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IMPROVEMENT OF WHEAT (*TRITICUM AESTIVUM* L.) YIELD BY APPLICATION OF PACLOBUTRAZOL

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ABSTRACT

In Iran, wheat is considered as a valuable crop to achieve political and economic stability, and also it is considered as an important factor in improving the income of many farmers. The objective of the present study was the effect of priming and foliar application of Paclobutrazol at different concentration of it on increasing wheat production and higher yield per unit area. This experiment was carried out as factorial in a Randomized Complete Block Design with 16 treatment and three replications in the research farm of Department of Agriculture, Maragheh University, in 2013-2014 years.The first factor included priming at 4 levels (Control, hydro-priming, priming with 25 and 100 mg. lit^{-1} PBZ); and the second factor included foliar application at 4 levels (distilled water (Control), 30, 60 and 90 mg. lit^{-1} PBZ). The characteristics of plant height, number of fertile tillers per plant, peduncle length, penultimate length, days till heading, spike number per m^2, seed number per spike, 100-seed weight, spikelet number per spike, seed yield, biological yield and harvest index (HI), protein percentage and protein yield were measured. The obtained data were subjected to a statistical analysis using SPSS, MSTAT.C; StatisticalAnalysis System. The analysis of variance showed that seed priming had significant ($p \leq 0.01$) effects on number of spikelets per spike, grain number per spike, biological yield, protein yield and was ($p \leq 0.05$) significant on the plant height and stem length, spike length, 100-seed weight and grain yield. The interaction of seed priming and foliar had significant ($p \leq 0/05$) effect on Penultimate length and Harvest Index. The means of the collected data from the different treatments during both PBZ applications were compared using Duncan's test, with $P \leq 0.05$ and $P \leq 0.01$ as significant. The analysis of variance showed that the effects of seed priming and the interaction of priming and foliar had significant effect ($p \leq 0.01$) on the number of plants per m^2 Consequently, seed priming PBZ application could be suggested as one effective ways to the seed yield improvement and increase.

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KEY WORDS
Paclobutrazol, Wheat, Priming, Foliar application

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INTRODUCTION

Wheat (*Triticum aestivum* L.) grain is a major staple crop in many parts of the world (Titouan et al., 2015). In Iran, wheat is considered as a valuable crop to achieve political and economic stability, and also it is considered as an important factor in improving the income of many farmers (Naqizadeh and Gholami Turanposhti, 2014). Although wheat production per unit area in Iran has significantly increased during the past year, it still does not supply enough amount for annual domestic demand. Therefore, finding a way to increase this crop's production is one of our country's research priorities; and its higher production can be a factor in reducing food import dependency (Ismailpoor, 2007). Wheat averagely provides 60 percent of humans' energy intake; and as being the world's major agricultural crop, most of the world's farmlands is devoted to wheat cultivation (Kayden et al., 2006). In recent years, due to some limitations regarding increasing the area under wheat cultivation, efforts have been made to increase wheat production through increasing its yield per unit area. But statistics show that Iran's average wheat yields is far less than global average. Plant growth regulators have plentiful applications in agriculture such as delaying or accelerating the maturation, stimulation of flowering and so on (Frantes et al., 2004). Plant growth regulators are widely used in modern agricultural systems and in main inputs (Sainio et al., 2003). These materials are used naturally or as synthesized substances. They alter life process of the plant or improve plant's morphology; and in some cases, they increase yield. The main purpose of these substances' application in agriculture is improving the production via modifying plant growth and increasing the quantity and quality of the production under various conditions, especially under stressful conditions. The triazoles are the largest and most important group of systemic compounds developed in the 1960s for the control of fungal diseases in plants and animals. The triazole compounds are chemicals belong to a group of compounds known as ergosterol biosynthesis inhibitors and are used as fungicides and also as plant growth regulator (Jaleel et al., 2007). It is noteworthy that these chemicals are very active group of chemical plant growth inhibitor compounds and are the most important commercial regulators of plant growth (Fletcher et al., 1986). Inhibition of gibberellin (GA) biosynthesis is the most salient feature of triazolic growth regulators (Jalil et al., 2007; Jalil et al., 2008). In fact, the triazoles are the most active group of growth inhibitors which inhibit stem elongation; an obvious response of the plant to these compounds is the reduction of internode elongation , and as a result, the plant length will be decreased (Fletcher et al., 1986). The ability of triazoles in regulation of plant growth lesser than others and also their lack of toxicity are two advantages of this group over other plant growth inhibitors (Fletcher et al., 1986). Compared to other growth regulators, the triazoles are more effective in lower doses and are non-toxic (Davis et al., 1998). A vast domain of growth regulation features of triazoles becomes possible via altering the balances of gibberellic acid, abscisic acid and cytokinins. However, in the mentioned condition, auxin amount remains intact (Fletcher and Hofstra, 1985). Some of growth inhibitors- such as triazoles, pyrimidines and ammonium compounds- inhibit stem elongation by preventing sterols and gibberellin biosynthesis (Arteca, 1996). Foliar application of PBZ at five week decreased internode length and dry-weight of aerial organs of tomato (Lycopersicum esculentom L.) (Jafari et al., 2006). PBZ increased root diameter of Soybean (Glycine max L.) by increasing the size of cortical parenchymal cells (Barnes et al, 1989). PBZ treatment of potato plants which were grown under greenhouse conditions, resulted strong plants with thicker and dark-green leaves, and with thicker stem and roots (Tekalign and Hammes, 2004). The leaves of treated plants showed increased amount of chlorophyll a and b, thicker epicuticular wax, longer and thicker epidermis, spongy mesophyll cells. PBZ application significantly increased starch grains accumulation in cells of stem central parenchymal tissue, and cortical dermal cells of stem and root. Like other related experiments, this study reported the increase of leaf, stem and root thickness (Tekalign and Hammes, 2004). The objective of the present study was the effect of priming and foliar application of Paclobutrazol at different concentration of it on increasing wheat production and higher yield per unit area. Consequently, seed priming PBZ applicatin could be suggested as one effective ways to the seed yield improvement and increase.

MATERIALS AND METHODS

This experiment was carried out as factorial in a Randomized Complete Block Design with 16 treatment and three replications in the research farm of Department of Agriculture, Maragheh University, in 2013-2014 years. The first factor included priming at 4 levels (Control, hydro-priming, priming with 25 and 100 mg. lit-1 PBZ); and the second factor included foliar application at 4 levels (distilled water (Control), 30, 60 and 90 mg. lit-1 PBZ).

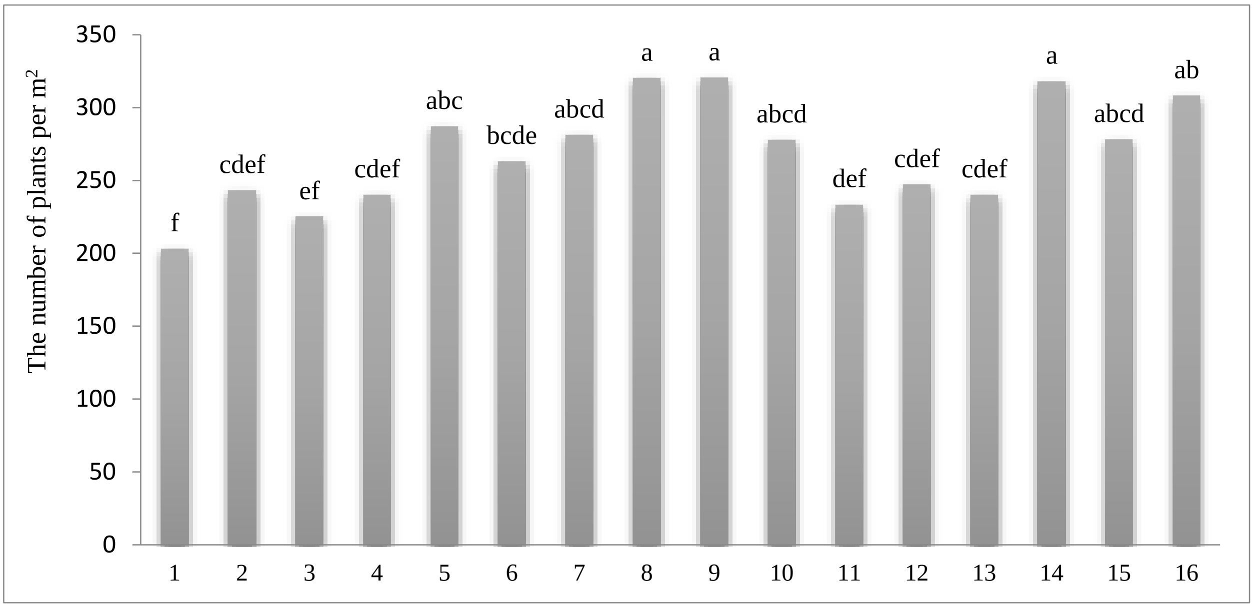
For making seeds ready for priming and protecting them against fungal infections, seeds disinfected with a 2% sodium hypochlorite for 5 minutes. To prevent the disinfectant harm on the seeds, they were rinsed three times with distilled water. After the aforementioned processes, the seeds became ready for pretreatment. For hydropriming, the seeds were soaked in distilled water for 6 hours in germinator at 200C. After passing the mentioned time, the seeds were dried at room temperature for 48 hours to reach their original weight. For PBZ priming, 4 g solid NaOH was dissolved in 100CC distilled water and 1 normal NaOH solution was made. To prepare our desired solutions, 2 different weights of PBZ, a plant growth inhibitor, i.e. 25 mg (50 ppm) and 100 mg (200 ppm) of PBZ were weighed by precise balances; then each one of these weights of PBZ was separately dissolved in 10CC of NaOH 1 normal; and after complete dissolution, 10CC HCl was added to each one of these solution to neutralize the effect of NaOH. After complete combination of HCl and NaOH in the solutions, 980CC distilled water was gradually added to each one of these solutions; and by adding distilled water, the solutions reached the desired volume (1lit.). Prepared seeds were soaked in the separate solutions (25 and 100 mg. lit-1 PBZ.) and were maintained in a germinator for 6 hrs at about 200C. After passing the mentioned time, pretreated seeds were rinsed three times with deionized distilled water and then they were dried at room temperature for 48 hours to obtain their original weight.

Prior to planting, soil preparations such as deep plowing in the autumn and surface plowing in the spring, disc plow at two stages, and land levelering were done. The total number of available plots was 48 and the area of each plot was 5.4 m2. In each plot, there were 5 planting lines with a distance of 20cm. supplement such as irrigation and manual control of weeds were done. Foliar application of PBZ and distilled water (control) with the concentrations of 30, 60 and 90 mg.lit-1 PBZ. and distilled water were done at the end of tillering stage (at the beginning of jointing stage). Finally at harvesting stage, 1m2 of harvest were taken, and the characteristics of plant height, number of fertile tillers per plant, peduncle length, penultimate length, days till heading, spike number per m2, seed number per spike, 100-seed weight, spikelet number per spike, seed yield, biological yield and harvest index (HI), protein percentage and protein yield were measured. With the help of SPAD-502, chlorophyll content were also determined during wheat growing stage. The obtained data were subjected to a statistical analysis using SPSS, MSTAT.C; Statistical Analysis System (2013[20]). The means of the collected data from the different treatments during both PBZ applications were compared using Duncan's test, with $P \leq 0.05$ and $P \leq 0.01$ as significant.

RESULTS AND DISCUSSION

The number of plants per m2

The analysis of variance showed that the effects of seed priming and the interaction of priming and foliar had significant effect ($p \leq 0.01$) on the number of plants per m2 (Data not shown). The mean comparison of interaction of priming and foliar on the number of plants per m2 showed that those priming which sprayed with different levels of Paclobutrazol and priming mostly had more plants per m as compared to control (Fig. 1).Under normal and stress conditions, priming seeds with plant growth hormones not only improved germination and emergence index, but also increased growth and the final yield (Ahmad et al, 1995). In application of Paclobutrazol- the growth regulator- as seed priming, most of its intensifying effects emerge in wheat seedling and plant's primary growth. Application of other substances as seed priming often had the same effects of Paclobutrazol. For instance, increased speed of emergence and the final percentage of emergence was observed in the most primed wheat genotypes (Abutalebian, 2005).



1. Control, Control
2. Control, foliar with 30 mg.lit^{-1} PBZ
3. Control, foliar with 60 mg.lit^{-1} PBZ
4. Control, foliar with 90 mg.lit-1 PBZ
5. Hidroprime, Control
6. Hidroprime, foliar with 30 mg.lit^{-1} PBZ
7. Hidroprime, foliar with 60 mg.lit^{-1} PBZ
8. Hidroprime, foliar with 90 mg.lit^{-1} PBZ

9.Seed priming with 25 mg.lit-1 PBZ, Control
10.Seed priming with 25 mg.lit-1 PBZ, foliar with 30 mg.lit^{-1} PBZ
11.Seed priming with 25 mg.lit-1 PBZ, foliar with 60 mg.lit^{-1} PBZ
12.Seed priming with 25 mg.lit-1 PBZ, foliar with 90 mg.lit^{-1} PBZ
13. Seed priming with 100 mg.lit-1 PBZ, Control
14.Seed priming with 100 mg.lit-1 PBZ, foliar with 30 mg.lit^{-1} PBZ
15.Seed priming with 100 mg.lit-1 PBZ, foliar with 60 mg.lit^{-1} PBZ
16 Seed priming with 100 mg.lit-1 PBZ, foliar with 90 mg.lit^{-1} PBZ.

Fig. 1: The interaction of seed priming and foliar PBZ application on the number of plants per m

Plant height and stem length

The analysis of variance showed that the effect of seed priming was ($p \leq 0.05$) significant on the plant height and stem length (Data not shown). According to the results of mean comparison of seed priming, the highest length of plant and stem was observed in the priming with 25 mg. lit-1 solution which were 41.568 and 34.991 respectively, and their lowest length was observed in control which were 38.246 and 31.811 respectively (Fig. 2 & 3). In priming the seed with Paclobutrazol solution, increasing the concentration of Paclobutrazol (100 mg. lit-1) had less effect on the plant and stem length as compared to the priming with 25 mg.lit-1 Paclobutrazol solution; however, these concentrations did not show significant differences. The results showed that although spraying Paclobutrazol solution in the late tillering stage had not significant effect on the aforesaid characteristics (Data not shown), it partially reduced the plant and stem length as compared to Hydroprime. And spraying the seed with 60 mg.lit-1 Paclobutrazol solution caused less increase of the plant and stem length as compared to spraying with 30 and 90 mg.lit-1 Paclobutrazol solution.

Since Paclobutrazol decelerates GA biosynthesis, plant growth will be affected and again this will change the partitioning of assimilate (El-Khashab et al, 1997). Paclobutrazol application could reduce the number of cells and their length in Safflower (Carthamus tinctorius L.) stem (Potter et al, 1993). In fact, unlike the main effect of Paclobutrazol which is obtained in its direct application, most of its intensifying effects emerge in seedling and primary growth of the plant in its application as seed priming. By investigation of Barrett and Bartoska (1982) it becomes clear that those plants which Paclobutrazol was sprayed on their stem were shorter than those plants which Paclobutrazol was sprayed on their leaves (Barrett and Bartuska, 1982). This matter can be one of the reasons which caused Paclobutrazol foliar on canopy at the late tillering stage be insignificant in the final report of our experiment.

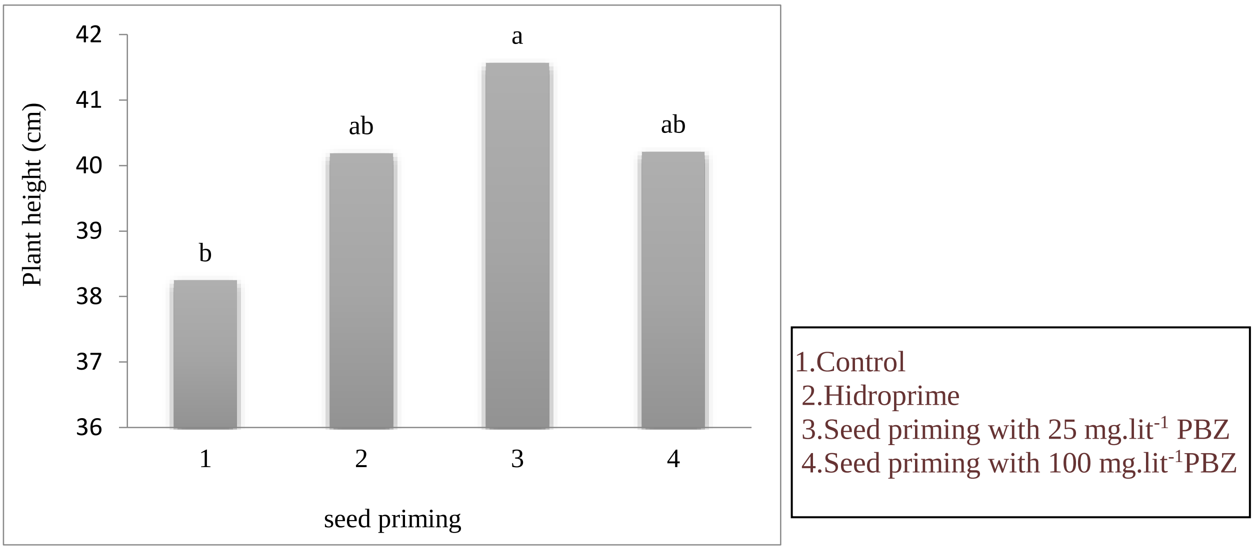


Fig. 2: Influence of seed priming PBZ applicationon the plant height.

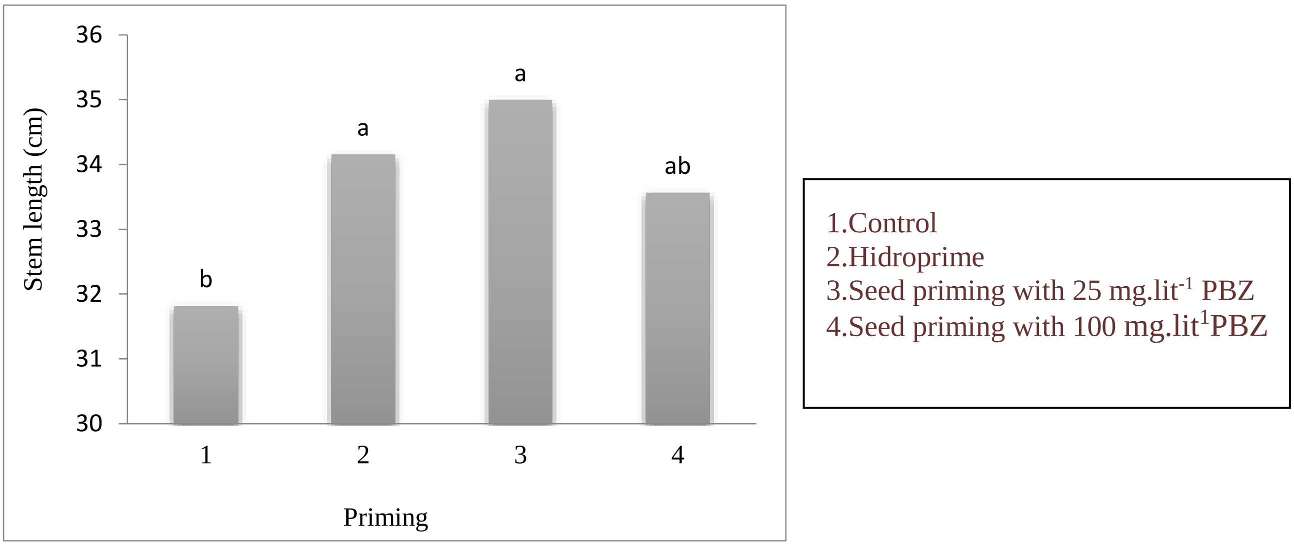


Fig. 3: Influence of seed priming PBZ application on stem length.

Penultimate length and Peduncle length

The analysis of variance showed that the main effects of priming and foliar was not significant on Penultimate and Peduncle lengths, but the interaction of seed priming and foliar had significant ($p \leq 0/05$) effect on Penultimate length. The mean comparison results of Penultimate length showed that those priming which contained foliar with different levels of Paclobutrazol had longer Penultimate as compared to control [Fig. 4].

Stored carbohydrates are known as one the sources for supplying photosynthetic materials (Yang and Zang, 2006). When production of photosynthetic materials is more than sinks requirement, these carbohydrates are stored in different parts of the plant such as various internodes of stem; these carbohydrates will be transferred to the seeds at the final stages of growth when request for photosynthetic materials is more than their availability (Joodi et al, 2010). In recurrence of cereals' stored carbohydrates, Peduncle (the first internode from the top of stem), and Penultimate (the second internode from the top of stem) play more important role than lower internodes (Ehdaie, 1996). Wardlow and Wilenbrink (1994) declared that in wheat, Penultimate and Peduncle internodes stored the highest amount of carbohydrates. In this respect, Daniel and Elkoca et al (2006) pointed to the higher amount of storing soluble sugars in upper internodes of barley as compared to its lower internodes. The results of our experiment oppose those of Fletcher et al (2002) who reported that by preventing GA biosynthesis, triazoles cause the reduction of internodes' length; and also our findings oppose those of Fletcher et al (2002) where they claimed that PBZ is a preventer of GA biosynthesis and it slows down growth rate of wide range of crops that it happens due to shortening of internodes and stopping the growth for a long time.

Some of the reasons which caused contradiction between our experiment and the results given by other researchers can be the concentration of growth moderators, application method, application time, application number, the formula of used substance, and components of the soil.

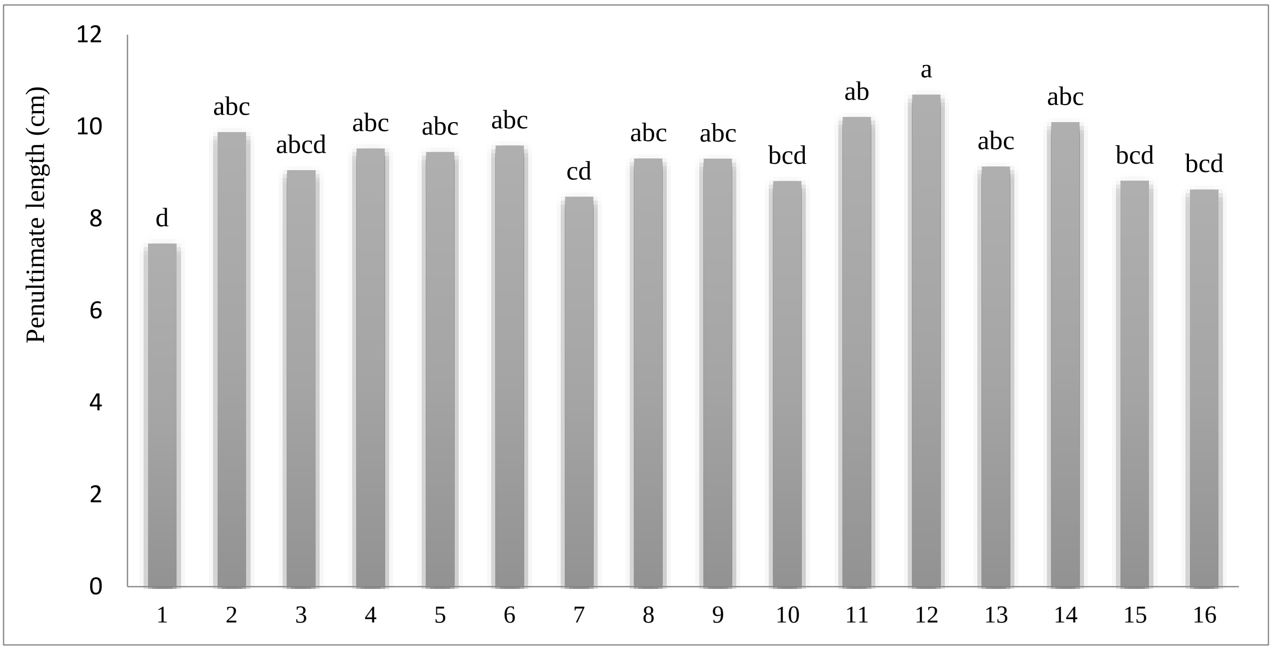


Fig. 4:The interaction of seed priming and foliar PBZ application on Penultimate length.

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1. Control, Control
2. Control, foliar with 30 mg.lit^{-1} PBZ
3. Control, foliar with 60 mg.lit^{-1} PBZ
4. Control, foliar with 90 mg.lit-1 PBZ
5. Hidroprime, Control
6. Hidroprime, foliar with 30 mg.lit^{-1} PBZ
7. Hidroprime, foliar with 60 mg.lit^{-1} PBZ
8. Hidroprime, foliar with 90 mg.lit^{-1} PBZ

9.Seed priming with 25 mg.lit-1 PBZ, Control
10.Seed priming with 25 mg.lit-1 PBZ, foliar with 30 mg.lit^{-1} PBZ
11.Seed priming with 25 mg.lit-1 PBZ, foliar with 60 mg.lit^{-1} PBZ
12.Seed priming with 25 mg.lit-1 PBZ, foliar with 90 mg.lit^{-1} PBZ
13. Seed priming with 100 mg.lit-1 PBZ, Control
14.Seed priming with 100 mg.lit-1 PBZ, foliar with 30 mg.lit^{-1} PBZ
15.Seed priming with 100 mg.lit-1 PBZ, foliar with 60 mg.lit^{-1} PBZ
16 Seed priming with 100 mg.lit-1 PBZ, foliar with 90 mg.lit^{-1} PBZ.

Spike Length

The analysis of variance showed that seed priming had significant ($p \leq 0/05$) effects on spike length (Data not shown). As far as the spike length concern, an obvious advantage was observed among those priming which their seeds were pretreated by Paclobutrazol as compared with the Hydroprime and the control. The results of mean comparison of priming effect showed that seed priming with 100 mg.lit-1 Paclobutrazol. had the longest spike and the lowest rate of this characteristic was observed in Hydroprime (Fig. 5). Generally with increasing the concentration of paclobutrazol in seed priming, the length of spikes also increased; however there were not significant differences between the two concentrations of 25 and 100 mg.lit-1 Paclobutrazol solution. The effect of foliar on canopy at the final stage of tillering was not significant on the spike length.

Giry and Schlinger (2003) reported the same results that the plants produced by pretreated wheat seeds had more and longer spikes due to favorable germination and rapid growth. The conducted researches show that Paclobutrazol application decreases inflorescence length and increases the number of inflorescence and flower in inflorescence (Jamalian et al, 2007); and these results are in opposition of our research's results.

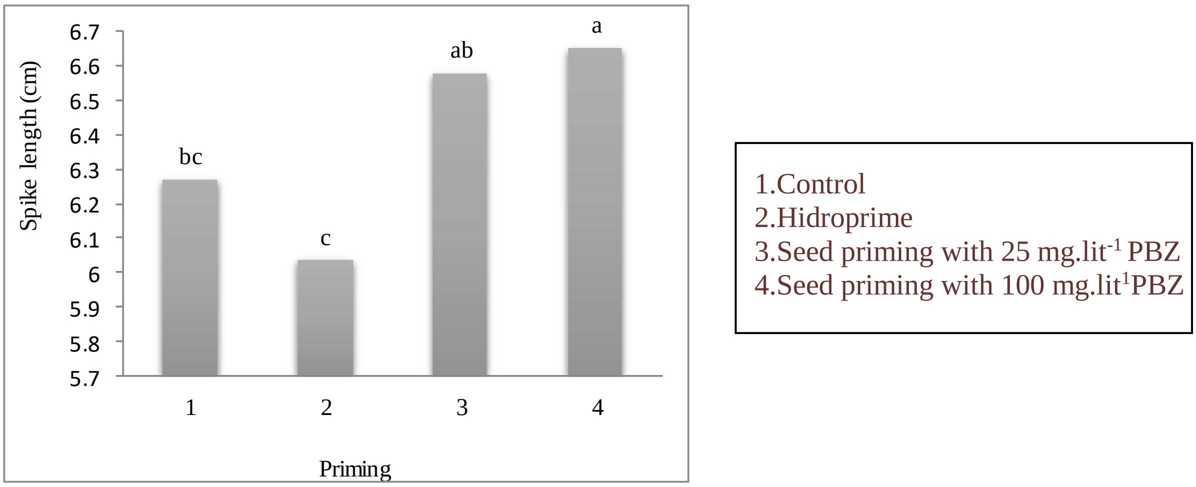

Fig. 5: Influence of seed priming PBZ application on spike length.

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spikelet number per spike

The analysis of variance showed that seed priming had significant (P< 0/01) effect on the number of spikelets per spike (Data not shown). In terms of spikelet number per spike, the seeds primed by Paclobutrazol solution had an obvious advantage over Hydropriming and the control. According to the results of mean comparison, priming with 25 and 100 mg.lit-1 Paclobutrazol had the highest number of spikelets per spike and Hydropriming had the lowest number (Fig. 6). The analysis of variance showed that spraying on canopy at the final stage of tillering had not significant effect on the number of spikelet per spike (Data not shown). However, spikelet number per spike reduced by increasing the concentration of Paclobutrazol, and priming with 30 mg.lit-1 Packloburazol. had the highest number of spikelets per spike. The interaction of seed priming and spraying was not significant on spikelet number per spike.

The conducted researches show that Paclobutrazol application cause the reduction of inflorescence length and increases the number of inflorescence and flower in inflorescence (Jamalian et al, 2007); the results of the mentioned research is in agreement with the results of the present study.

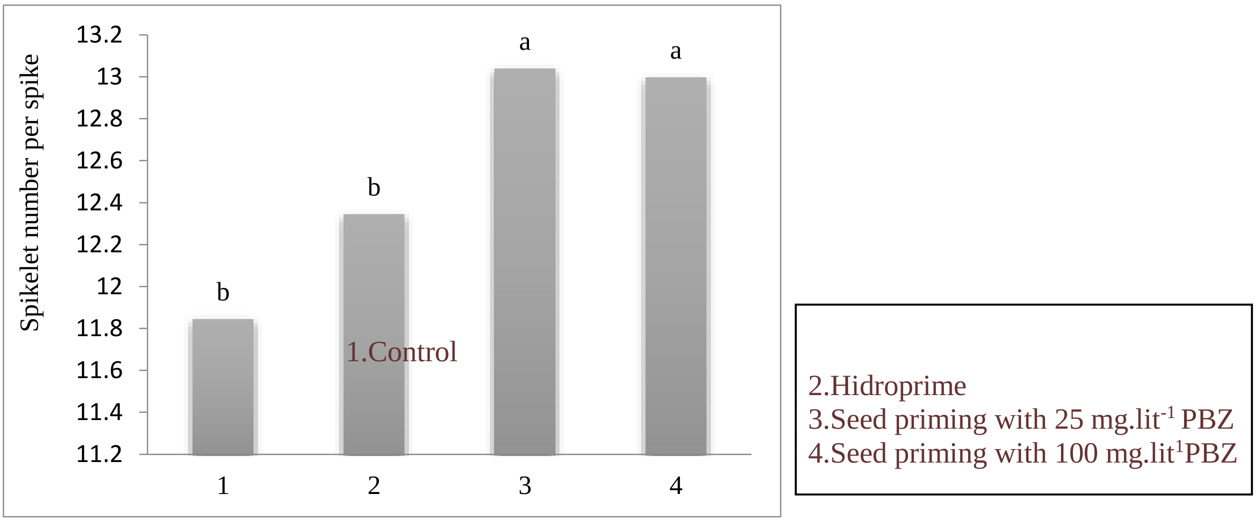

Fig. 6: Influence of seed priming PBZ application on the number of spikelets per spike.

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Grain Number per Spike

The analysis of variance showed that seed priming had significant (p≤ 0/01) effect on grain number per spike (Data not shown). The seeds primed by Paclobutrazol solution had an obvious advantage over Hydropriming and the control in terms of grain number per spike. According to the results of mean comparison, priming with 25 and 100 mg.lit-1 Paclobutrazol had the highest number of grain per spike and Hydropriming and the control had the lowest number of grain per spike (Fig. 7). Generally in seed priming, grain number per spike increased by increasing the concentration of Paclobutrazol; however there was not significant differences between the two concentration of 25 and 100 mg.lit-1 PBZ. The analysis of variance showed that spraying on canopy at the final stage of tillering had not significant effect on the grain number per spike (Data not shown).

Using various methods of priming in Safflower (Carthamus tinctorius L.) seed improved plants number per square meter, number of head per plant, grain number per head, and finally grain yield (Movahedi Dehnavi et al, 2012). In corn, Paclobutrazol spraying caused significant increase of grain number per row, i.e. 1.27 percent as compared to the control (Sepehri and Bayat, 2014). It is reported that grain number per cluster and 1000-seed weight were increased in plants grown from pretreated seeds, and this increase finally led to improvement of grain yield in rice (Farooq et al, 2006). Using osmo-priming, hardening priming, and matric priming in Canola (Brassica napus L.) increased grain yield via improvement of indicators such as the number of grains per pod and 1000-seed weight (Afzal et al, 2004).

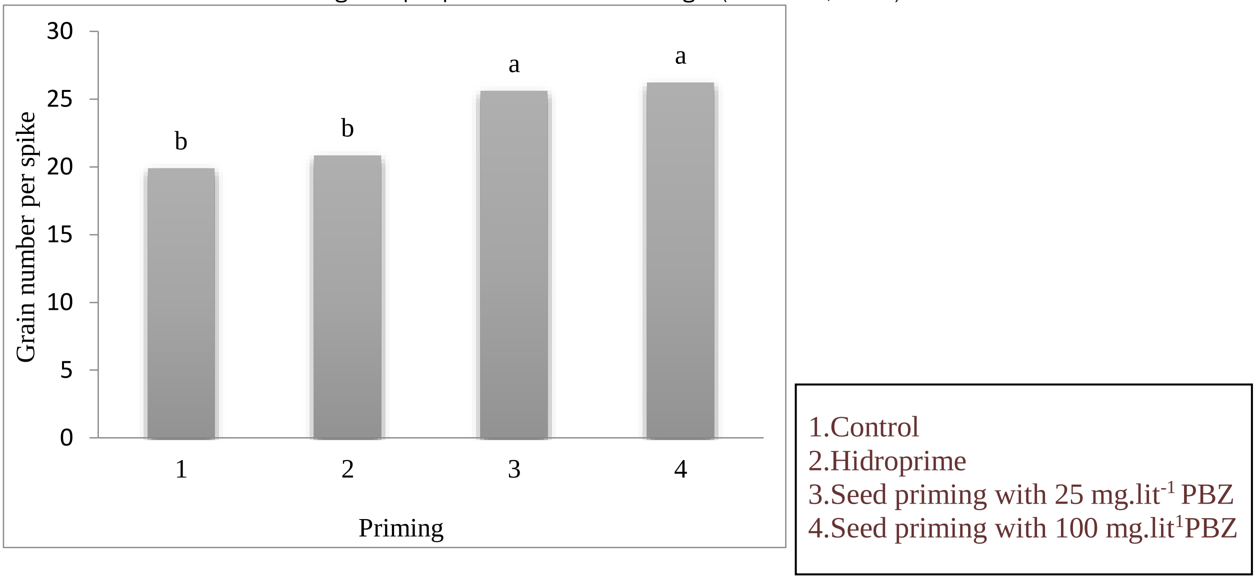

Fig. 7:Influence of seed priming PBZ application on grain number per spike.

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100-seed weight

The analysis of variance showed that seed priming had significant (p≤ 0/05) effects on 100-seed weight (Data not shown). In terms of 100-seed weight, seed primings had an obvious advantage over the control. By increasing PBZ concentration, 100-seed weight was reduced, but significant differences were not observed between two concentrations of 25 and 100 mg.lit-1 PBZ. The results of mean comparison showed that priming with 25 mg.lit-1 Paclobutrazol had the highest 100-seed weight and the control had the lowest 100-seed weight [Fig. 8]. The analysis of variance showed that spraying on canopy at the final stage of tillering had not significant effect on 100-seed weight (Data not shown). However, foliar with PBZ solution increased 100-seed weight as compared to the control. Priming with 30 mg.lit-1 PBZ had the highest 100-seed weight; and by increasing PBZ concentration, 100-seed weight decreased.

The most salient morphological feature of PBZ is reducing vegetative growth; and then by changing the distribution manner of materials obtained from photosynthesis, it leads these materials to reproductive parts; and as a result, more flower buds will be produced, consequently fruit production will be increased (Lever, 1986). Generally, triazoles decrease vegetative growth and reduce competition between vegetative and reproductive organs for gaining photosynthetic materials. Most of the available reports indicate that PBZ priming increases fruiting and flowering percentages (Sedighi et al, 2007). The effect of PBZ on the plants' reproductive organs shows itself in different ways. According to Abraham et al. 2008, in priming with PBZ, Sesame seed weight increased under drought stress.

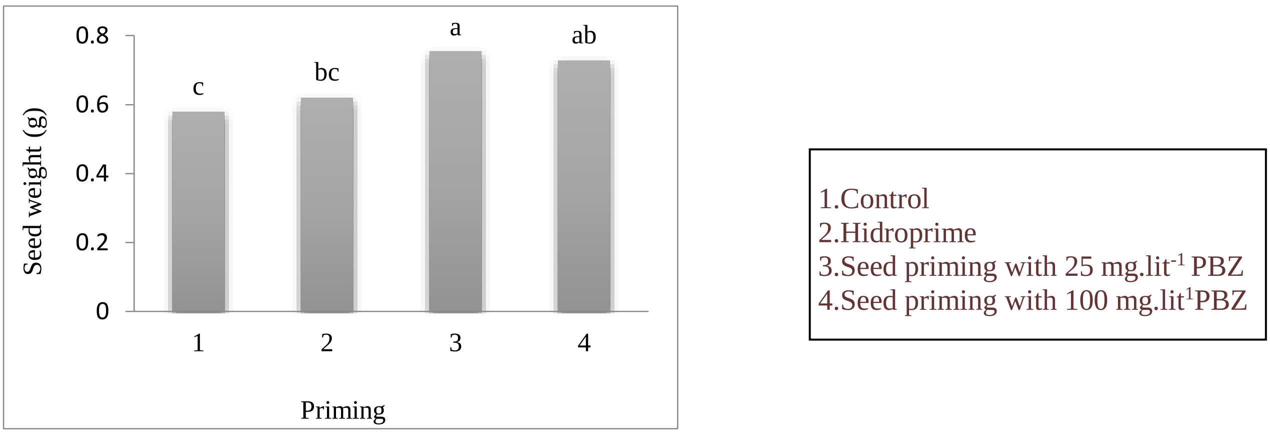

Fig. 8 : Influence of seed priming PBZ application on 100-seed weight.

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Biological Yield (Total dry-material)

The analysis of variance showed that seed priming had significant (p≤ 0/01) effects on biological yield (Data not shown). The mean comparison showed that priming with 25 mg.lit-1 PBZ had the highest biological yield, i.e. 191.891 g, and the control had the lowest biological yield, i.e. 140.406 g [Fig. 9]. In terms of biological yield, seed primings had an obvious advantage over the control; seed priming with PBZ increased biological yield as compared to Hydropriming. Although increasing the concentration of PBZ (100 mg.lit-1) decreased biological yield as compared to priming with 25 mg.lit-1 PBZ, there were not significant differences between these two concentrations 25 and 100 mg.lit-1 PBZ).

There are some reports which show that priming with proper concentrations of plant growth hormones effectively increase yield in various crops under water stress and normal condition (Harley et al, 1991; Lee et al, 1998; Pakmehr, 2009). Spraying PBZ in the stem elongation stage of Canola (Brassica napus L.) increased dry weight of plants. Also in various cultivars of winter Canola, Mixatole and PBZ primings significantly increased plant dry-weight (Mohammadi et al, 2011). Faroogh et al, (2008b) reported that seed priming increased the number of tillers, grain yield, biological yield and harvest index of wheat under late cultivating condition, but had no effect on plant height, spikelet number, grain number and 1000-seed weight. It is reported that the activity of acid Invertase was increased in meristem tissues of pea plants grown from primed seeds, and its increased activity caused increase of plant growth and biomass (Kaur et al, 2005). Also there are some reports which indicate that seed priming involves in increasing the activity of those enzymes which participate in metabolism such as sucrose synthase and sucrose phosphate synthase; also by raising chlorophyll content and increasing photosynthesis, it increases the source power and availability of photoassimilates, and by doing so, it improves yield and biomass (Kaur et al, 2005). Amin et al (2008), Faroogh et al (2008b), Mirsadeqhi et al (2010) reported an increase of biological yield due to salicylic acid application.

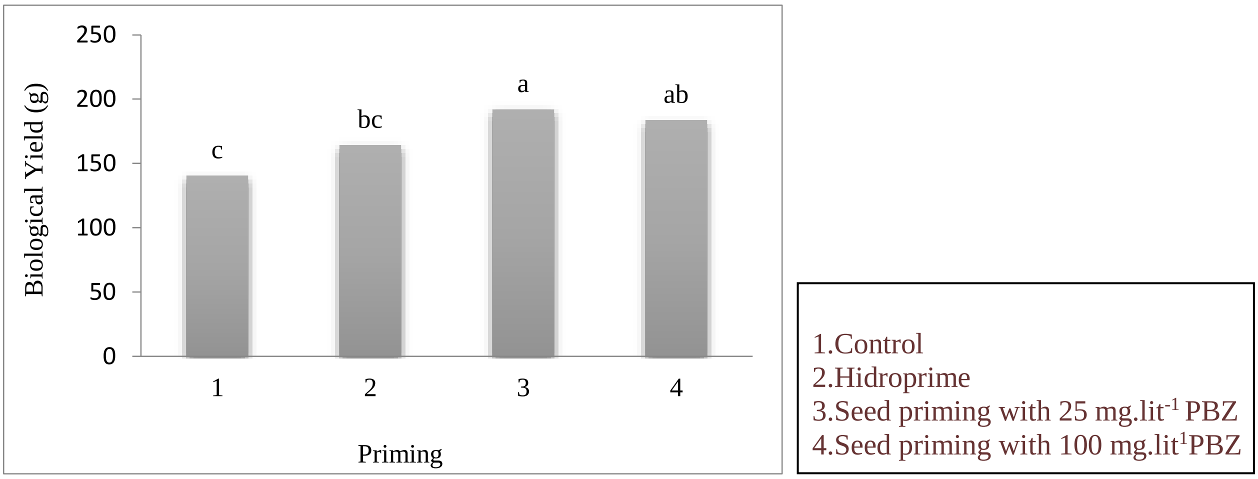
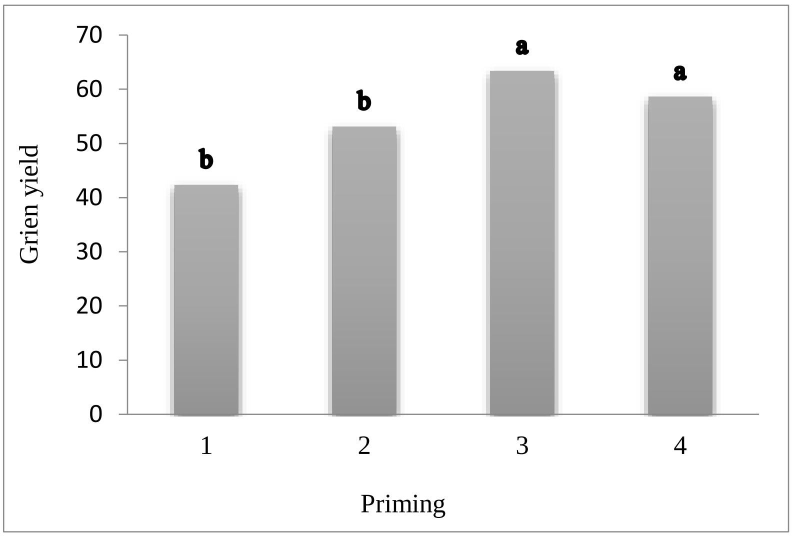


Fig. 9: Influence of seed priming PBZ application on biological yield.

Grain Yield

The analysis of variance showed that seed priming had significant (p≤ 0.05) effects on the grain yield (Data not shown). The mean analysis showed that priming with 25 mg.lit-1 produced the highest grain yield (63.35), and the control had the lowest amount of grain yield (42.28) (Fig. 10). In terms of grain yield, primed seeds had an obvious advantage over the control. Although grain yield was reduced by increasing PBZ concentration, seeds priming with PBZ increased grain yield as compared to Hydropriming and the control. The analysis of variance showed that foliar application (of PBZ) at the final stage of tillering didn't have significant effect on grain yield (Data not shown). However, foliar application of PBZ increased grain yield as compared to the control (foliar application of distilled water); and foliar with 30 mg.lit-1 PBZ, produced the highest grain yield. Increasing PBZ concentration did not increase the grain yield.

Application of plant growth stimulators had useful effects on wheat grain yield (Logendra et al, 2004). priming of seeds with PBZ solution increased the grain yield of rainfed wheat (Azar2) (Karami et al, 2014). There are some reports which indicate that seed priming increased grain yield under rainfed conditions (Rajabi, 2011). Application of plant growth regulators at any level increases grain yield (Heidari and kavousi, 2013). In field experiments, application of growth regulators at mid-tillering stage increased grain yield of spring barley 10 to 17 percent and increased grain yield of winter barley 12 to 18 percent. The reason of this increase in grain yield was the increase of spike number per unit area (Heidari and kavousi, 2013). Some other researchers claim that this increase in grain yield happens due to the increase of physiological source power (Waddington and cartwright, 1986). The researches done by Shokofa and Imam (2005) shows that growth regulators significantly increased grain yield of wheat due to the increase in grain number per spike, spike elongation, and the number of spikes per unit area. Under moderate and severe drought stresses, PBZ can be effective in reducing drought effects on plants; and foliar application of PBZ, under moderate and severe drought stresses, significantly increased grain yield as compared to those primings which PBZ did not applied on them under the same conditions. During two stages of tillering and stem elongation, foliar application of rooting (rhizogenic) hormones such as PBZ and Daminozide, Abscisic acid and Atifen, and using Twin as a surfactant did not have significant effects on straw yield and dry seed of rainfed wheat. The reduction of yield with foliar application of PBZ under favorable moisture conditions can be related to an increase in concentration of Abscisic acid hormone. The mentioned hormone (Abscisic acid) reduces grain yield via reducing the number of endosperm cells, followed by decreasing grain size and also stimulating for embryonic loss, and decreasing grain number (El-Khallal et al, 2009). According to our reports, and Smith's (1992), growth stimulators don't accumulate dry matters in cereals, rather they affect the distribution patterns of dry matters which depending on the environmental conditions, cause positive or negative effects on grain yield. During particular period, the plant growth regulators in assimilate distribution show its effects in bush, leaves and tillers more than roots (Rajala and Peltonen-Saninio, 2001).



1.Control
2.Hidroprime
3.Seed priming with 25 mg.lit^{-1} PBZ
4.Seed priming with 100 mg.lit^{1}PBZ

Fig. 10: Influence of seed priming PBZ application on the grain yield.

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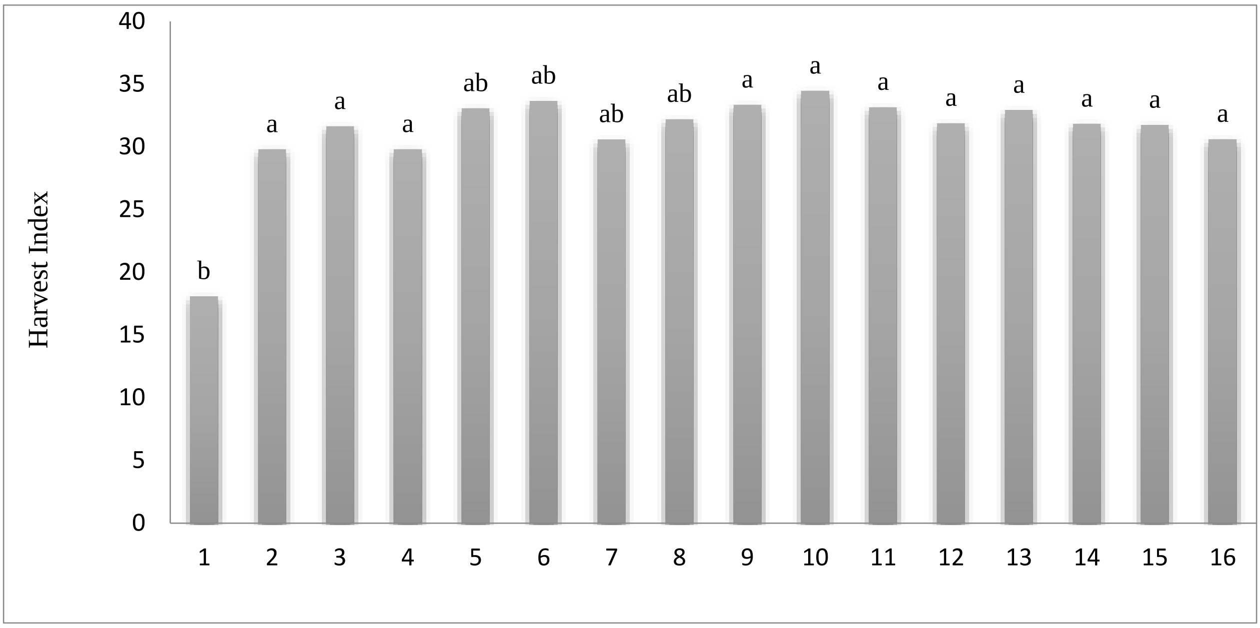
Harvest Index

The analysis of variance showed that the effects of seed priming were significant ($p \leq 0.01$) on harvest index, and the interaction of seed priming and foliar application had significant ($p \leq 0.05$) effects on harvest index (Data not shown). The mean comparison of the interaction of seed primings and foliar application on harvest index showed that the interaction of all seed primings along with foliar application had the highest harvest index (Fig. 11). In recent years, what has been reported about the high yielding wheat varieties show that harvest index (HI) is the main factor in increasing wheat yields per ha. The average of wheat HI is 50 percent and many agricultural experts believe that it can be increased up to 65 percent; while in Iran, wheat HI is about 47 percent (Rashed-Mohassel, 1998; Rahnama et al, 2000). There is a similar report which indicates that seed priming with PBZ solution could increase grain yield and HI of rainfed wheat (Azar2) (Karami et al, 2013). In the experiments of Hussain et al. (2009), and Setia et al. (1995), foliar application of PBZ did not have significant effects on HI of the plants under their studies, and this result is in agreement with our experiment. It is reported that priming of Sunflower seeds changed the distribution manner of dry matters in favor of the grains, and increased its HI and grain yield (Hussain et al., 2009).

Protein yield

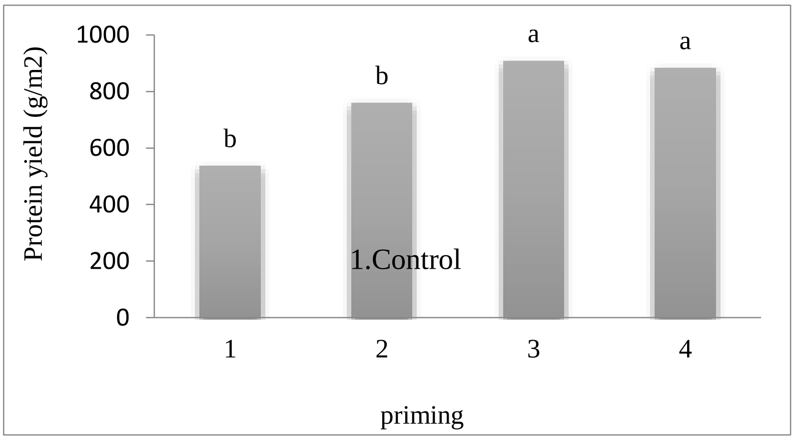
The analysis of variance showed that seed priming had significant ($p \leq 0.01$) effects on protein yield (Data not shown). The mean comparison showed that seed priming with 25 mg. lit-1 PBZ had the highest protein yield (907.3216 g/m2) and its lowest amount (536.0181 g/m2) was observed in the control (Fig. 12). Primed seeds with PBZ had an obvious advantage over Hydroprime and control. Seed priming with PBZ increased protein yield, though increasing PBZ concentration reduced its amount. However, significant differences was not observed between 25 and 100 mg. lit-1 PBZ.

One of the primary effects of growth regulators is that they affect GA, Sterols and Abscisic acid biosynthesis, and they indirectly affect starch percentage; and as a result, protein yield will be increased (Sawan, 2008). It is reported that increased amount of amino acids in primed seeds may be happens due to releasing these amino acids from protein storages. Various experiments show that protein synthesis is increased while priming and germination of primed seeds of lettuce, tomato, pepper, leek, wheat and corn is improved (Harris 1999, 2001, 2002). Proteins concentration is increased while priming and their amount remains high even after dryness of the seeds (Harris 1999, 2001, 2002). There are similar reports which indicate that priming wheat seeds with PBZ increases the amount of proteins (Nouriyani, 2012). Also, there are other similar results which show that PBZ application increases the amount of proteins under stress and non-stress conditions (Razavizadeh and Amu Beigi, 2013). Foliar application of PBZ on onion, Texas Early Grano variety, caused a 65 percent increase in protein amount of aerial organs as compared to control, however its foliar application did not cause significant differences in protein amount of root as compared to control. Protein amount of onion primed by PBZ was significantly increased as compared to control. Both concentrations of PBZ significantly increased protein amount in onion and the concentration of 2000 mg. lit-1 increased its amount up to 238 percent as compared to control. PBZ primings didn't cause any difference in the protein amount of roots (Arvin et al, 2003).



1.Control, Control
2.Control, foliar with 30 mg.lit^{-1} PBZ
3.Control, foliar with 60 mg.lit^{-1} PBZ
4.Control, foliar with 90 mg.lit-1 PBZ
5.Hidroprime, Control
6.Hidroprime, foliar with 30 mg.lit^{-1} PBZ
7.Hidroprime, foliar with 60 mg.lit^{-1} PBZ
8.Hidroprime, foliar with 90 mg.lit^{-1} PBZ
9.Seed priming with 25 mg.lit-1 PBZ, Control
10.Seed priming with 25 mg.lit-1 PBZ, foliar with 30 mg.lit^{-1} PBZ
11.Seed priming with 25 mg.lit-1 PBZ, foliar with 60 mg.lit^{-1} PBZ
12.Seed priming with 25 mg.lit-1 PBZ, foliar with 90 mg.lit^{-1} PBZ
13. Seed priming with 100 mg.lit-1 PBZ, Control
14.Seed priming with 100 mg.lit-1 PBZ, foliar with 30 mg.lit^{-1} PBZ
15.Seed priming with 100 mg.lit-1 PBZ, foliar with 60 mg.lit^{-1} PBZ
16 Seed priming with 100 mg.lit-1 PBZ, foliar with 90 mg.lit^{-1} PBZ.

Fig. 11: The interaction of seed priming and foliar PBZ application on harvest index.



1.Control
2.Hidroprime
3.Seed priming with 25 mg.lit^{-1} PBZ
4.Seed priming with 100 mg.lit^{1}PBZ

Fig. 12: Influence of seed priming PBZ applicatinon protein yield.

CONFLICT OF INTEREST

There is no conflict of interest.

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FINANCIAL DISCLOSURE
None

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