Storage duration and temperature of hydroprimed seeds affects some growth indices and yield of wheat

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Abstract

One of the methods for achieving more yields is to use seed priming technique correctly. When it comes to using seed priming, practically important issues should be taken into account including interval between priming to planting and conditions for storage of primed seeds. Thus, it is very crucial to be informed of duration and temperature for storage of primed seeds. This research seeks to compare the effect of temperature and duration of hydroprimed wheat seeds (var Kouhdasht) on growth indices and grain yield. This test was carried out with three replications in Research Farm of Agricultural Faculty of Lorestan University, as completely randomized block design. The relevant factors include storage temperature (15, 20 and 25° C) and storage duration of hydroprimed seed (0, 2, 4, 6, and 8 days). The results showed that hydropriming increased number of productive spike and grain yield. Nevertheless, delay (8 days storage) in planting and storage seeds at high temperature (25° C) could decrease benefits of priming. Storage temperature and duration of hydroprimed seeds affect morpho-physiological characteristics as well as yield. Seeds stored at 15 and 20° C showed a better yield than those stored at 25° C. Primed seeds stored at 20° C for 2 days showed a better performance than the other applied treatments.

Key words: seed storage; priming; leaf area index; wheat; yield

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Introduction

Wheat (*Triticum aestivum* L.) is the most important foodstuff that supplies a considerable part of human food demand in various countries of the world, especially in the developing countries. Economic importance of wheat in terms of either production or nutrition is more than other crops and it may be cultivated in areas where other plants cannot be cultivated (Shabestari, 2001). Throughout the world, sixteen percent of the cultivated lands are allocated to wheat that produces more than 709 million tons. In Iran, half of farming lands are allocated to wheat: 6.65 million hectares that produce 14 million tons of wheat (FAO, 2013).

Seed germination is one of the most important phonological stages of crops which determines success of agro-ecosystems. This stage is highly affected by environmental conditions and quality of seed (Soltani et al., 2007). Hence, seed quality improving by applying some treatments before planting is suggested by

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many researchers (Faroog et al., 2008; Satar et al., 2010; Hardegree and Emmerich, 1992).

Hydropriming improves seedling emergence and establishment of wheat (Farooq et al., 2008). Basra et al. (2003) concluded that hydropriming increases length of radicle and cell wall extensibility of the embryo. In the primed seeds of wheat and barley, the number of fertilized tillers is more due to proper germination and fast growth in the beginning of the season, and at the same time, length of spikes would be increased and, additionally, seed formation and filling may be improved (Duman 2006). Hydropriming treatment decreases the interval between planting to germination and protects seeds against living and non-living factors during critical stages of establishment of seedling. More uniform and rapid germination due to seed priming will result in improvement of crops yield (Basra et al., 2004). Hydropriming practically guarantees fast and uniform germination, producing least number of abnormal seedlings (Shivankar et al., 2003).

Beneficial effects of priming on improvement of germination and appearance of seedlings in crops such as grasses, wheat, sugar beet, corn, soybean, sunflower (Parera and Contlifee 1994), and broomegrass (Eisvand et al., 2010) are approved. Indeed, seed priming in these crops accelerates enzyme activity and growth of embryo (Ashraf and Harris, 2005). The seed vigor may be decreased during maturation, harvesting, and storage, based on temperature and humidity. High temperature during storage results in fast consumption of foods reserve of seeds by increasing respiration and thereby deteriorating the seeds. Thus, it disturbs seed germination, seedling emergence, and establishment of wheat in the farm (Marshal and Lewis, 2004).

Factors such as storage temperature and seed moisture content affect quality of primed seeds (Rajjo et al., 2008). Also, long storage of primed seed may lower its life (Hill et al., 2007). Bruggink et al. (1991) showed that primed seeds, which are kept in lower temperatures, have a longer life. Low temperature plays an important role in prevention from many of harmful processes due to high viscosity and low molecular movement. However, high temperatures during storage may lower viscosity and increase molecular movement.

Research has been conducted on various plants investigating the effect of storage on quality of primed seeds. Shafiei Abnavi and Ghobadi (2012) suggested that storage of wheat seed after priming primarily improves the length of plumula, radicle, shoot dry weight, and radicle as well as increase in germination percentage and speed. Studies on storage of sweet corn after priming at 25° C for a period of 3 months showed that germination, growth of radical, and yield will be eventually decreased (Chiu et al., 2002). In another study, the effect of storage on rapeseed seed under osmopriming and hydropriming conditions was investigated. According to the obtained results, osmopriming and seed storage for periods of 8 and 4 h, respectively, affect positively leaf area index, dry matter accumulation, crop growth speed, and seed yield in comparison with hydropriming (Shahzad et al., 2003). Research conducted by Hossein et al. (2015) concerning storage of rice seed after priming suggested that beneficial effects of priming on seed would appear when the seeds are stored for a period of 15 days at 25° C. In case the term and temperature of storage exceeds the mentioned levels, seeds' yield will be degraded in comparison with the non-primed seeds. As a result, negative effects of storage are primarily dependent upon temperature. When primed seeds of *Salvia officinalis* arstored at 5° C for a period of 1 to 16 weeks, they have a lower rate of germination and lose their germination potential very soon (Carpenter, 1989). Priming of seeds of *Senecio cineraria* that are stored for a period of 16 weeks at 5° C and relative humidity of 52% showed no effects on germination (Carpenter, 1989).

In a research conducted by Carpenter and Boucher (1991) concerning duration of storage of primed seeds of viola, it was discovered that when primed seeds of viola are stored in very low temperatures, they require less days to reach maximum germination than non-primed seeds. In other words, more uniform and fast germination is observed in primed seeds in comparison with the non-primed ones. In case the seed moisture content of primed viola would be in the range of 12 to 20% and the primed

Table 1
Farm soil analysis for mineral and carbon

C (%)	Cu ppm	Zn ppm	Mn ppm	Fe ppm	K ppm	P ppm	N (%)
1.02	1.06	0.86	8.56	4.22	285	7.8	0.101

seeds would be stored for a period less than 4 weeks at 5° C, the maximum benefits of priming may be obtained. In primed seeds of tomato, it was observed that the seeds that were stored for a period of 6 months at 30° C showed delay and degradation of germination in comparison with control seeds (Argerich et al., 1989).

In practice, a farmer may not be able to sow the primed seed immediately after priming because of some problems such as defect in machinery or unpredicted problems. Therefore, this is a question how long the primed seed can be preserved without loss of priming benefits and what storage temperature may be more suitable? Therefore, the present research seeks to examine effects of two important factors (temperature and duration of storage) of hydroprimed seeds in Kouhdasht wheat variety.

Materials and Methods

The e xperiment was carried out in 2014-2015 at Research Farm of Agricultural Faculty of Lorestan University, Khorram Abad, Iran. Experimental model was factorial based on a completely randomized block design (CRBD) with three replications. This research had 15 treatments from two factors including storage temperature (15, 20 and 25° C) and storage period (0, 2, 4, 6, and 8 days) of hydroprimed seed of a rainfed wheat (var Kouhdasht). In addition, non-primed seeds were planted in each block.

The seeds were hydroprimed in distilled water at 20° C for 12 hours according to Aliabadi Farahani and Maroufi (2011). During priming process, the required oxygen for respiration was provided by aquarium pump. After priming, the seeds were dried at room temperature (25° C) to reach the primary moisture content (8.5%). Then they were stored at three different temperatures (15, 20, and 25° C) for different durations (0, 2, 4, 6, and 8 days).

Seedbed preparation

Soil of the farm was analyzed before sowing to apply required fertilizers (NPK) at the proper time (Table 1).

Seedbed preparation including plowing, grinding, and leveling the farm was carried out by workers. After hydropriming and storing (according to temperature and duration mentioned above) the seeds were planted on November 8, 2014, two days after a rainfall. The first rain occurred 7 days after sowing. Each plot included 6 lines as P×P and R×R were 1.5 and 20 cm, respectively. In addition, weeds were thinned many times before and after tillering.

At the tillering stage, ten seedlings of each plot were sampled for numbering the root branches. Seedling leaf area index (SLAI) was measured at the beginning of stem elongation by Delta T-scan instrument. Chlorophyll index was measured using SPAD instrument (Minolta Company, Japan).

After harvesting, traits including number of fertilized spike and number of grains per spike were recorded. Then the samples were oven dried at 75° C for 24 hour and the 1000-seed weight, grain, and biological yields were measured. To measure biological yield, all plants in 1*1 m^2 of each plot were harvested at harvest maturity, oven dried at 75° C for 24 hour, and calculated as Kg/h. Harvest index (HI) was calculated according to formula of Gardener et al. (1985) as follows:

HI= (Grain yield/Biologic yield) ×100

Statistical analysis was carried out by MSTAT-C software. Means comparisons were done by Duncan multiple range test.

Results

Number of root branches

Results showed that the highest number of root branches was observed when the seeds

Table 2
Mean comparisons for the effects of storage temperature and duration of wheat hydroprimed seeds on the evaluated traits

	Storage duration (day)	No. of root branches	Chlorophyll Index (SPD number)	SLAI (cm^2/seedling)	No. productive Spike
Non-stored	0	8.473^{ab}	32.51^{a}	38.47^{ab}	2.467^{ab}
15 °C	2	7.777^{abc}	29.91^{ab}	37.01^{abcd}	2.237^{b}
	4	7.150^{abc}	29.27^{abc}	33.00^{def}	1.857^{b}
	6	6.490^{bcd}	29.37^{abc}	32.06^{efg}	2.077^{b}
	8	5.910^{cd}	26.59^{bcd}	29.77^{fgh}	2.060^{b}
20 °C	2	9.477^{a}	33.56^{a}	39.53^{a}	2.933^{a}
	4	8.793^{abc}	31.00^{ab}	37.92^{abc}	2.303^{ab}
	6	7.647^{abc}	29.92^{ab}	34.39^{bcde}	2.210^{b}
	8	7.370^{abc}	29.32^{abc}	33.53^{cdef}	2.157^{b}
25 °C	2	5.630^{cd}	24.92^{cde}	29.11^{fgh}	1.957^{b}
	4	5.550^{cd}	22.70^{de}	27.75^{gh}	1.940^{b}
	6	4.780^{d}	21.74^{e}	27.13^{h}	1.907^{b}
	8	4.563^{d}	21.01^{e}	26.12^{h}	1.750^{b}
Non-Primed		6.127^{bcd}	29.67^{abc}	36.11^{abcde}	1.903^{b}
LSD($P \leq 0.05$)		2.083	4.302	3.996	0.6098

*Means in each column followed by similar letter(s) are not significantly different at 5% probability level, using Duncan's Multiple Rang Test.

were stored at 20° C for a period of 2 days while the least number was observed at storage treatment 25° C and 8 days (Table 2). At each level of storage temperature, number of root branches decreased with increasing the storage duration to 2 days forward.

Chlorophyll index

The maximum chlorophyll index was related to the treatment where seeds were stored at 20° C for a period of 2 days. However, there was no significant difference between this treatment and non-primed seeds Also, long storage of hydroprimed seeds at 25° C, decreased chlorophyll index significantly (Table 2).

Seedling leaf area index (SLAI)

Maximum and minimum SLAI were obtained in the hydroprimed seeds stored at 20° C for 2 days and 25° C for 8 days, respectively. However, there was no significant difference for SLAI between non-primed and primed seeds stored at 20° C for 2 days. In addition, SLAI decreased when storage temperature was 25° C and storage duration increased under this temperature (Table 2).

Number of productive spike

Hydroprimed seeds which were stored for a period of 2 days at 20° C produced the maximum number of productive spikes on the order of 2.933 (Table 2). But, seeds sstored at 25° C for 8 days showed the least productive spikes per bush with an average of 1.750 (Table 2). In general, storage period more than 2 days, decreased number of productive spike at all three storage temperatures, especially at 25° C.

1000-grain weight

The highest 1000-grain weight was obtained from hydroprimed seeds that were stored at 20° C for 2 days. The lowest 1000-grain weight on the other hand, belonged to hydroprimed seeds which were stored at 25° C for 8 days (Table 3).

Grain per spike

Mean comparisons showed that the highest and lowest grain per spike were related to hydroprimed seeds which were stored at 20° C for 2 days and hydroprimed seeds which were stored at 25° C for 8 days, respectively (Table 3).

Table 3
Mean comparisons for the effects of storage temperature and duration of wheat hydroprimed seeds on the evaluated traits

	Storage duration (day)	1000-grain weight (g)	Grain per spike	Grain yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Non stored	0	32.74[ab]	35.37[ab]	3820[b]	9981[a]	38.46[ab]
15 °C	2	32.79[ab]	33.41[b]	3663[bc]	10460[a]	35.16[abcd]
	4	32.34[abc]	32.48[b]	3520[bcde]	10170[a]	34.55[bcd]
	6	32.22[abc]	32.32[b]	3353[cdef]	9714[a]	34.76[abcd]
	8	32.10[abc]	31.55[bc]	3307[def]	10320[a]	32.05[d]
20 °C	2	34.34[a]	40.76[a]	4113[a]	10610[a]	39.01[a]
	4	32.81[ab]	33.54[b]	3697[b]	10040[a]	36.80[abc]
	6	32.55[abc]	33.40[b]	3631[bcd]	10420[a]	34.94[abcd]
	8	32.44[abc]	32.51[b]	3582[bcd]	10330[a]	34.67[abcd]
25 °C	2	31.43[abc]	30.31[bc]	3247[ef]	9950[a]	32.63[cd]
	4	31.23[abc]	29.84[bc]	3140[f]	9980[a]	31.46[d]
	6	30.81[bc]	28.82[bc]	3057[f]	9181[ab]	33.18[cd]
	8	29.52[c]	25.37[c]	2637[g]	8368[ab]	31.65[d]
Non-primed		31.07[bc]	31.11[bc]	3335[def]	9500[a]	35.10[bcd]
LSD(P≤0.05)		2.729	5.737	290.9	2450	3.794

*Means in each column followed by similar letter(s) are not significantly different at 5% probability level, using Duncan's Multiple Rang Test.

Grain yield

Increase in storage duration of hydroprimed seeds more than 2 days decreased the grain yield (Table 3). Hydroprimed seeds that were stored at 20° C for 2 days produced maximum grain yield (4113 Kg per hectare). Minimum yield (2637 Kg per hectare) belonged to hydroprimed seeds stored at 25° C for 8 days.

Biological yield and Harvest Index (HI)

Biological yield did not improve by hydropriming significantly (Table 3). On theother hand, appropriate hydropriming increased HI. Maximum harvest index (39.01%) was observed when the hydroprimed seeds were stored at 20° C for 2 days. Nevertheless, long storage generally decreased HI, especially at 25° C (Table 3).

Discussion

Seeds have an important role in crop production. In case an improper seed is used, other effective factors of production could not play their role in production and increase in yield. Although, in the present research, difference in temperature and storage duration of hydroprimed wheat seed was not great, it affected the yield because seed quality during storage depends on important factors such as temperature and duration. In fact, these factors are effective in longevity of seed (Kirshnan, 2005). According to the results of this research, two simple pre-treatment of temperature and storage duration of hydroprimed wheat seeds may affect the growth indices and grain yield. In other word, meaningfulness of these two pre-treatments shows relative importance of these factors.

Results of Shafiei Abnavi and Ghobadi (2012) showed that primed seeds of wheat cultivated after storage within a proper time and in appropriate temperature would have proper germination percentage and speed. Priming of wheat seeds increases germination speed and growth of seedling. Such an increase in germination speed and percentage may be caused by decrease in basic temperature of germination (Abotalebian, 2005). As reported by Satar et al. (2010) fast germination and growth of seedlings play important roles in proper establishment of wheat. In fact, seed priming is a helpful, cheap, and low risk technique which may result in improvement in establishment of seedlings under various environmental conditions. But, by increasing temperature from 20° C to 25° C and storage time from 2 to 8 days, seed were destroyed and their quality degraded. Seed deterioration causes not only a decrease in viability, but also in speed of germination, seed vigor and establishment of seedlings (Nash, 1981). Due to disorders made in cellular organelle like mitochondria and glyoxysomes, reactive oxygen species (ROS), hydroxyl and superoxide radicals would be increased (Bailey et al., 2004). ROS results in peroxidation of lipids and proteins in membranes and destroys membrane structure (Goal and Sheoran, 2003).

In some plant such as Solanom lycopersicum (Bradford and Murray, 1983), lettuce (Cantliffe, 1981), viola (Carpenter and Boucher, 1991) and salvia (Carpenter, 1989), the advantage of seed priming was neutralized when they were stored which caused dryness of embryo during storage period (Bewley and Black, 1985). Increase in speed of seedling emergence and establishment may accelerate their speed in uptake of water and nutrients that enable them to use more sunlight (Finch-Savage et al., 2004).

It seems that seeds hydropriming may increase total contents of chlorophyll, chlorophyll a and b, and rate of photosynthesis and as a result increase the source strength and provision of photo assimilates; eventually, this results in improvement of plant biomass (Roy and Srivastava, 2000). Siosemardeh et al. (2003) reported no meaningful difference in terms of rate of chlorophyll. In the present research, the chlorophyll index and SLAI index decreased by increasing storage temperature from 20° C to 25° C and storage time from 2 to 8 days. In case interval between priming till planting and seed storage conditions are proper, the rate of yield and key factors affecting the yield are also appropriate.

Yield in crops is defined as growth and allocation of biomass to economic parts of plant. As a result, any factor that could increase growth speed would improve the plant yield (Shekari et al., 2010). According to reports by Giri and Schillinger (2003), priming increases grain formation and filling. Maybe increase in yield and growth by seed priming is caused by increase in the rate of transfer of photosynthesis materials from leaves to seeds (Ray and Choudhuri, 1981). Wheat seed priming affects positively the grain yield (Rashid et al., 2004).

It is also reported that priming has increased yield of wheat, corn, and rice and causes fast germination and better tolerance of dryness in semi-dry conditions (Harris et al. 2001). Osmopriming of rapeseed seeds for a period of 8 hours and storing it for 4 hours has affected positively the crop growth rate and grain yield in comparison with hydropriming (Shahzad, 2003). Therefore to justify improvement of yield resulting from hydropriming, it may be concluded that hydropriming may improve the yield by lowering mean germination time and establishment of seedlings, increasing leaf area index, and utilizing sunlight energy more properly.

Yield components including 1000-grain weight, number of grain per spike, number of productive spike, and harvest index are also affected by storage temperature and duration of hydroprimed seeds. There are some reports stating increase in yield of modern species of wheat as a result of increase in number of seeds per spike and number of grain per square meter (Shekari et al., 2010). Results of the present research suggested that the increase in yield is caused by increase in number of spikes per bush and number of grain per spike.

In cereal, harvest index represents distribution of photoassimilates between vegetative part and grain. In fact, this index determines the amount of allocated carbon for grain production. Gent and Kiyomoto (1989) reported that difference in harvest index might be resulted from difference in transfer of photosynthetic materials to the seeds. Ability of plant for preservation of remobilization of photoassimilates may affect harvest index and yield. Wheat with higher ability in remobilization to the grain may produce a high yield. Research conducted by Farooq et al. (2006) suggested that seed priming improves its harvest index. Of course, high harvest index is not a mere basis. It is possible that biological or seed yields are low, but harvest index is high, which represents an improper production in plant. High harvest index would be proper when the plant is close to its genetic potential in terms of both seed and biological yields. Generally, a treatment with proper biologic yield and harvest index is considered as an appropriate treatment (Hashemi et al., 1995).

There are some reports suggesting that priming allows seeds for early DNA transcription and repair, increase in RNA, and synthesis of protein. In addition, it helps in embryo growth and finally it lowers leakage of metabolites by repairing the membrane. It may improve uniform germination and emergence of seedlings (Vieira, 2001). Success in this way is dependent upon proper priming and after-priming processes including drying, seed storage in proper temperature, and duration, and finally proper sowing in the farm.

Conclusion

It seems that storage of hydroprimed seeds of wheat for 2 days at 20°C allows seeds to utilize advantages of priming better than other temperatures and durations. Helpful effects would finally affect the yield. Therefore, it seems that there would be no concerns for immediate planting of hydroprimed seeds of the wheat var Koohdasht. If the farmer could not sow them immediately for various reasons, he may store them for 2 days in 20°C and then use them without any quality losses.

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