Journal of Agricultural Technology 2012 Vol. 8(7): 2157-2167
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Effects of seed priming with some plant growth regulators (Cytokinin and Salicylic acid) on germination parameters in wheat (*Triticum aestivum* L.)

Ghobadi, M., Shafiei Abnavi, M.*, Jalali-Honarmand, S., Mohammadi, G.R. and Ghobadi, M.E.

Department of Agronomy and Plant Breeding, Faculty of Agriculture and Natural Resources, Razi University, Kermanshah, Iran

Ghobadi, M., Shafiei Abnavi, M., Jalali–Honarmand, S., Mohammadi, G.R. andGhobadi, M.E. (2012) Effects of seed priming with some plant growth regulators (Cytokinin and Salicylic acid) on germination parameters in wheat (*Triticumaestivum* L.). Journal of Agricultural Technology 8(7):2157-2167.

This experiment was seed germination and seedling growth in two wheat (*Triticum aestivum* L.) cultivars, with 2 phytohormone salicylic acid (SA) and Cytokinines (CKs). This study consisted of two separate experiments. Each experiment was a factorial arranged as a completely randomized design with four replications. In experiment 1 and 2, we tested priming with CK and SA, respectively in five concentrations (0, 50, 100, 150 and 200 ppm) in four times (12, 18, 24 and 30 h) on germination parameters in two wheat cultivars. The results showed that there were significant differences between seed priming and non seed priming treatment. The best treatment in both experiments was seed priming with CK and SA at 50 ppm concentration in12 hours.

Key words: Wheat, seed priming, speed of germination, germination percentage
Abbreviations:CKs,Cytokinins; SA, salicylic acid; GP, germination percentage; MGR, mean germination rate; BAP, benzyl amino purine

Introduction

Cytokinins (CKs) are involved in various processes in the growth and development of plants including cell division, apical dominance, root formation, leaf senescence, stomatal behaviour, and chloroplast development (Brault and Maldiney, 1999; Davies, 1995). The known interactions of cytokinins with other plant hormones as well as with environmental signals (Brault and Maldiney, 1999; Roshotte*et al.* 2005), suggest that cytokinins modulate developmental processes in plants under stress full environments. Cytokinins are often considered abscisic acid (ABA) antagonists (Dru and shco,

*Corresponding author: Shafiei Abnavi, M; e-mail: mehdishafie1371@yahoo.com

1992). Auxins and cytokinins have also been shown to interact in several physiological and developmental processes, including apical dominance, control of the cell cycle, lateral root initiation, regulation of senescence and vasculature development (Brault and Maldiney, 1999; Swarup*et al.,* 2002).

Naturally occurring cytokinins are adenine derivatives with distinct substitutions attached to the N6-position of the adenine ring. Therefore, the differences in structure are likely to affect the function of the cytokinin (Iqbal and Ashraf, 2006). For example, Biddington and Thomas (1976) demonstrated that benzyl amino purine (BAP) is more active than any other cytokinin in increasing germination rate, and in breaking dormancy of celery and lettuce seeds. SA is considered as a hormone-likes substance, which plays an important role in regulating a number of physiological processes such as growth, photosynthesis, nitrate metabolism, ethylene production and flowering (Raskin 1992; Hayat 2007) and also provide protection against biotic and abiotic stresses such as salinity (Kaya *et al.,* 2002) in plants. SA is recognized as an endogenous signal molecule mainly involved environmental stress tolerance in plants (Hussein, 2007). SA also had been reported which is an essential component of the plant resistance to pathogens and participates in the plant resistance to adverse environmental conditions (Bosch, 2007) and Complementary biochemical and genetically approaches are being used to dissect the signaling network that regulates the innate immune response in plants (Bosch, 2007). Receptor- mediated recognition of abiotic and biotic stresses triggers a signal amplification Loop that is based on synergistic inter actions between nitric oxide, reactive oxygen intermediates and salicylic acid (Bosch, 2007). The exact mechanisms which SA caused tolerance in plants against salinity are not known (Bosch, 2007). Wheat grain is a staple food used world wide. Poor germination and seedling establishment are the results of soil salinity (Grag and Gupta, 1997). It is an enormous problem adversely affecting growth and development of crop plants and results in to low agricultural production (Grag and Gupta, 1997). Germination percentage, rate of seedling emergence and seedling establishment have been low in various area due to a variety of unfavorable factors such as drought, high and low temperatures, poor quality of seeds and untimely sowing (Tosellli and Casenava, 2002).

Rapid seed germination and stand establishment are critical factors for crop production under stress conditions. 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 and Foolad, 2005). Priming will cause more uniformity in seed germination and better seedling establishment in the field (Eisvand, 2008). Primed seeds pass phases imbibition and lag phase of

germination and are ready for germination in the base of physiological and biochemical conditions (Eisvand, 2008). Positivepriming effects such as improvement in germination and emergence have been shown in most plants especially in vegetables (Kaur*et al.,* 2002). 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 and 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). El- tayeb etal. (2005) found an improvement in germination of these seeds pretreated with SA solution than those of un-treated seeds. Khodary (2004) who reported that SA increased the fresh and dry weight of shoot and roots of salt stressed maize plant. Presoaking seeds with optimal concentrations of CKs has been shown to be beneficial to germination, growth, and the yield of some crop species grown under saline conditions (Kaur*et al.,* 2002; Khan *et al.,* 2002). The purpose of this study was that we can get solutions for rapid and uniform germination and seedling establishment to show appropriate.

Materials and methods

The experiment carried out at the Seed Research Laboratory of Agriculture Faculty of Razi University, Kermanshah, Iran, from August to December 2011 to determine seed priming effects on germination and seedling growth of two winter wheat cultivars (CrosAlborz and Sardari). Seeds of wheat (*Triticumaestivum* L.) cv. Cross Alborz and Sardari were obtained from Dryland Agricultural Research Center Sararood, Kermanshah, Iran. These cultivars are among widely cultivated bread wheat cultivars under

Drylandfarming conditions in Kermanshah, Iran. In August of 2011 and, 250 g of seed of both cultivars was placed in individual nylon net bags and immersed in liquid priming media. 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. The study consisted of two experiments. Each experiment was as factorial with four replications. In experiment 1, we tested priming with SA in five concentrations (0, 50, 100, 150 and 200 ppm) in four times (12, 18, 24 and 30 h) on two wheat cultivars. In experiment 2, we tested seed priming with CKs in five concentrations (0, 50, 100, 150 and 200 ppm) and in four times (12, 18, 24 and 30 h) on two wheat cultivars. After treatment seeds were given three surface washings with distilled water and retried to original weight with forced air under shade at 23± 2°C (Basra et al. 2003). 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 conditions. Seeds were considered germinated when radicle protruded for 2 mm. Germinated seeds were recorded daily up to day 7 after the start of the experiment. Germination percentage (GP) was calculated based on following equation (Ashraf and Abu-shakra, 1978):

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

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

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. Shoot and radicle length, shoot and radicle dry weight, speed of germination and germination percentage were measured eight days after beginning of the 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.

Results

Low germination percentage and rate were observed in control treatment compared with seed priming in both the cultivars (Table 2, 4). The seeds treated

with CKs showed significant difference (P<0.05) to control. The germination percentage and rate in 50ppm CKs treatment were different to 100, 150 and 200 ppm CKs treatments. So, 50 ppm CKs was found most suitable treatment (Table 2). Both 150 and 200 ppm concentration of CKs and SA did not show any major difference in respect of germination. This result showed the higher concentration that was not as good as the lower concentration, rather it decreased the germination percentage and rate. Root height, germination rate and percentage in both cultivars declined severely with increasing of CKs concentration (Table 3). The germination percentage was decreased when the concentration increased, which showed that higher concentration inhibited germination (Table 3, 4). Maximum shoot and radicle length, shoot and radicle dry weight, speed of germination and germination percentage in cv.CrossAlborz and cv. Sardari were observed when the seeds primed by CKs 50 ppm for 12h (Table 3). Observations revealed that both the growth hormones response uniformly to radicle elongation (Table 3, 4). The longest radicle length was observed at seed priming whit 50 ppm CKs (14.7 cm) in cv. Cross Alborz (Table 2). Substantial variation on aspects of germination was found between both the wheat species (Table 1, 3). In generally, it was observed that for germination enhancement of Cross Albors and Sardari cultivars, CKs with lower concentrations were better (Table 3). SA treatment affected significantly (P < 0.05) on final germination percentage and rate in cultivars (Table 4). Seed treatment with Salicylic acid, particularly the concentration of 50 ppm was effective in increasing germination rate in two cultivars (Table 3). In contrast, high concentrations of SA inhibited germination (Table 4). The best treatment Salicylic acid in both cultivars was observed in concentration of 50 ppm for 12 hours (Table 4). However, plants derived from seeds treated with the different priming agents improved shoot dry weights for both cultivars.

Table 1. Means comparison of cv. Cross Alborz compared withcv. Sardari in CKs treatments

Wheat Cultivar	**Shoot dry weight (mg)**	**Radicle dry weight (mg)**	**Shoot length (cm)**	**Radicle length (cm)**	**Speed of germination**	**Germination percentage**
Cross Alborz	152.42 [b]	93.32[a]	11.35[a]	6.55[a]	14.90[a]	80.76[a]
Sardari	162.80 [a]	85.26[b]	9.92[a]	7.15[a]	16.03[a]	87.79[a]
CV%	10.4	9.7	11.3	10.2	8.5	8.9

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

Table 2. Means comparison of cv.CrossAlborz compared with cv. Sardari in SA treatments

Cultivar wheat	Shoot dry weight (mg)	Radicle dry weight (mg)	Shoot length (cm)	Radicle length (cm)	Speed of germination	Germination percentage
Cross Alborz	169.48[a]	94.88[a]	10.88[a]	7.78[a]	15.16[a]	89.24[a]
Sardari	173.58[a]	87.46[b]	8.78[b]	8.09[a]	15.14[a]	86.10[a]
CV%	12	11.7	10.7	10.3	7.4	8.01

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

Table 3. Means comparison of cv. Cross Alborz and Sardari with control in Cytokinins treatments

CK Concentrations (ppm)	Times	Shoot dry weight (mg)	Radicle dry weight (mg)	Shoot length (cm)	Radicle length (cm)	Speed of germination	Germination percentage (%)
cv. Cross Alborz	control	202[b]	115[bcd]	11.91[def]	10.10[cd]	17.74[c-f]	97.50[ab]
50	12	229.50[a]	141.50[a]	15.90[a]	14.70[a]	23[a]	100[a]
50	18	184.25[c]	104.25[d-g]	13.37[dc]	7.55[de]	14.87[d-i]	91[abc]
50	24	145[e-i]	82.75[i]	12.40[edf]	5.32[fe]	13.12[f-i]	81.25[d-h]
50	30	92.75[j]	65[j]	7.05[jk]	2.77[h]	8.72[jk]	63.50[ij]
100	12	185[c]	123[b]	13[cde]	10.3[b]	8.3[k]	87.90[cde]
100	18	181.50[c]	113[bcd]	12.62[edf]	7.47[de]	18.20[a-e]	89.75[bcd]
100	24	141.25[f-i]	101.25[d-g]	11.72[edf]	5.57[fe]	19.25[a-d]	73.75[e-h]
100	30	90.25[j]	80.25[i]	6.54[k]	3[gh]	14.01[e-i]	62[ij]
150	12	176.30[c]	103.75[d-g]	13.12[cde]	8[cd]	11.17[h-j]	85[c-f]
150	18	160[de]	81[i]	12.40[fde]	7.40[de]	15.05[d-i]	89.50[bcd]
150	24	143.50[e-i]	64[j]	11.97[def]	5.07[fg]	18.75[a-e]	79.75[e-h]
150	30	89.75[j]	63.75[j]	6.80[k]	3.52[fgh]	11.70[g-i]	61.[5ij]
200	12	182[c]	105[c-g]	13.75[cde]	7.30[de]	10.67[igk]	76[gh]
200	18	144.25[e-i]	101.31[d-g]	11.80[def]	5.10[fe]	11.95[h-j]	90.50[bcd]
200	24	138[hi]	79.75[i]	12.05f[de]	4.75[fgh]	12.20[g-i]	79.60[e-h]
200	30	88[j]	62.50[j]	6.55[k]	3.02[gh]	12[g-i]	65[i]
cv.Sardari	control	175.75[c]	111.25[b-f]	11[fe]	10.44[b]	17.67[c-f]	97[ab]
50	12	215[ab]	143.50[a]	15.40[a]	14.50[a]	22.40[a]	100[a]
50	18	180[c]	122[b]	12.25[fde]	8.30[cd]	19[a-e]	88[cde]
50	24	158[fe]	112.75[bcd]	9h[i]	5.52[fe]	15.50[d-h]	76.75[gh]
50	30	139.75[ghi]	97.25[fg]	7[jk]	3.77[fgh]	12[g-i]	57.50[ij]
100	12	185[c]	124[b]	12[def]	9.80[bc]	21.25[abc]	92[abc]
100	18	172.25[c]	123.25[b]	11f[e]	8.55[bcd]	18.50[a-e]	87[c-f]
100	24	160.25[de]	112.5[bcd]	9.42[gh]	5.70[fe]	16d-[g]	78f[gh]
100	30	140.75[f-i]	97.75[efg]	7.75[jhi]	3.57[fgh]	12.50[g-i]	56.25[ij]
150	12	178.75[c]	119[bc]	10.90[fe]	9.70[bc]	21.75[abc]	90[abc]
150	18	160.78[de]	118.75[bc]	12[def]	8.05[cd]	18.40[a-e]	86[c-f]
150	24	156.75[efg]	110.70[b-f]	8.75[jhi]	5.8[fe]	14.50[d-i]	74.75[h]
150	30	137.75[hi]	94.50[gh]	7.50[jik]	4.52[fgh]	12[g-i]	58.75[ij]
200	12	175[cd]	119[bc]	11.25[fe]	7.55[de]	14.01[e-i]	85.25[c-g]
200	18	154.25[e-h]	106.25[c-g]	9[hi]	6.80[de]	14[e-i]	73.75[h]
200	24	142[f-i]	100[d-g]	8.20[jhi]	5.05[fg]	12.30[g-i]	65[i]
200	30	136.25[i]	94[g-h]	6.25[k]	4.05[fgh]	10.75[h-i]	55.75[j]
	CV%	9.7	10.3	11.2	9.9	10.4	10.8

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

Table 4. Means comparison of cv.CrossAlborz and Sardari with control in Salicylic Acid treatments

SA Concentrations (ppm)	Times	Shoot dry weight (mg)	Radicle dry weight (mg)	Shoot length (cm)	Radicle length (cm)	Speed of germination	Germination percentage (%)
cv. Cross Alborz	control	204.75^{b}	119^{b}	12.62^{b}	9.59^{c-f}	17.75^{c}	97^{ab}
50	12	231.75^{a}	140.5^{a}	15.50^{a}	12.55^{a}	23.75^{a}	100^{a}
50	18	188^{c}	113^{bc}	12.80^{b}	9.12^{e-g}	16.90^{cd}	89.30^{bcd}
50	24	171.75^{cd}	95^{cf}	10.70^{b-f}	6.90^{h-k}	14.25f^{gh}	83.25^{fde}
50	30	144.30^{e}	76.75^{f-i}	8.50^{g-j}	7.55^{g-j}	13.12^{h}	75.54^{fgh}
100	12	185.50^{cd}	120^{b}	12.30^{bc}	9.70^{cde}	17^{cd}	89^{bcd}
100	18	184^{cd}	110.75^{b-e}	11.80^{bcd}	8.55^{c-h}	16.55^{d-f}	88.25^{bcd}
100	24	169.30^{cd}	93.75^{d-g}	10.20^{c-f}	6.40^{igk}	13.75^{h}	82.25^{d-g}
100	30	142.25^{e}	74.75^{ghi}	7.80^{hig}	6.80^{h-k}	12.87^{h}	74.25^{gh}
150	12	185.70^{cd}	116.50^{b}	12.42^{b}	8.92^{c-h}	15^{e-h}	90^{bcd}
150	18	172^{cd}	112^{bcd}	12.30^{b}	8.80^{ch}	16.65^{d-f}	89.50^{bcd}
150	24	168.75^{d}	93^{efg}	9.70^{e-i}	7.75^{e-i}	13.50^{h}	83.75^{fde}
150	30	141.75^{e}	75.75^{f-i}	9^{g-j}	6.30^{ijk}	12.64^{h}	77.25^{e-h}
200	12	169.50^{cd}	110.50^{b-e}	11.87^{bcd}	10^{dc}	12.10^{h}	76^{e-h}
200	18	143^{e}	91^{fg}	10.6^{b-f}	8.80^{c-h}	16.30^{c-g}	87.75^{bcd}
200	24	140^{e}	70.75^{hi}	9.95^{d-h}	6.20^{ijk}	13.40^{h}	81.25^{d-g}
200	30	139^{e}	68^{i}	7.50^{ij}	6.37^{ijk}	12.35^{h}	69^{h}
cv.Sardari	control	175.50^{cd}	115.75^{b}	11.32^{b-e}	9.62^{cde}	17.79^{c}	97^{ab}
50	12	203^{b}	135^{a}	14.90^{a}	12.40^{a}	21.25^{b}	100^{a}
50	18	169^{cd}	96^{c-f}	7.72^{ij}	7.30^{g-k}	16.75^{cde}	96^{ab}
50	24	168.5^{d}	77.75^{f-i}	7.70^{hij}	8.25^{d-i}	14.57^{e-h}	85.75^{cde}
50	30	176.75^{cd}	71^{hi}	7.15^{j}	5.75^{kg}	12.87^{h}	72.50^{h}
100	12	181^{cd}	111.75^{bcd}	12.50^{b}	10.10^{dc}	16.50^{d-f}	100^{a}
100	18	173^{cd}	92^{fg}	7.80^{hij}	8.30^{d-i}	16.25^{c-g}	96^{ab}
100	24	169.25^{cd}	76.50^{fi}	7.70^{hij}	7.27^{g-k}	14.32^{e-h}	85.3^{cde}
100	30	176.75^{cd}	67^{i}	7.47^{ij}	5.42^{k}	12.62^{h}	72.70h
150	12	174^{cd}	95^{c-f}	12.17^{bc}	10.35^{bc}	12.50^{h}	85^{cde}
150	18	176.20^{cd}	93^{fg}	7.78^{hij}	8.34^{d-i}	16^{5c-g}	94^{ab}
150	24	170^{cd}	77.50^{f-i}	7.55^{ij}	7.24^{g-k}	14.60^{d-h}	85.24^{cde}
150	30	168^{cd}	72^{hi}	7.105^{j}	5.80^{kj}	12.83^{h}	72.80^{h}
200	12	176^{cd}	91^{fg}	8.20^{g-i}	9.90^{cd}	15.90^{c-g}	70^{h}
200	18	173.50^{cd}	75.90^{f-i}	7.50^{hij}	8.75^{ch}	16.30^{c-g}	95.30^{ab}
200	24	170.50^{cd}	74^{f-i}	7.60^{hij}	7.37^{g-k}	14.07^{gh}	85de
200	30	150de	65.70^{5i}	7.17^{j}	5.37^{k}	12.37^{h}	72^{h}
	CV%	11	10.7	8.4	9.2	8.2	10.6

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

Discussion

In view of some earlier studies it is now evident that pre-soaking or priming of seed of different crops causes improvement in germination, seedling establishment and in some cases enhances crop yield (Ahmad *et al*., 1998; Harris *et al.*, 1999). Presoaking seeds with optimal concentrations of CKs has been shown to be beneficial to germination, growth, and the yield of some crop species grown under saline conditions (Kaur*et al.*, 2002; Khan *et al.*, 2002).

However, an adequate CK supply is essential for normal plant development (Takei *et al.,* 2002; Schmulling *et al.,* 1997). The results of the present study are in agreement with Aldesuquy and Ibrahim (2001) indicated that improvement in wheat productivity (grain yield) due to the increased germination rate by hormone pretreatment and Gadallah (1999), Debez *et al.* (2001) demonstrated that concentrations of phytohormones has been shown to be beneficial to the germination, growth, and yield of some crop species, possibly by increasing nutrient reserves through increased physiological activities and root proliferation (Darra*et al.,* 1973). Our results showed that seed priming with CKs and SA increased the germination parameters, which is in agreement with yarnia *et al*. (2012) showed that hormones type, time of seed priming and hormone concentration had significant effect in root and seedling length, germination percent and seedling dry weight, Priming by 6, 12 and 18 hours with hormones increased germination percentage and against Iqbal *et al*. (2006) reported that cytokinins-priming did not show consistent effects on germination and early seedling growth. Lada *et al.* (2004) stated that hormonal priming enhanced germination in low temperature (5C) after priming the seeds of two carrot cultivars with salicylic acid and gibberellin. In present experiment we observed that both 150 and 200 ppm concentration of CKs and SA were not observed any major difference in respect of germination. So, the higher concentrations were not as good as the lower concentration rather it decreased the germination percent and rate. Our results are in agreement with Eisvand *et al.* (2011) indicated that increase in hormone concentration caused the reduced emergence percentage. Similarly, Mazaheri and Tehrani (2005) reported that high concentrations of SA reduced the germination of canola (*Brassica napus* L). Increasing of salicylic acid concentration enhances ABA synthesis which can stop the seed germination (Wu *et al.,* 1998). Shakirova *et al.* (2003) found that soaking of wheat seeds in (0.05 mM) SA reduced the damaging effects of salinityon seedlings growth and accelerated the growth processes. Our results indicated that salicylic acid can increase shoot and root length that are in agreement withdelavari *et al.* (2010) indicated that Priming with SA showed maximum root length.

Conclusion

Seed priming had significant positive effect on different aspects of seed germination. Our results showed significant improvement in germination and early growth of wheat due to CK priming and SA priming treatment Compared to control. The best treatment was seed priming with CK and SA at 50ppmin 12 hours.

Acknowledgements

The authors would like to thank Dr. Mohsen Saeidi and Dr.HojatHashemi-nasab from Agronomy and Plant Breeding, College of Agriculture and Natural Resources, Razi University, Kermanshah, Iran for their cooperation and supported.

References

Ahmad, S., Anwar, M. and Ullah, H. (1998). Wheat seed pre-soaking for improved germination. J Agron Crop Sci. 181:125-127.

Aldesuquy, H.S. and Ibrahim, A.H. (2001). Water relations, abscisic acid and yield of wheat plants in relation to the interactive effect of seawater and growth bioregulators. J Agron Crop Sci. 187:97–104.

Ashraf, M. and 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. Advagron 88:223-271.

Ashraf, C.M. and Abu-Shakra, S. (1978). Wheat seed germination under low temperature and moisture stress.Agron J. 70:135-139.

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

Biddington, N.L. and Thomas, T.H. (1976). Influence of different cytokinins on the germination of lettuce (*Lactucasativa*) and Celery (*Apiumgraveolens*) Seeds. J Plant Physiol. 37:12–16.

Bosch, S.M., Penuelas, J. and Liusia, J. (2007). A deficiency in salicylic acid alters isoprenoid accumulation in water-stressed NahG transgenic Arabidopsis plants. J Plant Sci. 172(4):756-762.

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

Brault, M. and Maldiney, R. (1999). Mechanisms of cytokinin action. Plant PhysiolgyBiochemi. 37:403–412.

Darra, B.L., Seth, S.P., Singh, H. and Mendiratta, R.S. (1973). Effect ofhormone directed presoaking on emergence and growth of osmotically stressed wheat (*Triticumaestivum*L.) seeds. J Agron.65:292–295.

Davies, P.J. (1995). Plant hormones: physiology, biochemistry and molecular biology. Kluwer Academic Publishers, Dordrecht.

Debez, A., Chaibi, W. and Bouzid, S. (2001). Effect of NaCl and growth regulators on germination of Atriplexhalimus L. Cah Agric. 10:135–138.

Delavari, P.M., Baghizadeh, A., Enteshari, S.H., Kalantari, K.h.M., Yazdanpanah, A. and Mousavi, E.A. (2010). The Effects of Salicylic Acid on Some of Biochemical and Morphological Characteristic of OcimumBasilicucm under Salinity Stress. AJBAS. 4(10):4832-4845.

Dru¨ge, U. and Scho¨nbeck, F. (1992). Effect of vesicular– arbuscularmycorrhizal infection on transpiration, photosynthesis and growth of flax (*Linumusitatissimum* L.) in relation to cytokinin levels. J Plant Physiol. 141:40–48.

Eisvand, H.R., Shahrosvand, S., Zahedi, B., Heidari, S. and Afroughe, S.H. (2011). 'Effects of hydro-priming and hormonal priming by gibberellin and salicylic acid on seed and seedling quality of carrot (Daucuscarota var. sativus)'. Iranian Journal of Plant Physiol. 1(4):233-239.

Eisvand, H.R. (2008). Effects of Some phytohormones on physiological quality improvement of tall wheatgrass (Agropyronelongatum) aged seeds under drought stress. Ph.D. thesis, University of Tehran.

Ellis, R.H., Hong, T.D. and 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.

El-tayeb, M.A. (2005). Response of barley grains to the interactive effect of salinity and salicylic acid. Plant Growth Regul. 45:215-224.

Farooq, M., Basra, S.M.A. and Saleem, B.A. (2008). Seed priming enhances the performance of late sown wheat (Triticumaestivum L.) by improving chilling tolerance. J Agron Crop Sci. 194(1):55-60.

Gadallah, M.A.A. (1999). Effects of kinetin on growth, grain yield and some mineral elements in wheat plants growing under excess salinity and oxygen deficiency.Plant Growth Regul. 27:63-74.

Garg, B.K. and Gupta, I.C. (1997). Plant Relations to salinity. In: Saline wastelands environment and plant growth. pages 79121. Scientific Publishers, Jodhpur.

Halmer, P. (2004). Methods to improve seed performance in the field. In: Handbook of Seed Physiology; Application to Agriculture. R.L. Benech-Arnold and R.A. Sanchez (eds.). pages 125165 The Haworth Press, New York.

Harris, D., Joshi, A., Khan, P.A., Gothkar, P. and Sodhi, P.S. (1999). On-farm seed priming in semi-arid agriculture:development and evaluation in maize, rice and chickpea in India using participatory methods. Experimental Agri. 35:15-29.

Hayat, S., Ali, B. and Ahmad, A. (2007). Salicylic Acid: Biosynthesis, Metabolism and Physiologica1 Role in plants In: Salicylic Acid, a Plant Honnone, Hayat S. and A. Ahmad (Eds.). Springer.Drodrecht, pp. 114.

Hussein, M.M., Balbaa, L.K. and Gaballah, M.S. (2007). Salicylic Acid and Salinity Effects on Growth of Maize plants. J AgrBiol Sci. 3(4):321-328.

Iqbal, M. and Ashraf, M.A.J. (2006). Seed enhancement with cytokinins: changes in growth and grain yield in salt stressed wheat plants. Springer Sci. 50:29–39.

Kaur, J., Singh, O.S. and Arora, N. (2002). Kinetin like role of TDZ (thidiazuron) in salinity amelioration in wheat (Triticumaestivum). J Res Punjab agri Univ. 39:82–84.

Kaya, C., Kimak, H., Higgs, D. and Saltali, K. (2002). Supplemental calcium enhances plant growth and fruit yield in strawbeny cultivars grown at high (NaC1) salinity. Science Hod. 93:65-74.

Khan, M.A., Gul, B. and Weber, D.J. (2002). Improving seed germination of Salicorniarubra (Chenopodiaceae) under saline conditions using germination-regulating chemicals.Western North American Nati. 62:101–105.

Khodary, S.E.A. (2004). Effect of salicylic acid on the growth, photosynthesis and carbohydrate metabolism in salt-stressed maize plants. Int J Agric& Biol. 6:5-8.

Lada, R., Stiles, A., Surette, M.A., Sturz, A.V., Blake, T.J., Caldwell, C. and Nowak, J. (2004). 'Stand establishment technologies for processing carrots'. ActaHorticultu. 631:105-116.

Mazaheri, T. and Manouchehri, K. (2005). 'Effects of the role of salicylic acid, drought stress, ethylene and interaction of three factors on seed germination of Brassica napus'. Iranian Journal of Biol. 19(4):408-418.

Parera, C.A. and Cantliffe, D.J. (1994). Pre-sowing seed priming. Rev Horticultural. 16:109-141.

Rashotte, A.M., Chae, H.S., Maxwell, B.B. and Kieber, J.J. (2005). The interaction of cytokinin with other signals. Plant Physiol. 123:184–194.

Raskin, I. (1992). Role of salicylic acid in plants. Plant Physiol. 43:439-463.

Schmülling, T., Schäfer, S. and Ramanov, G. (1997). Cytokinins as regulators of gene expression.Physiol Plant 100:505–519.

Shakirova, F., MSakhabutdmova, A.R., Benukova, M.V., Fathudnova, R.A. and Fathutdinova, D.R. (2003). Changes in hormonal status of wheat seedlings induced by salicylic acid andsalinity. Plant Sci.164:317-322.

Swarup, R., Parry, G., Graham, N., Allen, T. and Bennett, M. (2002). Auxin cross-talk: integration of signalling pathways to control plant development. Plant Molecular Biol. 49:411–426.

Takei, K., Takahashi, T., Sugiyama, T., Yamaya, T. and Sakakibara, H. (2002). Multiple routes communicating nitrogen availability from roots to shoots, a signal transduction pathway mediated by cytokinin. Journal of Experimental Bot. 53:971–977.

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

Toselli, M.E. and Casenava, E.C. (2002). The hydrotime model analysis of cottonseed germination as tool in priming'. Seed Sci Technol. 30:549-557.

Wu, L., Guo, X. and Harivandi, M.A. (1998). 'Allelopathic effects of phenolic acids detected in buffalograss (*Buchloedactyloides*) clippings on growth of annual bluegrass (*Poaannua*) and buffalograss seedlings'. Environ Exp Bot. 39:159-167.

Yarnia, M. and Farajzadeh, E.M.T. (2012). Effect of Seed Priming with Different Concentration of GA3, IAA and Kinetin on Azarshahr Onion Germination and Seedling Growth.Journal basic applied sci. 2(3):2657-26.

(Received 28 August 2012; accepted 30 November 2012)