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The effects of on-farm seed priming and planting date on emergence characteristics, yield and yield components of a corn cultivar (S.C. 260) in Hamedan

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ABSTRACT

To evaluate the effects of on-farm seed priming treatments and planting date on emergence characteristics, yield, yield components and harvest index of corn, an experiment was conducted in Hamedan, research farm of Bu-Ali Sina University in 2010 as split plot in a randomized complete block design with three replications. Main plots included three planting dates containing early, on-time and late seeding time and subplots were representative of four on-farm seed priming treatments (priming with tap water, urea and zinc solutions and no primed). Results showed that the first planting date using zinc solution increased rate of emergence as well 30%. E mergence percent was increased in the first planting date with using zinc solution by10% and in the second and third planting dates with using urea solution by 13%. However in all planting dates priming with tap water produced maximum grain yield compared to no primed treatment. In this experiment seed priming increased the ear number per square meter and grain rows per ear. Also priming with tap water caused to increase 100 grains weight of corn meanwhile in first planting date priming with tap water and urea solution had more grain number per ear. Priming with zinc in the first planting date increased harvest index. Generally it is concluded that farmers by seed priming especially with tap water and zinc solution could plant corn earlier to increase growth season also if planting is delayed priming with tap water can compensate yield loss.

Key words: Planting date, on- farm seed priming, corn, emergence, yield.

INTRODUCTION

Corn is a C_4 crop that has developed due to high potential of grain yield and fodder for feeding livestock and birds [1]. Date of planting is the most important factor that affects plant physiological and morphological specifications like effect on vegetative and reproductive periods, harvest time, yield and its quality. Uniformity and percentage emergence of planted seeds have a great impact on grain yield [19]. Naturally, when speed and percentage emergence of germinating seeds are being high, growing sources like light, water and nutrient will be more used [6]. In this regard, a mechanism is required to enhance germination and establishment of emerging seeds under early or late planting times and provide using more of soil moisture, nutrients and solar radiation for the plant [4]. Thus, the plant will be able establish at lower temperatures in the early planting or end its growing period successfully in the late planting time before the early cold in fall [37]. On- farm Seed priming is included soaking seeds in water for a predetermined duration followed by surface drying before sowing [24]. On- farm seed priming has been effective on rapid germination, better establishment and increasing plant yield in unfavorable environmental conditions [38]. On-farm Seed priming is a simple, low risk and low cost technology that can improve speed emergence, seedling vigor and crop performance [5]. Priming causes occurrence a series of biochemical changes in seeds which is associated with a more successful start of germination, seed dormancy breaking, increasing inhibitors metabolism and activating enzymes involved in germination [2]. On the other hand, lack of zinc can limit the growth and productivity of a wide range of crops especially in corn [32]. Harris *et al*. (2002) reported that priming in corn improved seedling establishment, plant growth and caused earlier flowering and increasing yield. In these plants, increased yield was attributed to both priming and zinc. Since a wide range of soils in the world are deficient in zinc, seed priming combined with zinc element can be effective for the treatment of zinc deficiency in the soil. Ouzturk *et al*. (2006) found that high concentrations of zinc in root and coleoptile represents a critical physiologic role of zinc during early seedling development. Probably, zinc in these tissues is used for membrane protein synthesis, cell elongation and greater resistance to environmental stresses [10]. Also has been reported that using nitrogen during seed priming is significantly effective on speed emergence, seedling establishment and yield increase[7,3] On- farm seed priming of corn (soaking seeds in tap water for 17 hours before planting) in semi-arid regions has caused to improve corn establishment and its yield [18]. Also effect of on-farm seed priming were investigated in the fields of sorghum (*Sorghum bicolor*) in Nigeria during 2001 to 2003 that resulted to improve seedling germination and crop performance [31]. In the study of electrical conductivity of seed extract it was revealed that in primed seeds cell membrane structure has been in a more stability. So that the leakage of intracellular metabolites was less in the primed seeds. This has been proved about primed seeds of sweet corn, sugar beet, prune, radish, wheat and barley [30]. Studies by Harris *et al*. (2001) showed hydroprimed seed in India, Nepal and Pakistan has increased yield of wheat by amount 5 to 36 percent. The purpose of this study was to evaluate the effect of planting date and on-farm seed priming treatments on emergence characteristics, yield, yield components and harvest index of corn cultivar single cross 260 under Hamedan climate.

MATERIALS AND METHODS

In order to investigate the effects of on- farm seed priming and planting date on emergence characteristics, yield, yield components and harvest index of a corn cultivar (S.C. 260), an experiment was conducted at agricultural research station of Bu-Ali Sina University in Hamedan (35.02 ^{o} N, 48.5 ^{o} E and 1690 m) in 2010. Soil was clay – silt with pH 8.1, nitrogen 0.11% and zinc 0.88 ppm.This experiment was as split plot in a randomized complete block design with three replications. Main plots included three planting dates were considered: early planting (15thMay), on time planting (29thMay) and late planting (12thJune). Daily average air temperature on above planting dates were 14.6^{o} C, 19.3^{o} C and 22.8^{o} C respectively. Planting date was determined on the basis of the average temperature of Hamedan and base temperature for corn germination. The subplots were representative of four on-farm seed priming treatments (priming with tap water, urea solution (6 grams per liter), zinc solution in 0.01% concentration, equals to 0.35 gr per liter of zinc sulfate, and no primed). Priming time was 16 hours that was determined with a preliminary test for determining time and solutions concentration. Corn cultivar was single cross 260 naming Fajr was prepared by plant and seed breeding center in Karaj. One feature of this cultivar is to produce more than one ear per plant. Tillage processes included plow, disk and leveling, then adding100 kg/ha urea and 150 kg/ha phosphate as basic fertilizers. The rest of urea fertilizer (150 kg/ha) was used in the two stages of 7 leaves and tasselling as topdress fertilizer. Each plot was consisted of 5 rows grown just 7 m in length and row spacing 75 cm. Planting density was 78000 plants per hectare. The distance between the main plots and replicates were 2 m and between subplots was 75 cm. In order to measure the rate and percentage emergence after starting seed emergence, each day during the 10 days in a specified line, emergence seeds were counted for each experimental unit. Angular conversion (arcsin $\sqrt{x}$) was used for normaling percentage of germination. Seedling emergence rate was calculated by using equation 1:

Equation1: Emergence rate $= \frac{\sum ni}{\sum ni\ di}$

ni and di are respectively number of emergenced seeds and the number of days from planting time in i th counting. At the end of the growing season, harvesting was done from 2 square meters and yield and yield components were calculated. Statistical analysis was performed by using SAS and MSTATC statistical softwares and the comparison of means was conducted by Duncan test at 5%.

RESULTS AND DISCUSSION

Emergence rate

According to results of analysis of variance (Table1) main and interaction effects of planting dates and priming treatments on emergence rate were significant at 1% and there was a significant difference between priming treatments in the first planting date so that priming with zinc and urea solutions increased emergence rate compared to control (Table 2). However, there was no significant difference between priming treatments in the second and third planting dates because with increasing average air temperature in second and third planting dates, the emergence rate normally increased. This shows that the priming effect is more pronounced in unfavorable environmental conditions [12]. It was reported that seed priming can reduce germination base temperature [14]. In primed seeds activity of degrading enzymes such as alpha amylase are increased that cause of accelerated germination rate [25]. Also in primed seed increasing of bio-energy level (ATP), increasing of RNA and DNA synthesis and enhancement of mitochondrial performance have been reported [15]. It seems zinc and nitrogen have participated in above compounds construction and this has caused their superior treatment in compare to water. Reduction in the base temperature for seed germination makes germination to begin earlier and be more successful in competition with weeds and developmental stages of adaptation to environmental conditions should be better [22]. Seed hydropriming causes germination improving, emergence and seedling establishment by reducing the time required for water uptake [34]. Increased germination rate in seeds of corn, rice, chickpea by priming has also been reported [21].

Emergence percentage

It is considered the main and interaction effects were significant at 1% on the emergence percentage (Table 1). Generally in all three planting dates, Priming treatments increased the percentage of emergence (Table 2). Priming with zinc solution and water in first planting date, zinc and urea solutions in second priming date and only urea solution in third planting date caused to increase of emergence percentage. It seems that higher temperature in the third planting date has decreased limitation of zinc absorption however nitrogen uptake has been limited perhaps by gaseous loss causing of higher temperature at third planting date. Musa *et al*. (2001) reported that on-farm seed priming in chickpea caused increasing of emergence percentage because of priming increases seed metabolic activity. Also Nagar *et al*. (1998) showed that hydropriming has increased percent and rate of corn emergence in farm.

Number of ear per square meter

According to result of analysis of variance (Table 1) can be seen that the main and interaction effects of planting date and priming on the trait were significant at 1%. Results showed that in the first planting date, priming with water and zinc solution and in the second and third planting dates priming with water and urea solution had most ear per square meter. In third planting date the most number of ear were achieved in priming with water and urea (Table 3). This increase resulted of the effect of treatments on tillering ability of maize, especially in case of late planting which can compensate low planting density in the case of corn silage. The corn cultivar has been studied produces tillers naturally. It seems that increasing of number of tiller in primed treatment by urea is reason of increasing in number of ear in this treatment. Sharma and Bandana (2003) reported that seed priming increased the number of wheat spikes per square meter resulted of increasing the number of wheat tillers. Harris *et al*. (2001) observed that formation and evolution of the ear in primed corn was significantly accelerated. Harris *et al*. (2002) reported that zinc will affect increasing the number of ear by increasing the amount of growth regulators, helping to metabolism and reproductive process.

Number of grain rows per ear

Effects of planting date, seed priming and their interaction on the number of grain rows per ear were significant at 1%. Due to Table 3, there was significant difference between priming treatments and control in all three planting dates that the effects of priming treatment are very clear. It seems that the seed priming is effective on reproductive development, this mode will cause increasing the potential number of grain ovule that is determined in the early stages of emergence [23].

Number of grains per row

Priming treatment, planting date and their interaction did not have significant effect on this trait. It seems that this trait is under the control of plant genetics [35] because of number of grains per row is controlled by number of ovules that is developing and producing the tassel, however, there are reports indicating the effect of environmental conditions on this trait. For example Finch-Savage *et al*. (2004) reported that drought stress, nutrient deficiency or radiation during 10 to 14 days before the pollination are reducing significantly the number of grains per row. On the other hand, number of grains per ear row depends on plant genetic potential to convert vegetative meristems to their reproductive and growing tassel.

Number of grain per ear

Results of analysis of variance showed that priming treatment, planting date and their interaction affected significantly on number of grain per ear (Table 1). Priming with water in all three planting dates increased number of grain per ear but using zinc and urea solutions in first planting date and zinc solution in third planting date also increased number of grain per ear (Table 3). It seems that for this trait, only priming regardless of the type of solution, has an important influence. Harris *etal*. (2007) also reported that.

100 grains weight

The results of analysis of variance showed that effect of planting date, seed priming and their interaction on the 100 grains weight were significant at 1% (Table 1). Water treatment increased 100 grains weight in the first and third planting dates (Table 3). Bakht *et al*. (2010) reported that primed seeds produced larger grains. Also, Farooq *et al*. (2006) reported priming rice seeds before planting increased its 1000 grains weight significantly at harvest time. Vigorous seedlings produced by seed priming can produce higher leaf area index, higher durable leaf area and uptake nutrients efficiently from soil. According to the results it is considered that priming has a determinant role for grain weight increasing. Kaur *et al*. (2005) reported that the sink activities was higher than control treatment in chickpea plants were grown from hydroprimed seeds. It was determined through the more activity of enzymes involved in sucrose metabolism that caused yield and 100 grains weight increase. Harris *et al*. (2002) also reported seed weight increasing by priming effect.

Ear length

The main factors and their interaction had significant effect on ear length at 1% (Table 1). Due to Table 3 in all three planting dates, priming has increased ear length but priming with urea solution in first planting date, with zinc solution in second planting date and with tap water in third planting date have increased ear length more.

Ear diameter

Effects of planting date, seed priming and their interaction on the ear diameter were significant at 1% (Table 1). Ear diameter has been affected by priming treatments only in first and second planting dates. In the first planting date priming with water and urea solution and in the second planting date priming with zinc solution increased ear diameter significantly (Tale 3).

Grain yield

Due to the results of analysis of variance the main effects and their interaction on grain yield were significant respectively at 1% and 5% (Table 1). Results showed that yield, in priming with water was equal in all three planting dates that showed priming has compensated late planting disadvantage (Table 4). Gupta (1985) in the study of effect of planting date on corn reported that early and late planting reduced grain yield. He expressed that yield loss in late planting was due to low cumulative growing degree days from tasselling to seed physiological maturity. In this study, maximum yield was related to first and second planting dates by priming with water (Table 4). Harris *et al*. (2001) stated that hydropriming by improving seed vigor in rainfed rice, corn and chickpea caused faster development, earlier flowering and higher yield in that crops. Rashid *et al*. (2004) reported that hydropriming of bean seeds during 8 hours increased yield. Ghasemi *et al*. (2008) showed that hydropriming increased yield and yield components through increasing rate and percentage emergence. Seed priming can increase the yield of harvested wheat, corn and cotton in the subtropical regions. This increasing is function of plant type, variety, environmental conditions and type of used treatment [28]. Harris *et al*. (2001) reported that hydropriming treatments for maize seed increased yield also they expressed that water and zinc sulfate treatment has led to increased yield by improving indices such as number of grains per ear. Harris *et al*. (2001) reported that seed priming with zinc sulfate increased the grain yield of wheat and maize respectively 16% and 26%. In this study increasing yield by zinc solution priming occurred on first and second planting dates (Table 4). Since in low temperature (early planting date), absorption of micronutrients especially zinc is low, priming with zinc can partly compensate this limitation, however in this study just on-farm seed priming regardless of involved nutrients was able to increase grain yield. Rashid *et al*. (2002) reported the total biomass, ear weight, grain yield in maize increased by 24 hours seed priming. Seed priming can improve establishment of many plants that can lead to rapid growth, early flowering and higher yield (Harris *et al*., 1999). Bastia *et al*. (1999) improved the number of plant per unit area, number of heads per bush, number of grains per plants,1000 grains weight and yield of safflower by using seed hydropriming treatments and changing planting date.

Harvest index
Analysis of variance for harvest index is shown in Table 1. Effects of planting date, seed priming and their interaction are significant respectively at 1% and 5%. In all planting dates, priming with zinc has a higher harvest index (Table 4). This is more important for late planting date that priming with zinc solution can extenuate yield loss by increasing harvest index. Effect of seed priming on sorghum yield was reported in Nigeria farms during 2001-2003. Farmers stated that seed priming helps to accelerate germination, maturity and increase of harvest index and pest attack and diseases extent in sorghum were reduced [31]. According to Harris *et al*. (2008) wheat seed priming with water and zinc sulfate increased grain yield and total dry matter however harvest index did not have any increasing but Bakht *et al*. (2010) reported that harvest index was increased by priming.

CONCLUSION

Generally for maize, on-farm seed priming with tap water is a good option in every planting date, however for better performance in the early planting date especially in cold regions such as Hamedan, priming of seeds with zinc solution can be recommended so that growing season can be longer, also on-farm seed priming can reduce complications of late planting to a desired level.

Table 1: Analysis of variance for planting date and seed priming on different characteristics of corn (SC 260).
(ns, *, ** : Non-significant, significant at the 5% and 1% probability levels, respectively)

		Mean Squares										
S.O.V	df	EmergenceRate	Emergence Percentage	No Ear/ m^2	No Row/Ear	No Grain/Row	No Grain/Ear	Seed Weight	Ear Length	Ear Diameter	GrainYield	Harvest index
Replication	2	0.00001^{ns}	1.19^{ns}	0.538^{ns}	0.11^{ns}	35.02^{ns}	698.3^{ns}	49.33^{ns}	0.0124^{ns}	0.059^{*}	309618.4^{ns}	8.29^{ns}
Planting date	2	0.0125^{**}	178.1^{**}	30.08^{**}	1.44^{**}	41.69^{ns}	4402.8^{**}	960.7^{**}	6.1^{**}	0.89^{**}	2268012.8^{**}	60.7^{**}
Error(a)	4	0.0001	1.73	0.416	0.11	35.1	253.1	20.2	0.11	0.006	302953.6	8.1
Priming	3	0.0001^{**}	57.66^{**}	63.43^{**}	5.3^{**}	100.9^{ns}	39474.1^{**}	3441.7^{**}	8.5^{**}	1.041^{**}	13385827.4^{**}	358.8^{**}
Planting date*priming	6	0.00007^{**}	67.55^{**}	12.26^{**}	2.3^{**}	75.10^{ns}	3079.6^{**}	939.56^{**}	3.5^{**}	1.21^{**}	812874.6^{*}	21.78^{*}
Error(b)	18	0.000005	0.925	0.324	0.11	36.45	257.18	23.13	0.11	0.109	246856	6.61
Coefficient of Variation (%)		1.64	1.137	3.85	1.94	14.97	2.27	1.93	1.6	2.12	5.013	5.01

Table 2: Means comparison of priming and planting date interactions on emergence traits (PD: Planting Date)

	Emergence Rate			Emergence Percentage		
Treatments	PD1	PD2	PD3	PD1	PD2	PD3
Control	0.106d	0.13b	0.174a	76e	86bc	80.6d
Tap water	0.107cd	0.126b	0.177a	78.3cd	86.6bc	74cd
Urea	0.113c	0.126b	0.173a	77e	91.3a	91.3a
Zinc	0.125b	0.132b	0.175a	82.3b	91.6a	81.3d

Table 3: Means comparison of priming and planting date interactions on yield components and corn characteristics (PD: Planting Date).

	Ear No/ m^2			Rows No/Ear			Grains No/Ear			100 Seeds Weight (gr)			Ear Length (cm)			Ear Diameter (cm)		
Treatments	PD1	PD2	PD3	PD1	PD2	PD3	PD1	PD2	PD3	PD1	PD2	PD3	PD1	PD2	PD3	PD1	PD2	PD3
Control	12 d	10 d	10 d	16 b	16 b	16 b	591 g	659 ef	652 f	240.6 cd	265.6ab	234 de	20.7 de	19.3 g	19.6 fg	4.9 bcd	4.7 de	4.7 de
Tap water	17 b	14 c	19 a	18 a	18 a	18 a	778 b	843 a	755 bc	265.3ab	277.3 a	265 ab	22.3 bc	21.3 cde	22.3 bc	5.1 ab	5 abc	4.9abcd
Urea	14 c	14 c	19 a	18 a	18 a	18a	734 bcd	703 def	687 def	244.6 cd	202.6 f	221.3 e	23.4 a	19.4 fg	20.4 ef	5.1 ab	4.5 e	4.9 abcd
Zinc	16 b	12 d	14 c	18 a	18 a	18 a	673 ef	666 ef	708 cde	255bc	278 a	233 de	21.6bcd	22.6 ab	21.4cde	4.9 bcd	5.2 a	4.8cde

Table 4: Means comparison of priming and planting date interactions on grain yield and harvest index (PD: Planting Date).

	Grain Yield (kg/ ha)			Harvest Index		
Treatments	PD1	PD2	PD3	PD1	PD2	PD3
Control	4808 cde	4125.6 de	3719.2 e	43.5 bcd	38.5 cd	41.3 cd
Tap water	6612 a	6572.8 a	6000 ab	42.1 bcd	44 abcd	34.6 d
Urea	5553.6 abc	5444.8 abc	5296.8 bcd	36.3 d	42.5 bcd	37.9 cd
Zinc	6576 a	6000.2 ab	5048 cd	52.2 a	43.4 abc	49 ab

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