drought stress conditions

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Abstract

In order to evaluate the effects of seed priming on morpho-physiological traits of winter wheat under drought stress, an experiment was conducted under semi–controlled conditions in the city of Ooshnaviyeh of Iran, during 2011-2012. This Study was carried out Factorial experiment based on RCBD design with 3 replications to determine the influence of Irrigation (normal and drought stress) and Priming control (with no priming), Ascrobat and hardening. Analysis of variance showed effect of irrigation on all characters except for 1000-grain weight and priming effect for all traits studied was significant. Also the interaction between priming and irrigation effects on Photosynthesis, Peduncle length, number grain per spike, number spike/m^{-2} was statistically significant. In this research drought significantly reduced all traits, as drought stress reduced grain yield 7.16% in comparison with control. Furthermore priming with Ascrobat increased plant height, photosynthesis, number spikelet per spike, 1000-grain weight (TKW) and grain yield in comparison with other treatments so that the priming with Ascrobat increased grain yield by 9% compared with control. Finally with regard to the compare mean of interaction between treatments it can be concluded, seed priming with Ascrobat modified the effect of drought stress.

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Introduction

In irrigated lands, winter wheat and sugar beet fallow is the dominant rotation in 130.000 hectares of West Azerbaijan province of Iran. Planting of winter wheat is delayed after harvesting of sugar beet. In addition, low precipitation and inadequate moisture of seed zone under rainfall conditions reduces grain yield potential (Evazi, 2012). Therefore, seed priming is a technology that enhances rapid (7-10 day) emergence and early establishment of wheat. Rapid and uniform field emergence is an essential prerequisite at two irrigated and rainfall conditions to reach the yield potential, quality, and ultimately profit in annual crops. Seed priming has been common pretreatment that reduces the time between seed sowing until emergence and synchronizes seedling emergence (Parera and Cantliffe, 1994).

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, K2SO4) and plant growth inducers (CCC, Ethephon, IAA) (Capron *et al.*, 2000; Chiu *et al.*, 2002; Harris *et al.*, 1999; Chivasa *et al.*, 1998).

Several investigations confirmed that seed priming has many benefits including early and rapid emergence, stand establishment, higher water use efficiency, deeper roots, increasing in root growth, uniformity in emergence, germination in wide range of temperature, break of seed dormancy, initiation of reproductive organs, better competition with weed, early flowering and maturity, resistance to environmental stresses (such as drought and salinity) and diseases (*Sclerotium rolfsii* L.): Higher grain yield in wheat (*Triticum aestivum* L.) (Ghana and Schillinger, 2003), corn (*Zea mays* L.) (Subedi and Ma, 2005), pearl millet (*Pennisetum glaucum* L.), chickpea (*Cicer arietinum* L.), rice (*Oriza sativa* L.) (Harris *et al.*, 1999 ; Harris *et al.*, 2005) lettuce (*Lactuca sativa* L.) (Cantliffe *et al.*, 1984) is reported from field and laboratory studies. Inversely, longevity of primed seed can be decreased (Bruggink *et al.*, 1999).

Singh and Agrawal (1977) found out that wheat which seeds were treated with DW for 12h increased nitrogen uptake for 11 kg/ha. Misra and Dwivedi (1980) reported that seed soaking in 2.5% KCl for 12 h before sowing increased wheat grain yield for 15%. Paul and Choudhury (1991) observed that seed soaking with 0.5 to 1% solutions with KCl or K2SO4 significantly increased plant height, grain yield and its components in wheat genotypes. Naghe Zade and Gholami (2012), in study effect of seed priming with salicylic acid on yield of wheat under drought stress showed drought stress significantly reduced number of grains per spike, Spike/m^{-2}, TKW, biomass and grin yield but pretreated with salicylic acid significantly increased grain yield and yield component.

The objective of this study was to evaluate the effect of Effect of seed priming on morpho-physiological traits of wheat (Zarrin cultivar) in drought stress conditions.

Materials and methods

Experimental Design and Plant Materials

This experiment was factorial carried out in a randomized complete block design with three replications in the form of field in the city of Oshnaviyeh in north-west of Iran. The factors of experiment including first factor (irrigation levels) which it implies two levels of controlled conditions (irrigation at every 20 days, once one time) and drought stress (once, every 35 days). The second factor includes the different levels of priming such as the controlled condition (non-primed) hardening (both making wet and drying in two-six hours cycles) Ascrobat 300 ppm (24h) the priming treatments with 1:5 ratios of priming solution and seed which are being used in this experiment. In the entire time of priming, the seeds are held to use the air, then, are removed to have rinsed with distilled water and finally they will be dried. The drying of the seeds is in a way that their weights comes back to the initial weight (before exercising of treatment) and are kept in the refrigerator till the cultivation. Each experimental piece would be considered per two squarer that the length of which is 2 meters and its width is one meter. To separate the controlled condition and the stress treatments, the framework of each piece to the 70 cm-depth was protected by the strong plastic-layer toward the waters influence. The seeds would be ranged with rows- 16 cm and seed- in density of 350 Seeds per meter square. Thus, the total number of plots equal 18.

Morpho-physiological measurements

In this regard the aspects that must be interrogated are the morphological traits of peduncle length, performance and other performances which will be measured in the time of whatever is called as the field –time or growing season. To measure the rate of photosynthesis of the leaf area (mol co2/m^{-1}) the machine IRGA, (model-lca4) producing by ADCS Company in England was used. In order to do that, with putting the middle part of the leaves stem inside the glass chamber of the machine for one minute, the traits were recorded (Halder and Burrage, 2004). All measurements from the flowering stage to the next stages over 16 days with the intensity of the ambient light accounting to 1200- 1400 micromole photons per square per second was carried out at 10 till 12. To measure the controlled condition, the measurement of the photosynthesis was suddenly done after the irrigation and concerning the stress treatment, the average of three times before the irrigation was considered.

Analysis of variance and mean comparison of traits (Duncan's multiple range tests at the 0.05 significance level) were carried out using MSTAT-C software. Excel software was used for drawing graphs.

Results and discussion

Photosynthesis

Analysis of variances showed that irrigation, priming and interaction had significant effect on Photosynthesis rate (Table1). The mean comparison showed drought stress reduced Photosynthesis rate so that drought stress decrease 30% in photosynthesis rate in contrast with normal irrigation. (Table2).

Table 1. Analysis of variance of morpho-physiological traits affected by irrigation and priming levels.

		Mean square								
Source of variation	df	Photosynthesis	Plant height	Peduncle length	Spike length	No. spikelet per spike	No. grain per spike	No. spike/m-2	1000 grain weight	Grain yield
Replication	2	0.607	0.722	1.97	0.157	0.722	0.722	8.22	3.647*	2.612
Irrigation (I)	1	88.44**	896.00**	30.42**	12.16**	6.72**	280.05**	272.22**	2.142	2339.5**
Priming(P)	2	6.94**	340.06**	9.16*	2.02**	2.72*	102.88**	109.72**	17.01**	1389.5**
I×P	2	2.22**	3.40	35.34**	0.267	0.056	13.55**	66.7**	0.89ns	302.85**
Error	10	0.289	4.79	1.22	0.534	0.389	2.78	7.022	0.886	11.70
CV%		5.42	2.25	3.81	7.05	3.61	2.96	1.28	5.28	10.11

* , **: significant at 5% and 1% probability level, respectively.

Evidences suggest that the drought stress would have impact on the biochemistry of the chloroplast such as the photo systems activity mitigation, the Calvin cycle –deterrence and the reduction of photo-phosphorelization. The evidences clear that through drought stress increment, the stomata resistance also will increase and it leads to the mitigation of photosynthesis in leaf (Samimi Sad *et al.*, 2007) According to the report, when the wheat expose the drought stress, it makes a remarkable reduction in the rate of photosynthesis. (Halder *et al.*, 2004).

Between priming treatments, priming with Ascrobat and hardening significantly had higher photosynthesis rate compared with control treatment. Interaction between treatments demonstrates drought reduced photosynthesis rate in all types of priming. The results express that the rate of photosynthesis of experimental treatments was influenced by drought conditions, even seed- priming was not able to decrease the negative effect of drought stress.

According to Table 3, in dry condition there was no different at the priming treatment, in fact, the rate of photosynthesis at the priming treatments of seed in compare with non-primed seed had not significant deference, but under the irrigation condition the seed-priming with both treatments including Ascrobat and hardening in compare with control treatment increased photosynthetic rate.

Table 2. Mean comparison of irrigation and priming treatments on morpho-physiological traits.

		Photosynthesis	Plant height	Peduncle length	Spike length	No. spikelet per spike	No. grain per spike	No. spike/m-2	1000 grain weight	Grain yield
Irrigation	normal	12.12a	104.44a	30.38a	11.33a	17.88a	60.33a	211a	41.2a	321.62a
	stress	7.68b	60.33b	27.78b	9.44b	16.66b	52.44b	203.22b	40.88a	298.82b
Priming	control	8.70b	88.83b	27.9a	10.63a	16.66b	54.16b	203.5b	39.50c	293.33c
	Ascrobat	10.76a	103a	30.36a	10.50a	18a	61.16a	211.83a	42.79a	322.83a
	hardening	10.25a	100.33a	29.0ab	10.03a	17.16b	53.83b	206b	40.85b	314.51b

Plant height

Analysis of variance indicated that irrigation and seed priming had significant effect on plant height (Table1). Comparison of treatments showed that drought reduced plant high significantly by rate of 14% (Table2). In drought stress condition due to loss of current photosynthesis, the seeds requirement to the reservoir rational materials would rise up and consequently the new transition will increase, it means that more transition equals more increment of the stems height.

Between priming treatments, priming with Ascrobat with an average of 103 cm allocated highest of plant height. Although the difference between the treatment and priming with hardening no statistically significant (Table2). In this research control treatment with average of 88.8 cm showed the minimum height of the plant's heights. Fateh *et al*., (2012) Observed seed priming with Ascrobat and hardening on the wheat had positive effect on plant height.

Table 3. Mean comparison of treatments on morpho-physiological traits.

		Photosynthesis	Plant height	Peduncle length	Spike length	No. spikelet per spike	No. grain per spike	No. spike/m-2	1000 grain weight	Grain yield
normal	control	10.23b	97.67b	28.5cd	11a	17.33b	59.66b	204c	39.33c	312c
	Ascrobat	13.46a	109.33a	29.66bc	11.66a	18.66a	65a	219a	39.66c	333.87a
	hardening	12.66a	107.33a	33a	11.33a	17.66ab	56.33c	210b	40.70bc	319b
stress	control	7.16c	81c	27.3d	9.06b	16c	48.66d	203c	41bc	274.64d
	Ascrobat	8.06c	96.67b	31.06ab	9.33b	17.33b	57.33bc	204c	42.33ab	311.8c
	hardening	7.83c	93.33b	25e	9.93b	16.66bc	51.33d	202c	43.25a	310.03

Peduncle length

The results of analyses of variance for Peduncle length are presented in Table 1. There was a significant difference among irrigation, seed priming and interaction between irrigation and seed priming. In represent study like other characters peduncle length reduced by drought stress so that normal and stress conditions, by average of 30.38 and 27.78 cm respectively (Table2). allocated the highest and lowest peduncle length. In priming treatments, priming with Ascrobat with average of 30.36 cm and control treatments with average of 27.9 cm achieved the longest and shortest peduncle length. Compare mean interaction between treatments indicate priming with hardening in both normal and stress conditions showed highest and lowest peduncle length.

Spike length

The results of analyses variance showed irrigation hade significant effect on spike length (Table1). According to results of compare means drought stress decrease spike length by rate of 14.66% compare with normal conditions (Table2).

Naghe Zade and Gholami (2012), in study Effect of seed priming with salicylic acid on yield of wheat under drought stress showed drought stress reduced the biomass and Spike length.

Number spikelet per spike

According to result of analyses of variance effect of irrigation and seed priming on number spikelet per spike was significant (Table1). In this study level of normal irrigation with average of 17.88 showed highest number of spikelets per spike compared to drought stress condition with average of 16.66.

Between priming treatments, priming with Ascrobat with average of 18 spikelets per spike showed the highest value of the said property. In additions between control and priming with hardening statistically significant differences were not observed (Table2).

Eivazi (2012) reported pretreatments with IAA, CCC, DW and MN increased Number spikelet per spike respectively by 54, 53, 52 and 51 grains per spike, Pretreatments with CCC for 1000-Kernel weight of 45 g and treatments by CCC, DW and MN which gave 372, 371 and 366 spikes per square meter were the highest values of these parameters (Fig. 3-C and D). The range of variations for number of spikes per square meter was between 277 and 392, related to cultivars Sardary and Zarrin, respectively.

Number grain per spike

Analysis of variance showed that the number of grains per spike was influenced by irrigation, priming and interaction between irrigation and priming (Table1). Similar to other characteristics water stress significantly reduced number grain per spike by rate of 13.3% (Table2).

In cereals, the most sensitive time to expose water stress, is period of heading to flowering. Before flowering cultivars can produce high biomass and increase storage assimilate of stem are tolerant cultivars. Stress at flowering stage reduce the number of seeds because of the reduced pollen fertility (Ji *et al.*, 2010).

Comparison priming treatment observed, only priming with Ascrobat was able to significantly increase the number of grains per spike. But between control and priming with hardening statistically significant differences were not observed.

Pretreatments resulted in high total dry matter production through effects on growth period. Primed seeds had after sowing faster germination, rapid establishment, and uniform growth. Such a plant expands root system at shorter time compared to the control and by up taking more water and nutrients produces photosynthetic organs rapidly and reaches earlier autotrophic stage (Duman, 2006).

Compare mean of interaction treatment showed Priming with Ascrobat achieved highest of number of grain per spike in both normal and water stress (Table3).

Naghe Zade and Gholami (2012), showed drought stress significantly reduced number of grains per spike but pretreated with salicylic acid significantly increased number of grains per spike.

Number spike per m^{-2}

In represent study irrigation, priming and interaction between irrigation had significant effect on Number spike per m^{-2} (Table1).

The normal level of irrigation by average of 211 was higher in number of spikes per square meter than water stress by average 203 significantly (Table2).

Among the types of priming, priming with Ascrobat by average 211.83 had highest number of spikes per square meter compared to control and hardening treatment. There was no significant difference between control and hardening.

Eivazi (2012), observed treatments by CCC, DW and MN which gave 372, 371 and 366 spikes per square meter were the highest values of these parameters.

According to interaction between treatments compare means, under normal conditions, priming with

Ascrobat had highest number of spikes per square meter, but in drought conditions, there was no significant difference between treatments interaction. Naghe Zade and Gholami (2012), reported effect of drought stress and Pretreatment on number of spikes per square meter was significant and drought stress reduced and pretreated with salicylic increased number of spikes per square meter.

1000 grain weight

Thousand grain weights were only affected by priming treatment so that priming with Ascrobat and hardening increased thousand grain weight by rate of 9.30% and 4.87% as compared to the control (Table2).

Eivazi (2012) pretreatments with CCC by average of 45 g increased 1000-Kernel weight compared with control and other treatments.

Grain yield

In represent study Grain yield influenced statistically by irrigation, priming and interaction between irrigation (Table1). According to result of compare mean drought conditions reduced grain yield by rate of 7.95% compare with normal conditions (Table2). It seems drought stress by reduced yield components, leading to a significant reduction in grain yield of wheat. Researchers believe decrease in grain yield under drought stress attributed to a decrease in photosynthesis (Uhart and Andrade, 1995). In this regard, Zarea and Ghodsi (2004) Plaut *et al* (2004) reported drought stress reduced grain yield by a reduction in number of grains per spike, number of Spike/m^{-2}, number of grains per spikelet.

Mean compare of priming treatments revealed that priming with Ascrobat with an average of 322.83 grams per square meter had highest and control treatment with an average of 293.32 grams per square meter had lowest amount of grain yield.

The increase of grain yield with pretreatments was due to the expansion of leaves, which resulted in higher photosynthesis, assimilation and ultimately higher production of total dry matter.

In this research priming in both water conditions show a greater yield than the control although regard to the compare mean of interaction between treatments it can be concluded, seed priming with Ascrobat modified the effect of drought stress. Accumulated priming materials in plants were effective during seed set and grain filling (Haris *et al.*, 1999; Haris *et al.*, 2004). Many researchers reported the increase of grain yield in wheat cultivars due to pretreatments, as 37% in (Misra and Dwibedi,1980), and 15% (Haris *et al.*, 1999; Haris *et al.*, 2004). Success in seed priming depends on type of cultivar, osmotic potential of solution, time of priming, temperature environment, seed vigor, the rate of seed re-drying the conditions during primed seed storage (Parera and Cantliffe, 1994).

Eivazi (2012) in study of Induction of drought tolerance with seed priming in wheat cultivars reported under field conditions, all of pretreatments at four cultivars gave bigger grain yield than control and among them CCC treatment gave the highest yield, yield, 591 g/m^2.

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