Journal of Agricultural Science; Vol. 4, No. 9; 2012
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

The Effects of Source of Priming and Post-priming Storage Duration on Seed Germination and Seedling Growth Characteristics in Wheat (*Triticum aestivem* L.)

Mehdi Shafiei Abnavi[1] & Mokhtar Ghobadi[1]

[1] Department of Agronomy and Plant Breeding, College of Agriculture, Razi University, Kermanshah, Iran

Correspondence: Mokhtar Ghobadi, Department of Agronomy and Plant Breeding, College of Agriculture, Razi University, Kermanshah, Iran. Tel: 98-918-339-8042. E-mail: m.ghobadi@yahoo.com

Received: June 6, 2012 Accepted: June 25, 2012 Online Published: August 8, 2012

doi:10.5539/jas.v4n9p256 URL: http://dx.doi.org/10.5539/jas.v4n9p256

Abstract

This study was designed to investigate the effects of seed storing after priming on germination of two wheat cultivars (Cross Alborz and Sardari). The study consisted of five experiments. In experiments 1- 4 we tested seed priming with distilled water (hydro priming), potassium nitrate (KNO_3), gibberellin (GA_3), PEG-6000 (osmopriming) in different concentrations (50, 100 150 and 200 ppm for GA_3) and (1%, 2%, 3% and 4% for KNO_3) and times (12, 18, 24 and 30 hours). Germination tests were subsequently performed on all above mentioned seed priming methods. The best treatment (time and concentration of media) which emanated from experiments 1-4 was considered for experiment 5. In experiment 5, we tested the effects of storing duration after seed priming (0, 30, 45 and 60 days) on germination characteristics of wheat. Maximum stem and radicle length, stem and radicle dry weight and speed of germination in cv. Cross Alborz and cv. Sardari were observed in priming treatments when the seeds primed by GA_3 50 ppm for 24h, KNO_3 1% for 24h, hydropriming 12h and osmopriming 12h.The results showed that storing of primed seeds improved shoot and radicle length, shoot and radicle dry weight, germination percentage and speed of germination.

Keywords: wheat, seed priming, seed storing, germination

1. Introduction

Wheat (*Triticum aestivum* L.) belongs to Poaceae family and is the most food crop in the world. In South Asia, earlier report showed that wheat production covered about 42% of the total cropped area and 32% of total rice (*Oryza sativa* L.) area in rice-wheat cropping systems (Iqbal et al., 2002). Rapid seed germination and stand establishment are critical factors for crop production under stress conditions, which includ in many crop species, seed germination and early seedling growth are the most sensitive stages to stresses.

Seed priming is known as the seed treatment which improves seed performance under environmental conditions (Ashraf et al., 2005). Gibberellins (GA_3) and cytokinins (CKs) control different developmental processes in plants. CKs act early during shoot initiation and control meristem activity, while GA_3 are responsible for expansion and cell division in shoot elongation, flowering and seed germination. All phytohormones exert their regulatory role in close relation with each other. Hormone signaling pathways form complex interacting network, which enables perceiving of numerous internal and external stimuli and generating respective plant responses. Additionally, exogenously applied growth regulators can alter the content of endogenous phytohormones (Pospíšilová, 2003). The biosynthesis of GA_3 is regulated by both developmental and environmental stimuli (Yamaguchi & Kamiya, 2000).

Rapid and uniform field emergence is essential to achieve high yield with respect to both quantity and quality in annual crops (Parera & Cantliffe, 1994; Subedi & Ma, 2005). Seed zone water content is the controlling factor for wheat seedling emergence, but soil temperature and depth of soil covering the seed are also important (Lindstrom et al., 1976; Kirby, 1993). The three early phases of germination are: (i) imbibition, (ii) lag phase and (iii) protrusion of the radicle through the testa (Simon, 1984). Seed priming can be used to enhance rapid and uniform seed emergence, and to achieve high vigor and better yields in vegetables and floriculture (Farooq et al., 2007; Farooq et al., 2008). Seed priming is a technique by which seeds are partially hydrated to a point where germination processes begin but radicle emergence does not occur (Bradford, 1986). Priming allows some of the

metabolic processes necessary for germination to occur without germination take place. In priming, seeds are soaked in different solutions with high osmotic potential. This prevents the seeds from absorbing in enough water for radicle protrusion, thus suspending the seeds in the lag phase (Taylor et al., 1998). Seed priming has been commonly used to reduce the time between seed sowing and seedling emergence and to synchronize emergence (Parera & Cantliffe, 1994). Seed priming treatments have been used to accelerate the germination and seedling growth in most of the crops under normal and stress conditions (Basra et al., 2003). Reported that primed crops grew more vigorously, flowered earlier and yielded higher (Farooq et al., 2008). It has also been reported that seed priming improves emergence, stand establishment, tillering, allometry, grain and straw yields, and harvest index (Farooq et al., 2008). Typical responses to priming are faster and closer spread of times to germination and emergence over all seedbed environments and wider temperature range of germination, leading to better crop stands and hence improved yield and harvest quality, especially under sub-optimal and stress condition growing conditions in the field (Halmer, 2004). Normally priming is done either in low water potential solution (osmopriming) or in tap water (hydro-priming), however, incorporation of plant growth regulators during priming have improved seed germination, establishment and crop performance (Afzal et al., 2002). In priming, seeds are soaked in different solutions with high osmotic potential. This prevents the seeds from absorbing enough water for radicle protrusion, thus suspending the seeds in the lag phase (Taylor et al., 1998). Seed priming has been commonly used to reduce the time between seed sowing and seedling emergence and to synchronize emergence (Parera et al., 1994). The beneficial effects of priming have been demonstrated in many other crops (Mhemet et al., 2006). The seed treatment with hormone and salt solution might have increased the metabolic activity of the plant in such a direction as to result in increased uptake of N, P, K^+ and Ca_2^+ (Chippa & Lal, 1988). Osmotic solutions are used to impose water stress reproducibly under in vitro conditions (Pandey & Agarwal, 1998). In osmoconditioning seeds are held at low water potential solutions while during matric conditioning seed hydration is controlled by the physical and osmotic characteristic of a solid matrix carrier (Kubik et al., 1989). Guzman and Olave (2006) reported that seed priming with nitrate solutions improved germination rate, radical growth and germination index. Considering the above points on the effects of seed priming to improve seed germination and subsequent plant growth, there is still scanty literature on the effects of seed storing duration after seed priming on germination behaviors. The objective of this study was to investigate the effects of primed seed storage duration on germination and seedling growth characteristics.

2. Materials and Methods

The study was conducted in the Physiology Laboratory, Department of Agronomy and Plant breeding, Faculty of Agriculture Razi University, Kermanshah, Iran (34º 18´ N and 47º 3´E) from August to December 2011. Wheat cultivars (Cros Alborz and Sardari) were received from Dryland Agricultural Research Center Sararood, Kermanshah, Iran. These cultivars are among widely cultivated bread wheat cultivars under dry land farming conditions in Kermanshah, Iran. Before the start of each experiment, seeds were surface sterilized in 1% sodium hypochlorite solution for 3 min, then rinsed with sterilized water and air-dried for 48h. The study consisted of five experiments. Each experiment was arranged in a factorial experimental design with four replications. All priming media were prepared in distilled water. Seeds were fully immersed in priming media at 20 ºC under dark conditions and thereafter, treatment seeds were given three surface washings with distilled water and retried to original weight (Thousand seed weight of each cultivar equal with 39.8g) with forced air under shade at 23± 2°C as earlier describe (Basra et al., 2002). All seeds were removed from priming media at the same time and then rinsed thoroughly with distilled water and hand dried lightly using blotting paper. Primed and non-primed seeds were placed in 9 cm glass Petri dishes on a layer of filter paper (Whatman # 41). Twenty five seeds were placed in each Petri dish and filter paper moistened with 10 ml of distilled water. Seed was kept at room temperature (20°C) in dark condition. Seeds were considered germinated when radicle protruded for up to 2 mm (Ashraf et al., 1978). Germinated seeds were recorded daily up to day 7 after the start of the experiment and this continued for 8 days. Germination percentage (GP) was calculated based on the following equation (Ashraf et al., 1978):

$$\mathrm{GP} = \frac{\text{Total germinated seeds after 8 days}}{\text{Total number of seeds}}$$

Then the mean germination rate was calculated according to the following equation (Ellis et al., 1987):

$$\mathrm{MGR} = n / Dn$$

Where MGR is the mean germination rate, n is the number of seeds germinated on day and Dn is the number of days from the start of test. Data in each experiment separated were analyzed using SAS (Statistical software, SAS institute, 2002) and treatment means were compared using Duncan's multiple range test at 5% level of probability.

2.1 Experiment 1

In experiment 1, effect of five hydro priming times (0, 12, 18, 24 and 30 h) were evaluated on germination of two wheat cultivars.

2.2 Experiment 2

In experiment 2, we tested priming with KNO_3 in five concentrations (0, 1, 2, 3 and 4%), in four times (12, 18, 24 and 30 h) on two wheat cultivars (Cros Alborz and Sardari).

2.3 Experiment 3

In experiment 3, we tested priming with GA_3 in five concentrations (0, 50, 100, 150 and 200 ppm), in four times (12, 18, 24 and 30 h) on tow wheat cultivars.

2.4 Experiment 4

In experiment 4, we tested osmopriming on two wheat cultivars, using PEG-6000 (-0.3Mpa) in four times (12, 18, 24 and 30 h).

2.5 Statistical Analysis

Each experiment was arranged in a factorial experimental design with four replications. Data in each experiment separated were analyzed using SAS (Statistical software, SAS institute, 2002) and treatment means were compared using Duncan's multiple range test at 5% level of probability.

The beast treatment combination (time and concentration of media) for Cross Alborz and Sardari cultivars were selected from each experiments. These four treatments were considered for experiment 5 in each cultivar.

2.6 Experiment 5

In experiment 5, we tested the effects of storage duration (0, 30, 45 and 60 days) after seed priming on germination characteristics. So, the four selected priming treatments were performed for each cultivar (GA_3 50ppm for 24h, KNO_3 1% for 24h, PEG-6000 for 12h and distilled water for 12h). All seeds were removed from priming media and then rinsed thoroughly with distilled water and dried at room temperature (20 °C) conditions. Then, primed seeds were stored at 20 °C under dark conditions. 0, 30, 45 and 60 days after seed priming, germination test carried out on primed seeds. Shoot and radicle length, shoot and radicle dry weight, speed of germination and germination percentage were measured eight days after beginning of the test. This experiment was as completely randomized design (CRD) with four replications.

3. Results and Discussion

3.1 Experiment 1

Seed priming had significant positive effect on different aspects of germinated seeds (Table 6). In both cultivars the effect of hydro priming was significant for 12h (Table 9).

3.2 Experiment 2

In KNO_3 treatments, solution (1%) for 24h was the beast. Storing duration after seed priming affected significantly on the germination parameters in two cultivars (Table 3 and 4). Comparison of means c.v Cross Alorz (Table 4) indicated that all of the adjectives under study were significant ($P<0.05$).

3.3 Experiment 3

Comparison of means Cross Alorz and Sardari cultivars (Table 1) indicated that almost of the adjectives under study were significant ($P<0.05$) when the seeds primed by GA 50 ppm for 24h. In general, in different concentrations at 18 and 24 hours were better than other times (Tables 1 and 2).

3.4 Experiment 4

In osmopriming treatments (Table 10) indicate that maximum shoot length, radicle length, shoot dry weight, and germination rate in cv.Cross Alborz and Sardari were observed when the seeds primed by PEG (-0. 3Mpa) for 12h. Results also showed that shoot length and radicle length in osmspriming improved compared to hormonal priming. Both GA_3 and PEG-6000 seed priming improved germination rate compared to the control treatment (Tables 1 and 10).

3.5 Experiment 5

Maximum shoot and radicle length, shoot and radicle dry weight, rate of germination and germination percentage in cv.Cross Alborz was observed in 60 days after seed priming. In general, 60 days after seed priming was better than other storage duration after seed priming (Tables 3-4). Comparison of means of storageafter seed

priming for germination characteristics in c.v Sardari (Table 3) showed that germination parameters among storing duration after seed priming were significant ($P<0.05$). For cv. Sardrri, the same cv. Cross Alborz , maximum were observed in 60 days after seed priming. These results showed that for both wheat cultivars germination test at 30, 45 and 60 days after seed priming had more shoot dry weight (Figure 1), more radicle dry weight (Figure 2), more shoot length (Figure 3), more radicle length (Figure 4), more speed of germination (Figure 5) and more germination percentage (Figure 6) than immediately after seed priming. CKs act early during shoot initiation and control meristem activity, while GA_3 are responsible for expansion and cell division in shoot elongation, flowering and seed germination. All phytohormones exert their regulatory role in close relation with each other. Hormone signaling pathways form complex interacting network, which enables perceiving of numerous internal and external stimuli and generating respective plant responses. Additionally, exogenously applied growth regulators can alter the content of endogenous phytohormones (Pospíšilová 2003), therefore one of reasons for the results of present study indicated that stored primed seeds had more germination characteristics than fresh primed seeds is probably the enzyme and hormonal disorders in seed that causes more activity. The superiority in speed of germination of KNO_3 priming was related to more nitrogen and potassium accumulation in seeds treated with KNO_3. The cultivars under study showed different responses to the KNO_3 priming. Increase in germination of KNO_3 primed seeds recorded over control. This increase in germination may be due to the activity of α-amylase due to osmopriming. Amylases are key enzymes that play a vital role in hydrolyzing the seed starch reserve, thereby supplying sugars to the developing embryo. In present study, KNO_3, GA_3, PEG-6000 and distilled water treatments improved germination parameters. One of results of this study was seeds primed with KNO_3 showed better germination parameters than seed primed with distilled water. This result in agreements with observations of Mohamadi and Amiri (2010) who reported that seeds primed with KNO_3 had better germination parameters than those primed with distilled water. Consistent with our results, similar finding were observed by Harris et al., (2001), Arif et al., (2003), Sung and Chang (1993), who reported improvement in seed germination, reduction in germination time and enhanced emergence in hydro primed seed. Ramezan et al., (2010) indicated that Potassium nitrate at 1% had a positive interaction with both time periods that in germination with result this study. It is possible that its positive effect might be due to its role in influencing the permeability of the membranes which ultimately leads to activation of enzymes involved in protein synthesis and carbohydrate metabolism (Preece and Read., 1993). Furthermore, hydro priming resulted in increase of normal germination (Basra et al., 2003). Seed priming with KNO_3 might have resulted in enhancement of nutrient supply (K^+ and NO_3^-) towards the developing seedling that results in higher weight. It has been reported that seed treatment with shikimic acid improved yield and yield components of cowpea plants by increasing the seed biomass. Aldesuquy and Ibrahim (2000), Neamatollahi et al., (2006) reported that hydro priming increased seedling dry weight under saline condition. Caseiro et al., (2004) Found that hydro priming was the most effective method for improving seed germination of onion. By result of this experiment and other experiments, we can conclude that suitable priming period, osmotic and hormonal priming. The two cultivars responded differently with respect to germination percentage, speed of germination, radicle dry weight and radicle length in hormonal priming. Cross Alborz cultivar showed the highest radicle length, radicle dry weight, germination percentage and speed of germination compared to Sardari cultivar. Higher germination in osmopriming was obtained at 12h for wheat cultivars. The results of the present study are in agreements with observations of Yari et al., (2010) who reported that maximum radicle length of Sardari cultivar was obtained at 20% PEG-6000 solution primed for 24h. Zareh et al., (2006) indicated that priming of wheat seed with GA_3 decreased germination but has a positive effect on shoot growth. Ghana et al., (2003) reported that seed priming has limited practical worth for enhancing emergence and yield of winter wheat planted deep into summer fallow. Pre-treatment of seeds with different type of hormones and plant growth regulators is much effective in alleviating stress effects of salinity on the plants at different stages especially at early stage and it has been shown to improve crop germination as reported earlier under salt stress (Ashraf and Foolad, 2005; Ashraf et al., 2008). The results of the present study are in agreements with observations of Chauhan et al., (2009) who reported that seeds treated with GA_3 showed significant difference to control, too indicated that the germination percentage decreases when the concentration increased, which shows that higher concentration inhibit germination and the longest radicle length was observed under GA_3 50 ppm. Also the results of the present study are in agreements with observations of Xingru (2009) who showed that shoot growth was promoted by GA_3 and root growth was promoted by GA_3. Afzal et al., (2004) also found that the osmopriming (jute mat) proved to be the best in reducing the time to 50% germination and mean germination time among all priming treatments. During emergence test, priming treatments i.e; osmopriming (jute mat) for 24 hours reduced the time to 50% emergence and mean emergence time. One of the this result show that PEG-6000 caused the maximum improved shoot length, radical length, shoot dry weight, radical dry weight, speed of germination, This result is not

agreement with Moradi Dezfuli et al., (2008) who indicated that PEG6000 soaked seeds did not act well from germination point of view, possibly due to low osmotic potential of the solution or long priming duration. Sharifzadeh et al., (2006) also found that osmopriming of wheat had no positive significant effect on germination characteristics. Enzymes such as amylase, protease and lipase have a great role in initial growth and development of embryo and every increase in activity of these enzymes results in faster initial growth of seedling therefore its establishment improvement result in higher yield. As Singh et a1., (1999) reported that osmotic priming of muskmelon with PEG result in higher amylase and dehydrogenises activity and germination rate increased in saline conditions.

Table 1. Means of seed germination and seedling growth features following seed treatment ingibberellic acid for cv.CrossAlborz and Sardari

GA Concentrations (ppm)	Times	Shoot length(cm)	Radicle length(cm)	Shoot dry weight(mg)	Radicle dry weight(mg)	Speed of germination	Germination percentage (%)
cv. cross Alborz	control	13.38^{b-h}	9.50^{b}	205.50^{c}	119^{b}	18.81^{b}	98^{ab}
50	12	13.86^{b-f}	6.80^{c-f}	156.50^{def}	73.25^{c}	10.05^{cd}	68^{d-j}
50	18	13.84^{b-f}	4.70^{def}	156.25^{def}	66.25^{cd}	12.94^{c}	81^{a-h}
50	24	16.85^{a}	12.20^{a}	232.19^{a}	160^{a}	21.05^{a}	100^{a}
50	30	12.10^{e-i}	4.77^{d-g}	143.25^{d-h}	63.50^{cde}	8.58^{cd}	60^{g-n}
100	12	14.40^{a-e}	4.27^{ed}	150.25^{d-g}	50.50^{d-g}	9.25^{cd}	66^{d-k}
100	18	15.35^{abc}	5.17^{d-g}	150.50^{d-g}	52.25^{c-f}	10.24^{cd}	62^{e-m}
100	24	16.21^{ab}	4.22^{d-g}	142^{d-h}	52^{c-f}	20.63^{a}	94^{abc}
100	30	13.66^{b-g}	4.07^{e-i}	153.25^{def}	55.75^{c-f}	9.60^{cd}	63^{e-l}
150	12	13.36^{b-h}	3.11^{f-j}	116^{df-i}	38.50^{f-j}	10.43^{cd}	57^{g-o}
150	18	15.20^{abc}	3.55^{f-j}	149.25^{d-g}	41^{f-i}	8.67^{cd}	76^{a-h}
150	24	15.54^{abc}	4.49^{edf}	164de	27^{h-m}	21.02^{a}	97^{ab}
150	30	14.76a^{-d}	2.96^{edf}	117^{e-i}	42.75^{e-i}	8.33^{cd}	54^{h-o}
200	12	13.42^{c-g}	4.40^{edf}	120.75^{e-i}	42^{e-h}	8.67^{cd}	59^{g-o}
200	18	13.84^{b-f}	3.11^{f-j}	137.25^{d-h}	36.50^{f-k}	9.07^{cd}	70^{b-i}
200	24	14.36^{a-e}	2.25^{g-k}	106.25^{g-j}	22.50^{i-m}	9.07^{cd}	57^{g-o}
200	30	13.59^{c-g}	3.55^{e-i}	82^{i-l}	33.50^{f-k}	9.67^{cd}	58^{g-o}
cv.Sardari	control	11.32^{f-k}	9.43^{b}	168.25^{cd}	110.75^{b}	18.18^{b}	96^{ab}
50	12	10.81^{h-k}	2.52^{g-k}	106.25^{ghi}	45.50^{d-g}	5.68^{d}	33no
50	18	12.34^{d-i}	5.59^{cd}	125.50^{d-i}	66.75^{cd}	7.18^{cd}	43^{i-o}
50	24	15.58^{abc}	10.72^{ab}	221.25^{b}	150^{a}	19.69^{a}	91^{a-d}
50	30	11.73^{e-i}	2.42^{h-k}	92^{ijk}	37^{f-k}	6.13^{d}	40^{k-o}
100	12	9.80^{ijk}	2.03^{ijk}	54.50^{k-n}	20.25^{i-m}	6.30^{d}	37^{l-o}
100	18	10.65^{ijk}	1.59^{jk}	65^{j-n}	24.25^{h-m}	6.35^{d}	36^{l-o}
100	24	11.82^{e-i}	1.75^{ijk}	68.75^{j-m}	24.75^{h-m}	12.94^{c}	81^{a-h}
100	30	10.78^{h-k}	0.69^{k}	41.25^{lmn}	10.50^{m}	5.82^{d}	31^{o}
150	12	9.1^{k}	0.98^{k}	44^{lmn}	15^{klm}	6.65^{cd}	42^{j-o}
150	18	10.79^{h-k}	1.07^{k}	81.75^{ijk}	24.75^{h-m}	7.61^{cd}	38^{l-o}
150	24	12.14^{e-i}	2.41^{h-k}	89^{ijk}	31.75^{h-m}	9.07^{cd}	70^{b-i}
150	30	11.97^{e-i}	1.98^{ijk}	41^{lmn}	10.07^{m}	5.86^{d}	34^{mn}
200	12	8.96^{k}	0.88^{k}	27^{nm}	13^{lm}	9.40^{cd}	43^{i-o}
200	18	10.78^{h-k}	1.40^{jk}	39.75^{lmn}	11.25^{lm}	6.80^{cd}	54^{h-o}
200	24	11.18^{g-k}	1.44^{jk}	40.50^{lmn}	16.25^{j-m}	8.33^{cd}	55^{h-o}
200	30	6.14^{l}	0.73^{k}	23^{n}	10.25^{m}	7.27^{cd}	41^{j-o}
CV%		13	12	11	9	11	8

*Values with at least one same letter in column, do not have significant difference (P<0.05).

Table 2. Means comparison of cv.Cross Alborz and Sardari with control in KNO_3 treatments

KNO3 Concentratins (%)	Times	Shoot length(cm)	Radicle length(cm)	Shoot dry weight(mg)	Radicle dry weight(mg)	Speed of germination	Germination percentage (%)
cv. cross Alborz	control	12.79^{i}	9.16^{e-l}	206.85 ^{bc}	120^{b}	18.66^{abc}	97^{ab}
1	12	18.10^{i-f}	12.12^{a-f}	179.75 $^{b-e}$	68^{c-g}	12.18^{cde}	69^{d-j}
1	18	18.57^{a-f}	13.56^{a-d}	196.25 $^{a-d}$	78.75^{dc}	12.60^{b-e}	82^{a-h}
1	24	19.75^{a}	14.70^{a}	220 ^{a}	138.7^{a}	22.36^{a}	100^{a}
1	30	17.12^{c-h}	10.77^{b-j}	162 $^{c-g}$	65.25^{c-h}	10.64^{de}	61^{g-n}
2	12	18^{a-f}	10.85^{b-j}	161^{c-g}	66.25^{c-h}	11.48^{de}	62^{d-k}
2	18	18.75^{a-e}	11.15^{b-i}	164.50^{c-g}	68.75^{c-f}	12.60^{b-e}	95^{abc}
2	24	19.47^{ab}	13.95^{abc}	166.50^{c-f}	59^{c-i}	9.66^{e}	62^{e-m}
2	30	17.70^{a-h}	10.75^{b-g}	157^{c-g}	58.75^{c-i}	9.70^{e}	64^{e-l}
3	12	18.10^{a-f}	7.80^{i-n}	110^{fgh}	44^{f-k}	11.20^{de1}	59^{g-o}
3	18	18.90^{a-d}	12^{a-f}	145.75^{d-g}	55.25^{d-i}	12.60^{b-e}	75^{a-h}
3	24	19.35^{ab}	12.29^{a-f}	159^{c-g}	58.25^{c-i}	21.74^{a}	96^{ab}
3	30	16.42^{gh}	6.95^{k-n}	107^{fgh}	40.50^{g-k}	10.04^{e}	54^{h-o}
4	12	17.95^{a-f}	8^{h-n}	119^{fgh}	43.25^{f-k}	10.62^{de}	59^{g-o}
4	18	18.72^{a-f}	8.79^{f-m}	121.50^{eh}	50^{e-j}	12.55^{b-e}	72^{b-i}
4	24	18.81^{a-e}	11.43^{b-h}	154^{c-g}	58^{d-i}	20.69^{a}	51^{g-o}
4	30	16.70^{e-h}	6.35^{lmn}	71.25^{h}	24^{jk}	6.08^{e}	59^{g-o}
cv. Sardari	control	12.77^{i}	10.76^{b-j}	167.50^{c-f}	112^{b}	17.70^{a-d}	98^{ab}
1	12	17.22^{d-k}	12.67^{a-e}	190.50^{bcd}	74.75^{cde}	8.70^{e}	82^{a-h}
1	18	18.30^{a-g}	13.21^{a-d}	207.50 ^{abc}	85.50^{c}	10.16^{e}	92^{a-d}
1	24	19.48^{ab}	14.05^{ab}	210 ^{ab}	138.75^{a}	20.44^{a}	100^{a}
1	30	16.62^{a-d}	10.19^{d-k}	157.25 $^{c-g}$	63.75^{c-h}	8.44^{e}	59^{g-o}
2	12	17.82^{a-h}	10.34^{c-k}	155 $^{c-g}$	54.75^{d-i}	7.47^{e}	59^{g-o}
2	18	18.43^{a-g}	10.81^{b-j}	160.25 $^{c-g}$	61.25^{c-i}	10.41^{e}	75^{a-h}
2	24	18.72^{a-f}	12.95^{a-d}	160.50 $^{c-g}$	67^{c-h}	19.91^{a}	81^{a-h}
2	30	16.83^{d-h}	10.90^{b-j}	151 $^{c-g}$	54^{d-i}	7.2^{e}	75^{a-h}
3	12	17.45^{b-h}	7.36^{j-n}	115.25 ^{fgh}	39^{h-k}	9.01^{e}	51^{g-o}
3	18	18.71^{a-f}	11.66^{a-g}	142.75 $^{d-g}$	52^{d-i}	10.01^{e}	62^{d-k}
3	24	19.06^{abc}	12.43^{a-e}	159.50 $^{c-g}$	56^{d-i}	19.25^{abc}	70^{b-i}
3	30	15.84^{h}	5.06^{n}	104 ^{gh}	35.50^{ijk}	8.06^{e}	42^{j-o}
4	12	17.62^{b-h}	7.55^{j-n}	114 ^{fgh}	40^{g-k}	8.20^{e}	62^{e-m}
4	18	18.70^{a-f}	8.15^{g-n}	117.75^{fgh}	45.50^{f-k}	11.10^{e}	54^{h-o}
4	24	19.21^{abc}	11.63^{a-g}	150.75 $^{c-f}$	54.50^{d-i}	19.42^{ab}	81^{a-h}
4	30	16.46^{gh}	5.41^{mn}	71.25 ^{h}	20.75^{k}	7.58^{e}	51^{g-o}
CV%		10	11	8	12	9	13

*Values with at least one same letter in column, do not have significant difference (P<0.05).

Table 3. Means comparison of storage duration after seed priming for germination characteristics in Sardari cultivar

Storing duration after seed priming (days)	Shootlength (cm)	Radicle length (cm)	Shoot dry weight(mg)	Radicle dry weight (mg)	Speed of germination	Germination percentage
Control (0)	14.78^{b}	7.77^{b}	176.73^{b}	109.85^{b}	18.74^{b}	82.66 ^{b}
30	17.09^{a}	10.88^{a}	217.09^{a}	118.7 ^{a}	20.09 ^{a}	92.45 ^{a}
45	16.74^{a}	11.11^{a}	220.8^{a}	121 ^{a}	20.76^{a}	92.55^{a}
60	16.87^{a}	11.38^{a}	227.6^{a}	129 ^{a}	22.95^{a}	100^{a}
CV%	8	9	10	10	12	11

*Values with at least one same letter in column, do not have significant difference (P<0.05).

Table 4. Means comparison of storage duration after seed priming for germination characteristics in Cross Alborz cultivar

Storing duration after seed priming (days)	Shoot length (cm)	Radicle length (cm)	Shoot dry weight (mg)	Radicle dry weight (mg)	Speed of germination	Germination percentage
Control (0)	13.95[c]	7.61[b]	172.85[b]	140[b]	18.92[b]	93.2[b]
30	16.22[b]	11.78[a]	258.7[a]	170.55[a]	24.21[a]	100[a]
45	16.96[ab]	11.65[a]	252.7[a]	166.05[a]	24.56[a]	99.8[a]
60	17.53[a]	11.53[a]	274.55[a]	165.35[a]	24.61[a]	100[a]
CV%	9.5	8.79	11	9	11	10.4

*Values with at least one same letter in column, do not have significant difference (P<0.05).

Table 5. Means comparison of cv.CrossAlborz compared with cv. Sradari in osmopriming treatments

Cultivar wheat	shoot length (cm)	Radicle length (cm)	shoot dry weight (mg)	Radicle dry weight (mg)	Speed of germination	Germination percentage (%)
Cross alborz	15.24[a]	11.32[a]	202.80[a]	115.88[a]	17.51[a]	90.60[a]
sardari	15.17[a]	10.23[a]	178.78[b]	107.05[b]	16.80[a]	87.20[a]
CV%	6.7	11	9.7	12	11	13

*Values with at least one same letter in column, do not have significant difference (P<0.05).

Table 6. Means comparison of cv.CrossAlborz compared with cv. Sradariin hormonal priming treatments

Cultivar wheat	shoot length (cm)	Radicle length (cm)	shoot dry weight (mg)	Radicle dry weight (mg)	Speed of germination	Germination percentage (%)
Cross alborz	15.29[a]	11.79[a]	160.3[a]	67.42[a]	16.79[a]	73.35[a]
sardari	11.94[b]	8.50[b]	124.2[b]	52.10[b]	13.30[b]	53.82[b]
CV%	7.5	8.7	10	11	10.4	10

*Values with at least one same letter in column, do not have significant difference.

Table 7. Means comparison of cv.CrossAlborz compared with cv. Sradariin hydropriming priming treatments

Cultivar wheat	shoot length(cm)	Radicle length(cm)	shoot dry weight(mg)	Radicle dry weight(mg)	Speed of germination	Germination percentage(%)
Cross alborz	13.82[a]	7.84[a]	157.20[a]	76.44[b]	16.61[a]	90.40[a]
sardari	13.70[a]	7.70[a]	128.91[b]	71.30[a]	16.05[a]	92.20[a]
CV%	10	10.3	8	8.4	7.6	11

*Values with at least one same letter in column, do not have significant difference (P<0.05).

Table 8. Means comparison of cv.CrossAlborz compared with cv. Sradariin KNO_3 priming treatments

Cultivar wheat	shoot length (cm)	Radicle length (cm)	shoot dry weight (mg)	Radicle dry weight (mg)	Speed of germination	Germination percentage (%)
Cross alborz	16.03[a]	11.28[a]	164.39[a]	75.18[a]	12.70[a]	76.07[a]
sardari	17.44[a]	10.94[a]	160.75[b]	65.93[b]	12.19[b]	71.81[b]
CV%	9	10.3	8.6	10.9	8.6	8.7

*Values with at least one same letter in column, do not have significant difference (P<0.05).

Table 9. Means comparison of the cv. CrossAlborz and Sradari with control in hydro priming treatments

cultivar	Times	shoot length(cm)	Radicle length(cm)	shoot dry weight(mg)	Radicle dry weight(mg)	Speed of germination	Germination percentage(%)
Cross Alborz	control	13.85^{bc}	10.52^{b}	199.50^{bc}	107.75^{b}	16.23^{b}	97^{a}
	12	16.17^{a}	12.89^{a}	261.50^{a}	136.50^{a}	21.73^{a}	100^{a}
	18	13.87^{bc}	6.21^{dc}	120.75^{fe}	42.25^{c}	15.60^{c}	85^{b}
	24	12.48^{bcd}	5.50^{cde}	98^{f}	34.75^{c}	15.40^{c}	86^{b}
	30	12.14^{dc}	4.11^{de}	93.75^{f}	35.25^{c}	14.09^{c}	84^{b}
Sardari	control	13.67^{bc}	10.46^{b}	166^{cd}	112.50^{b}	16.20^{b}	98^{a}
	12	16.47^{a}	12.52^{a}	224.75^{b}	132.70^{a}	21.08^{a}	100^{a}
	18	14.43^{ab}	7.21^{c}	138.25^{de}	52.50^{c}	15^{c}	87^{b}
	24	12.46^{bcd}	4.70^{de}	136.25^{de}	52.25^{c}	15^{c}	89^{b}
	30	12.05^{cd}	3.61^{e}	100.75^{f}	32.25^{c}	13^{d}	87^{b}
	CV%	10.7	12	11.4	12	10.2	9.7

*Values with at least one same letter in column, do not have significant difference (P<0.05).

Table 10. Means comparison of the cv. CrossAlborz and Sradari with control in osmopriming treatments

cultivar	Times	Shoot length(cm)	Radicle length(cm)	shoot dry weight(mg)	Radicle dry weight(mg)	Speed of germination	Germination percentage(%)
Cross Alborz	control	12.68^{b}	10.40^{bc}	203^{b}	117.4^{bc}	17.73^{b}	96^{a}
	12	16.62^{a}	14.10^{a}	231^{a}	141^{a}	22.43^{a}	100^{a}
	18	15.98^{a}	12.20^{b}	210^{b}	122^{b}	16.20^{c}	86^{b}
	24	15.63^{a}	11.20^{bc}	190^{c}	112^{c}	16.20^{c}	87^{b}
	30	15.3^{a}	8.70^{c}	180^{c}	87^{e}	15.03^{c}	84^{b}
Sardari	control	12.10^{b}	11.70^{bc}	165.7^{d}	111.75^{c}	18^{b}	96^{a}
	12	15.54^{a}	13.40^{a}	180.21^{c}	127^{b}	22^{a}	100^{a}
	18	16.01^{a}	9.08b^{c}	182^{c}	113.5^{c}	16^{c}	84^{b}
	24	16.60^{a}	8.58^{d}	185^{c}	100^{d}	15^{c}	80^{b}
	30	15.62^{a}	8.40^{c}	181^{c}	83^{e}	13^{d}	76^{bc}
	CV%	9.7	13	14.2	12	10.7	12.3

*Values with at least one same letter in column, do not have significant difference (P<0.05).

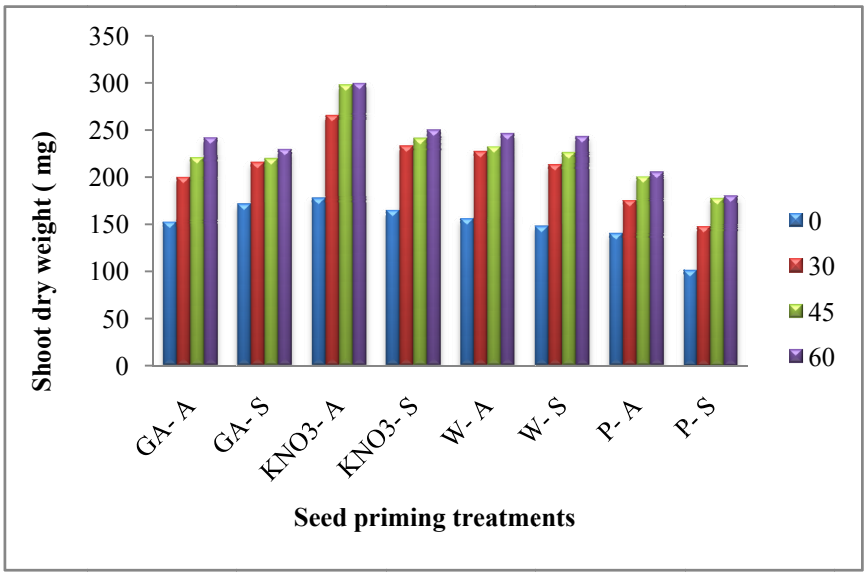

Figure 1. Influence of storing duration after seed priming on shoot dry weight of two wheat cultivars in germination test, GA-A =seed primed with GA in cv. Cross Alborz, GA-S=seed primed with GA in cv. Sardari, KNO_3-A=seed primed with KNO_3 in cv. Cross Alborz, KNO_3-S =seed primed with KNO_3 in cv. Sardari, W-A=seed primed with distilled water in cv. Cross Alborz, W-S=seed primed with distilled water in cv. Sardari, P-A=seed primed with PEG 6000 in cv. Cross Alborz, P- S=seed primed with PEG 6000 in cv. Sardari

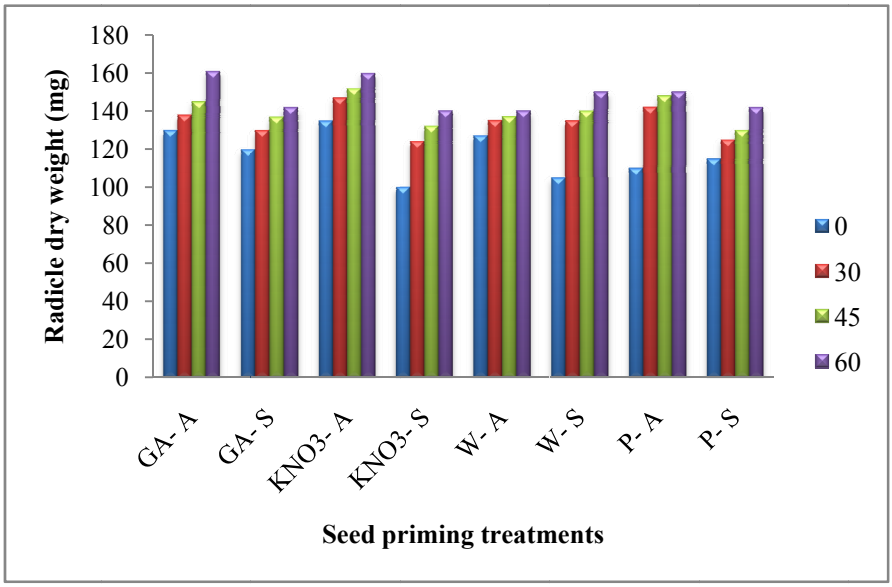

Figure 2. Influence of storing duration after seed priming on shoot dry weight of two wheat cultivars in germination test, GA-A=seed primed with GA in cv. Cross Alborz, GA-S =seed primed with GA in cv. Sardari, KNO_3-A =seed primed with KNO_3 in cv. Cross Alborz, KNO_3-S =seed primed with KNO_3 in cv. Sardari, W-A=seed primed with distilled water in cv. Cross Alborz, W-S=seed primed with distilled water in cv. Sardari, P-A =seed primed with PEG 6000 in cv. Cross Alborz, P- S=seed primed with PEG 6000 in cv. Sardari

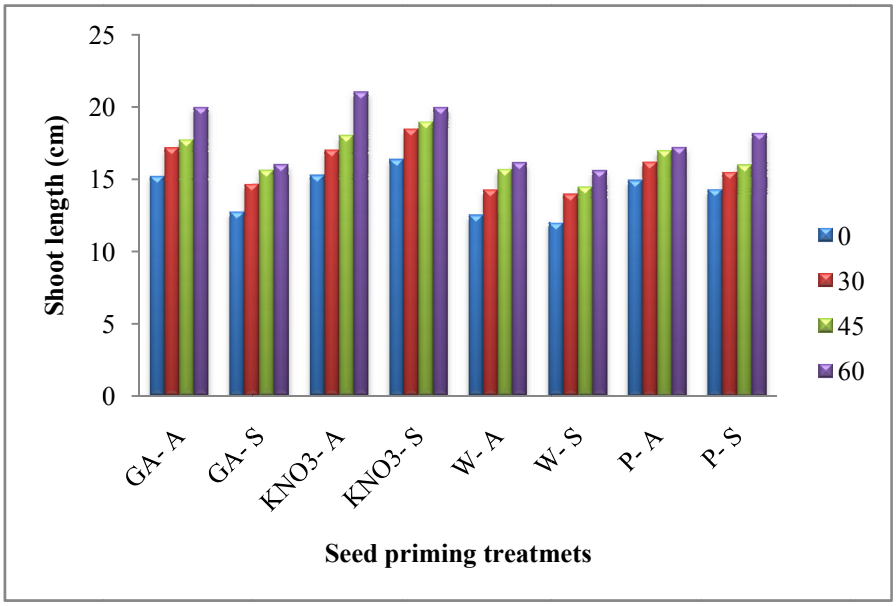

Figure 3. Influence of storing duration after seed priming on shoot dry weight of two wheat cultivars in germination test, GA-A =seed primed with GA in cv. Cross Alborz, GA-S=seed primed with GA in cv. Sardari, KNO3-A=seed primed with KNO3 in cv. Cross Alborz, KNO3-S=seed primed with KNO3 in cv. Sardari, W-A=seed primed with distilled water in cv. Cross Alborz, W-S=seed primed with distilled water in cv. Sardari, P-A= seed primed with PEG 6000 in cv. Cross Alborz, P-S=seed primed with PEG 6000 in cv. Sardari

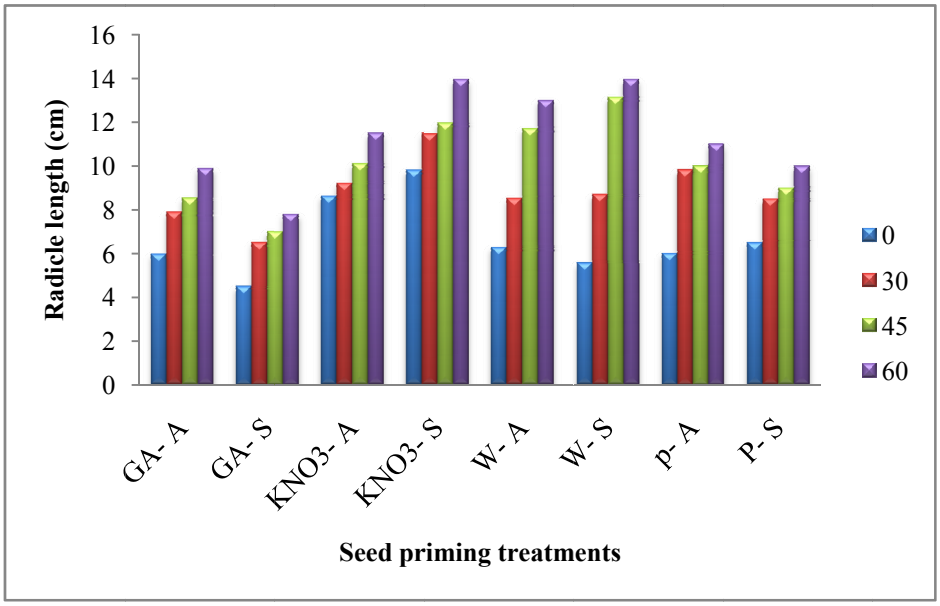

Figure 4. Influence of storing duration after seed priming on shoot dry weight of two wheat cultivars in germination test, GA-A= seed primed with GA in cv. Cross Alborz, GA-S=seed primed with GA in cv. Sardari, KNO_3-A=seed primed with KNO_3 in cv. Cross Alborz, KNO_3-S=seed primed with KNO_3 in cv. Sardari, W-A=seed primed with distilled water in cv. Cross Alborz, W-S=seed primed with distilled water in cv. Sardari, P-A =seed primed with PEG 6000 in cv. Cross Alborz, P-S= seed primed with PEG 6000 in cv. Sardari

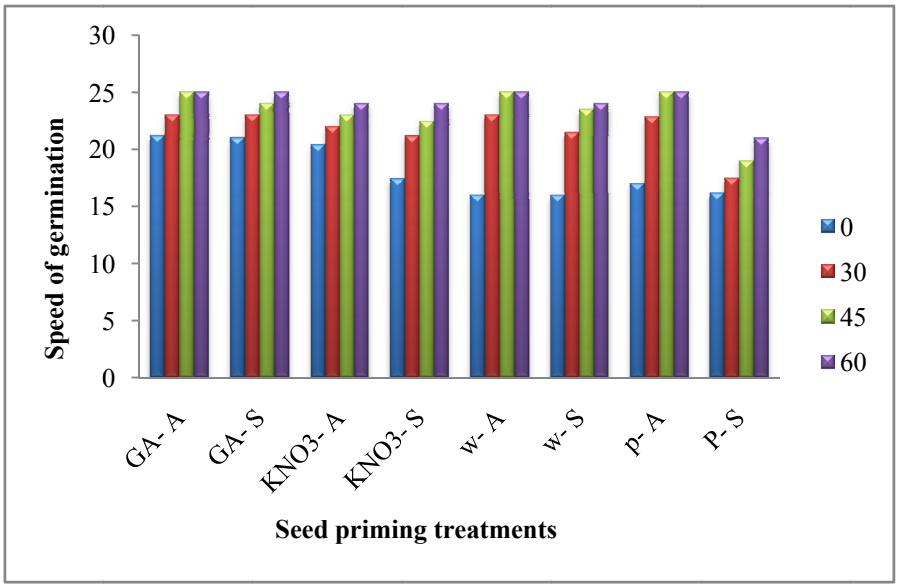

Figure 5. Influence of storing duration after seed priming on shoot dry weight of two wheat cultivars in germination test, GA-A=seed primed with GA in cv. Cross Alborz, GA- S = seed primed with GA in cv. Sardari, KNO_3-A=seed primed with KNO_3 in cv. Cross Alborz, KNO_3 - S = seed primed with KNO_3 in cv. Sardari, W-A=seed primed with distilled water in cv. Cross Alborz, W- S = seed primed with distilled water in cv. Sardari, P-A =seed primed with PEG 6000 in cv. Cross Alborz, P- S = seed primed with PEG 6000 in cv. Sardari

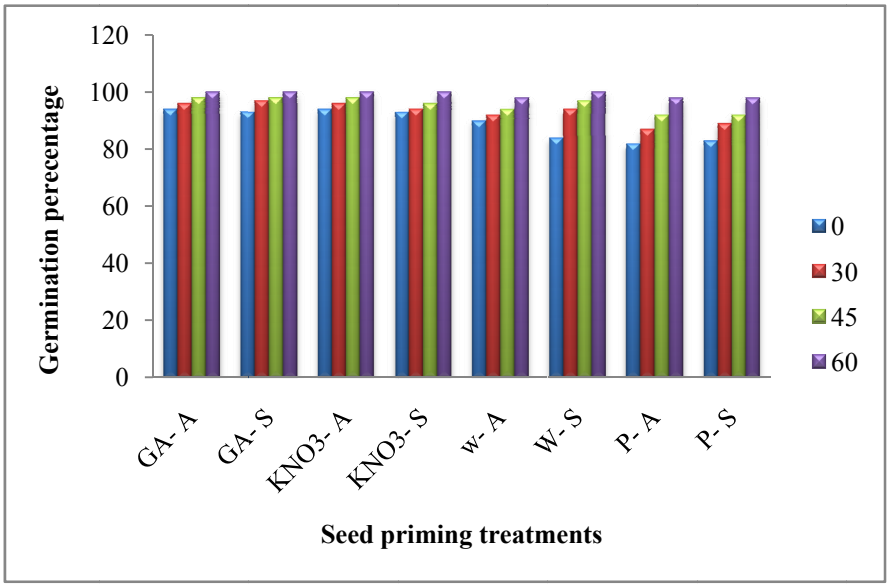

Figure 6. Influence of storing duration after seed priming on shoot dry weight of two wheat cultivars in germination test, GA-A=seed primed with GA in cv. Cross Alborz, GA-S = seed primed with GA in cv. Sardari, KNO_3-A=seed primed with KNO_3 in cv. Cross Alborz, KNO_3-S= seed primed with KNO_3 in cv. Sardari, W-A=seed primed with distilled water in cv. Cross Alborz, W-S= seed primed with distilled water in cv. Sardari, P-A=seed primed with PEG 6000 in cv. Cross Alborz, P-S= seed primed with PEG 6000 in cv. Sardari.

4. Conclusion

Our results showed significant improvements in germination and early growth of wheat (cv. Cross Alborz and cv. Sardari) due to hydro priming, halo priming (KNO_3), hormonal priming treatment compared to control. The results of priming among species, varieties, and seed lots have been variable (Heydecker, 1977). Because of this variability in response, Bradford (1986) has suggested that treatment conditions must be optimized for each seed lot. However, maximum priming can be achieved in a particular seed lot through various combinations of temperature, water potential and treatment duration. We also concluded that storing of primed seeds about 30 – 60 days improved germination characteristics compared to fresh primed seed.

References

Afzal, I., Basra, S. M. A., Ahmad, N., Cheema, M. A. E.,Warraich, A., & Khaliq, A. (2002). Effect of priming and growth regulator treatment on emergence and seedling growth of hybrid maize (*Zea mays*). *Int. J. Agri. Biol*., *4*, 303- 306.

Aldesuquy, H. S., & Ibrahim, A. H. A. (2000). The role of shikimic acid in regulation of growth, transpiration, pigmentation, photosynthetic activity and productivity of Vignasinensis plants. *Phyton.Horm*., *40*, 222-292.

Arif, M., Kaker, K. M., Jan, M. T., & Younas, M. (2003). Seed soaking enhances the emergence of mung bean. Sarhad. *J. Agric*., *19*, 439-441.

Ashraf, M., & Foolad, M. R. (2005) Pre-sowing seed treatment a shotgun approach to improve germination, plant growth, and crop yield under saline and non-saline conditions. *Adv. Agron*., *88*, 223-271. http://dx.doi.org/10.1016/S0065-2113(05)88006-X

Ashraf, C. M., & Abu-Shakra, S. (1978). Wheat seed germination under low temperature and moisture stress.*Agronomy. J., 70*, 135-139. http://dx.doi.org/10.2134/agronj1978.00021962007000010032x

Ashraf, M., Athar, H. R., Harris, P. J. C., & Kwon, T. R. (2008). Some prospective strategies for improving crop salt tolerance. *Adv. Agron*., *97*, 45-110. http://dx.doi.org/10.1016/S0065-2113(07)00002-8

Basra, S. M., Ullah, E., Warriach, E. A., Cheema, M. A., & Afzal. (2003). Effect of storage on growth and yield of primed canola (*Brassica napus*) seeds. *Int. J. Agr. Biol*., *5*, 117-1120.

Basra, S. M. A., Pannu, S., & Afzal, I. (2003). Evaluation of seedling vigor of hydro and matriprimed wheat (*Tritium aestivum* L) *seed. Int. J. Agric. Biol*., *5*, 121-123.

Basra, S. M. A., Zia, M. N., Mehmood, T., Afzal, I., & Khaliq, A. (2002). Comparison of different invigoration techniques in wheat (*Triticumaestivum* L.) seeds. *Pakistan Journal of.Arid. Agri*., *5*, 11-16.

Bradford, K. J. (1986). Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. *Hort. Sci., 21*, 1105-12.

Caseiro, R., Bennett, M. A., & Marcos-Filho, J. (2004). Comparison of three priming techniques for onionseed lots differing in initial seed quality. *Seed Sci. Technol*., *32*, 365-375.

Chauhan, J. S., Tomar, Y., Indrakumar, N., & Seema, A. (2009). Effect Of Growth Hormones On Seed Germination And Seedling Growth Of Black Gram And Horse Gram. *Journal of American Sci*., *5*(5), 79-84.

Chippa, B. R., & Lal, P. (1998). Effect of pre-soaking seed treatment in wheat grown on sodic soils. *Indian J. Plant. Physiol., 11*, 183-185.

Ellis, R. H., Hong, T. D., & Roberts, E. H. (1987). Comparison of cumulative germination and rate of germination of dormant and aged barley seed lots at different content temperatures. *Seed Sci. Technol*., *15*, 717-727.

Farooq, M., Basra, S. M. A., & Ahmad, N. (2007b). Improving the performance of transplanted rice by seed priming. *Plant Growth Regul*., *51*, 129-137. http://dx.doi.org/10.1007/s10725-006-9155-x

Farooq, M., Basra, S. M. A., & Saleem, B. A. (2008). Seed priming enhances the performance of late sown wheat (*Triticumaestivum*L.) by improving chilling tolerance. *J. of Agronomy and Crop Science*, *194*(1), 55-60. http://dx.doi.org/10.1111/j.1439-037X.2007.00287.x

Ghana, S., Giri, F., & William, F. (2003). Seed Priming Winter Wheat for Germination, Emergence, and Yield. *Crop Sci. Soc. America*, *43*, 2135-2141.

Halmer, P. (2004). Methods to improve seed performance in the field. In R. L. Benech-Arnold and R. A. Sanchez (eds.). *Handbook of Seed Physiology*, Application to Agriculture. (pp. 125-165). The Haworth Press, New York.

Harris, D., Pathan, M. K., Gothkar, P., Joshi, A., Chivasa, W., & Nyamdeza, P. (2001). On farm seed priming: using participatory methods to revive and refine a key technology. *Agri. Sys., 69*, 151-164. http://dx.doi.org/10.1016/S0308-521X(01)00023-3

Heydecker, W., & Coolbear, P. (1977). Seed treatments for improved performance - survey and attempted prognosis. *Seed Sci. & Tech*., *5*, 353-425.

Iqbal, M., Khan, M. A., & Anwar, M. Z. (2002). Zero-tillage technology and farm profits: a case study of wheat growers in the rice zone of Punjab. Pakistan. *Dev. Rev*., *41*, 665-682.

Kirby, E. J. M. (1993). Effect of sowing depth on seedling emergence, growth, and development in barley and wheat. *Field Crops Res*., 35, 101-111. http://dx.doi.org/10.1016/0378-4290(93)90143-B.

Kubik, K. K., Eastin, J. A., Eastin, J. D., & Eskridge, K. M. (1989). Solid matrix priming of tomato and pepper. *Proc. Intl. Conf. Stand.Establishment. For. Hort. Crops.* p. 86.

Liao, X., Sun, Q., Li, X., & Gao, J. (2005). Effect of gibberellic acid and abscisic acid pretreatment on seedling growth and α-amylase activity in endosperms of wheat. *Chinese Bul. Bot*., 1-12.

Lindstrom, M. J., Papendick, R. I., & Koehler, F. E. (1976). A model to predict winter wheat emergence as affected by soil temperature, water potential, and depth of planting. *Agron. J., 68*, 137-141. http://dx.doi.org/10.2134/agronj1976.00021962006800010038x

Mohamadi, G. R., & Amiri, F. (2010). The Effect of Priming on Seed Performance of Canola (*Brassica napus* L.) Under Drought Stress. *American-Eurasian J. Agric. & Environ. Sci*., *9*(2), 202-207.

MoradiDezfuli, P., Sharif-zadeh, F., & Janmohammadi, M. (2008). Influence of priming techniques on seed germination behavior of maize inbred lines (*Zea mays* L.). *ARPN Journal of Agricultural and Biological Sci., 3*(3), 22-25.

Neamatollahi, E., Bannayan, M., Souhani Darban, A., & Ghanbari, A. (2009). Hydroprimingand Osmopriming Effects on Cumin (*Cuminum Cyminum* L.) Seeds Germination. *World. Academy. of Science. Engineering.abd. Tech*., *57*, 526-529.

Pandey, R., & Agarwal, R. M. (1998). Water stressinduced changes in praline contents and nitrate reductase activity in rice under light and dark conditions. *Physiol. Mole. Biol. Plants*., *4*, 53-57.

Parera, C. A., & Cantliffe, D. J. (1994). Pre-sowing seed priming. *Hortic.Rev.*, *16*, 109-141.

Pospíšilová, J. (2003). Participation of phytohormones in the stomatal regulation of gas exchange during water stress. *Biol. Plant*, *46*, 491-506. http://dx.doi.org/10.1023/A:1024894923865

Preece, J. E., & Read, P. E. (1993). The biology of Horticulture crop.2nd ed., Jhon Wiley and Sons Publisher. p. 257-259.

Ramezan, A., Hafiz, I. A., Ahmad, T., & Abbasi, N. A. (2010). Effect of priming with potassium nitrat and dehusking on seed germinationof Gladiolus (*Gladiolusalatus*). *Pak. J. Bot*., *42*(1), 247-258.

Sharifzadeh, F., HeidariZolleh, H., Mohamadi, H., & Janmohamadi, M. (2006). Study of Osmotic Priming Effects on Wheat (*Triticumaestivum*) Germination in Different Temperatures and Local Seed Masses. *Agron. J., 5*, 647-650. http://dx.doi.org/10.3923/ja.2006.647.650

Simon, E. W. (1984). Early events in germination. In D. R. Murray (ed.) *Seed physiology*, *2*, 77-115. Germination and reserve mobilization. Academic. Press. Orlando. FL.

Singh, G., Gill, S., & Sandhu, K. (1999). Improved performance of muskmelon (*Cucwnismelo*) seed with osmoconditioning. *ActaAgrobot*., *52*, 121-126.

Subedi, K. D., & Ma, B. L. (2005). Seed priming does not improve corn yield in a humid temperate environment. *Agron. J*., *97*, 211-218.

Sung, J. M., & Y. H., Chang. (1993). Biochemical activities associated with priming of sweet corn seed to improve vigor. *Seed. Sci. Technol*., 21, 97-105.

Taylor, A. G., Allen, P. S., Bennett, M. A., Bradford, K. J., Burrisand, J. S., & Misra, M. K. (1998). Seed enhancements. *Seed.Sci. Res*., 245- 256.

Yamaguchi, S., & Kamiya, Y. (2000). It's Regulation by Endogenous and Environmental Signals. *Plant.Cell. Physiol*., *41*(3), 251-257.

Yari, L., Aghaalikani, M., & Khazaei, F. (2010). Effect of seed priming duration and temperature on seed germination on behavior of bread wheat (*Triticumaestivum* L.). *ARPN Journal of Agricultural and Biological Sci, 5*, 1- 6.

Zareh, M., Mehrabioladi, A., & Sharafzade, Sh. (2006). Evolution effects gibberellicacid(GA3) and IAI on germination and seedling growth of wheat under salinity. *Journal of Agricultural Sci. Twelve years, 4*, 855-865.