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Investigation Effect of Different Irrigation Regime and Super Absorbent Polymer on Seed Yield and Morphological Traits of Maize (*Zea mays* L.)

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ABSTRACT

BACKGROUND: Alternative furrow irrigation method is an effective procedure to reduce the amount of irrigation water in arid areas for economic production.

OBJECTIVES: Assessment seed yield, its components and morphological characteristics of corn affected different level of irrigation regime and super absorbent polymer (SAP) under warm and dry climate condition.

METHODS: This research was conducted according split plot experiment based on randomized complete blocks design during 2016 with three replications. The main factor included three irrigation regimes (I_1: Conventional irrigation or control, I_2: Alternate furrow irrigation from 4 leaves stage until silk emergence and after conventional, I_3: Normal irrigation until silk emergence and after alternate furrow irrigation), also three level of super absorbent polymer (S_1: non use of SAP or control, S_2: 25 kg.ha^{-1}, S_3: 50 kg.ha^{-1}) belonged to the sub factor.

RESULT: The results of analysis of variance revealed the effect of different irrigation regimes on all measured traits (instead number of row per ear) was significant, also effect of different level of SAP on all measured traits (instead number of row per ear) (instead Ear diameter, stem diameter and number of row per ear) was significant, but interaction effect of treatment on all measured traits (instead number of seeds per ear and seed yield) was not significant. Evaluation mean comparison result of different irrigation regimes indicated maximum amount of plant height, ear length, ear diameter, stem diameter, number of row per ear, number of seed per row, number of seed per ear, 1000-Seed weight and seed yield was noted for I_1 and minimum of mentioned traits belonged to I_2 treatment. Also compare different level of SAP showed that the maximum and the minimum amount of measured traits belonged to S_3 and S_1 treatments.

CONCLUSION: Generally according result of current research I_3 treatment had lowest decrease in seed yield, its components and morphological traits so in water resource limitation I_3 treatment with use 50 kg.ha^{-1} SAP it can be advice to producers.

KEYWORDS: *Corn, Deficit irrigation, Ear length, Plant height.*

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1. BACKGROUND

Corn is the third most important cereal after wheat and rice all over the world as well as in Iran. Global demand for maize will increase from 526 million tons to 784 million tons from 1993 to 2020, with most of the increased demand coming from developing countries (Bahrani *et al*., 2012). One of limitation factor in agricultural plants production in dry areas in the water tension at growth step negative effect of water tension on corn growth depends on the time of tension occurrence, the intensity, plant growth and genotype step. Low irrigation in one of strategies to expert agricultural plant tillage and scrounge in water use which is a proper method to produce harvest in water shortage, generally in this method water performance is reduced cognizant to be compensated by enter tillage surface expansion and in many areas of America, India, Africa and many other lands which have water shortage, this method is prevalent (Mojaddam *et al*., 2012). The restriction of water resources and the improvement of modern agriculture have caused the progress in the value of production inputs and the researches position of optimizing consumption of water and fertilizer. Considering that in some sources, in order to maximum use of water resources, the possibility of reduction of water usage in vegetative phase has been suggested, and it is stated that the reduction of water usage in the flowering stage might be justifiable (Nesmith and Ritchie, 1992). In semi arid area, for the control of soil moisture profile is suggested as the appropriate method of irrigation mnagement and it is estimated that the water requirement of maize in this region is 1.561 mm (Camp *et al*., 2006). To achieve the prospect of strategic method and sustainable use of water and soil resources, some indicators are effective, which the compilation and explanation of optimal model of water and fertilizer usage in agriculture is among the most important ones. Any deficiency in the amount of water or nitrogen will reduce the product (Sepaskhah *et al*., 2006). Optimization of water consumption means timely and enough irrigation, and is consistent with the principle of irrigation engineering (Foroughi, 2006). There is a relatively linear relationship between the amount of irrigation water and the crop yield but if the amount of water is more than 50% of full irrigation, the relationship will be nonlinear (Hanks, 1974). In the condition of deficit irrigation, the amount of produced yield per unit area becomes less than the maximum yield per unit area, but the profit will be increased (Mohammadpour *et al*., 2013). Water scarcity and drought are the major factors constraining agricultural crop production in arid and semi-arid zones of the world. Irrigation is today the primary consumer of fresh water on earth (Shiklomanov, 1998), and thus agriculture has the greatest potential for solving the problem of global water scarcity. Consequently, improvements in management of agricultural water continue to be called for to conserve water, energy and soil while satisfying society is increasing demand for crops for food and fiber (Kassam *et al*., 2007). Innovations for saving water in irrigated agriculture and thereby improving water use efficiency are of paramount importance in water-scarce regions. Conventional deficit irrigation (DI) is one approach that can reduce water use without causing significant yield reduction (Kirda *et al*., 2005). The limited and/or expensive available water supply makes it impractical to irrigate the entire irrigable land area. Therefore, irrigators must decide between fully irrigating a small area for maximum production and reducing the depth of water applied per unit area in order to increase the area put under irrigation. The latter strategy is called deficit irrigation, which will reduce reasonable crop yield per unit of land but increases the net return for the water applied. DI maximizes water productivity (WP), which is the main limiting factor (Salemi *et al*., 2011). Deficit irrigation is an optimal strategy for agricultural production under water scarcity conditions which yields to efficient water consumption and reduces the volume of irrigation without any negative effect on net income. This strategy is a technical and economical for organizing the relations of water consumption r and crop's yield. In this well-cropping technique in water deficit conditions, by knowing the plant, the technique reduces water needs of crop to the point that would be efficient by receiving less water than its needes (Ghorbani *et al*., 2009). Tavakoli (1999) has shown that the yield reduction in Iran is much lower than the water reduction under the DI. Thus, the selection of a method for DI by farmers is important. Geerts and Raes (2009), who had reviewed many research from around the world, confirmed that DI is successful in increasing WP for various crops without causing severe yield reductions. They further suggested that in regions where the available water supply limits agricultural production, farmers must select crops and irrigation strategies to maximize their crop yields and livestock production activities. The determination and analysis of the agricultural WP index in Iran are essential to find suitable methods for better and economical use of water for agriculture. Thus, field data such as crop yield, different levels of water use, and irrigation management practices are necessary and pertinent to the formulating of water resources policies for optimal agricultural production and advancement in Iran. Zwart and Bastiaanssen (2004) reported that the range of crop WP of maize, based on a review of 84 literature sources, is very large (1.1-2.7 $Kg.m^{-3}$) and it thus offers new water management practices for increasing crop production with 20–40% less water resources. A study which was conducted in China Irrigation Research Station, in sandy loam soils, three methods of fixed furrow irrigation (FFI), alternative furrow irrigation (AFI) and critical furrow irrigation for all tracks (CFI) were compared at three levels of 30, 22.5, and 45 mm dept of irrigation water. The significant results of this study are high seed yield and a 50% reduction in water usage in AFI method and high reduction in yield of two other treatments with the reduction in the amount of irrigation water.Overall results of the study showed that the AFI method is an effective procedure to reduce the amount of irrigation water in arid areas for corn irrigation (Kang *et al*., 2000a). Tagheianaghdam *et al*. (2015) by study the effect of deficit irrigation on seed yield and its components of sweet corn reported alternative furrow irrigation treatment was a better solution for water saving in arid and semi-arid region with 50% saving compaire to control treat only with 6.5% reduction on yield. Super absorbent polymers can hold 400-1500g of water per dry gram at hydrogel. The use of SAP has a great importance for their role in the increase of water absorption capacity and retention of water shortage conditions and decrease of bad effects of drought stress (Khalili Mahalleh *et al*., 2011). SAP is the dried-sugar like materials with capacity to absorb and retain water higher than their weight. Despite inflammation following water absorption, these particles have a fixed geometric shape before and after water absorption (Dorraji *et al.,* 2010). Considering the water saving potential, these particles could adjust soil osmotic potential and in turn, maintain the soil environment. Therefore, it seems to be a useful technique in the drought stress studies in which soil potential adjustment is necessary (Allah Dadi *et al.,* 2005). Islam *et al.* (2011) evaluate the effectiveness of different rates of SAP (low, 10; medium, 20; high, 30 and very high, 40 kg.ha^{-1}) for winter wheat production under drought-affected field and reported the optimum application rate of SAP would be 30 kg.ha^{-1} as it increases both wheat yield and soil fertility. Lower rates (10 and 20 kg.ha^{-1}) are not sufficient and higher rate (40 kg.ha^{-1}) is not economic. They suggested that the application of SAP at 30 kg.ha^{-1} could be an efficient soil management practice for winter wheat production in the drought-affected regions. Yousefi *et al.* (2010) showed that number of seeds, 1000 seed weight, yield, and harvesting index of corn were decreased due to drought stress, but they increased following super absorbent and manure appl icat ion. However, superabsorbent polymers could play crucial roles where drought stress is a major constrain such as natural systems. Rajaei and Raeisi (2010) concluded that the application super absorbents polymers increases the soil micro organisms activities such as the Nitrobacteria and Nitrosomonas, and it causes to accelerate the nitrification and other chemical activities which lead to alternate the soil nutrients.

2. OBJECTIVES

Assessment seed yield, its components and morphological characteristics of the corn crop affected different level of irrigation regime and super absorbent polymer (SAP) under warm and dry climate condition of Khuzestan province in southwest of Iran.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was conducted to evaluate seed yield, its components and morphological traits of corn affected different irrigation regime and super absorbent polymer via split plot experiment based on randomized complete blocks design during 2016 with three replications. The main factor included three irrigation regimes (I_1: Conventional irrigation or control, I_2: Alternate furrow irrigation from 4 leaves stage until silk emergence and after conventional, I_3: Normal irrigation until silk emergence and after alternate furrow irrigation). Three level of SAP (S_1: non use of SAP or control, S_2: 25 kg.ha^{-1}, S_3: 50 kg.ha^{-1}) belonged to sub factor. The place of study was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (South west of Iran). The average annual rainfall, temperature, and evaporation in region are 242 mm, 24 C and 3000 mm, respectively. The physical and chemical properties of studied soil mentioed in table 1.

Table 1. Physical and chemical properties of studied field

Soil depth (cm)	0-30	**EC (ds.m^{-1})**	4.29
pH	7.75	**O.C (%)**	0.58
P (ppm)	8.74	**K (ppm)**	179
Fe (ppm)	9.95	**Clay (%)**	32
Silt (%)	35	**Sand (%)**	33
Soil texture	Clay	**ρ_b (g.cm^{-3})**	1.37

The size of each plot was 6×5 m² and each block includes 9 treatments. Distance between rows was 75 cm with six rows per treatment. Spacing between main plots consisted of two nonplanting lines, and the distance between the subplots was 1 line. Selection of mentioned amounts of super absorbent polymer is due to the fact that in the various studies between 100 and 200 kg.ha^{-1} SAP was used, but in current research the the lowest amount of SAP was studied to maximize the economic efficiency can be achieved.

3.2. Farm Management

Plots were plowed and disked after winter wheat harvest in June. Nitrogen was applied in amount 250 $kg.ha^{-1}$ from urea source in two step, half with planting and the remaining half at the 8-leaf stage. Also 150 $kg.ha^{-1}$ phosphorus (from triple super phosphate source) and 150 $kg.ha^{-1}$ potassium (sulphate potassium source) was used before planting. For control weeds by herbicide, before planting field was sprayed by Atrazine (1 $kg.ha^{-1}$) and Laso (4 $L.ha^{-1}$) mix and after then the farm was discarded with the tractor. Also during the growth period, all plots were weeded manually. No serious incidence of insect or disease was observed, so no pesticide or fungicide was applied along planting until harvesting.

3.3. Measured Traits

Plant height was measured based centimeter unit from the soil surface to male inflorescence after rippening stage. The average length of six ears per plot was measured by the ruler. The diameter of the ear was measured and recorded with using a digital caliper (accurately 0.01 millimeter) from the middle ear (ten ear per plot). The final harvesting area was equal to 4.8 m^2 that was done from two middle lines of planting. Corn seed yields were determined by hand harvesting the eight m sections of three center rows in each plot. Then, seed yield values were adjusted to 15.5% moisture content. In addition, the 1000-seed weight, number of row per ear, number of seed per row and number of seed per ear were measured separately from the final harvest plants per plot values were also evaluated.

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via MSTAT-C software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Plant height

Result of analysis of variance revealed effect of different irrigation regime and SAP on plant height was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). Evaluation mean comparison result of different irrigation regime indicated maximum plant height (186 cm) was noted for I_1 and lowest one (167 cm) belonged to I_2 treatment (Table 3). The height of the plant is influenced by the number of nodes and the distance between nodes, the number of nodes depends on the availability of nutrients and the increase of nodes in the presence of water in the root environment. In this research, conventional irrigation (I_1 treatment) due to the increase crop growth had the highest plant height in compared to other treatments. Mentioned result confirmed by Salehi *et al.* (2012). It seems in I_2 treatment the competition for water between the crops increased therefore, the plant allocates more photosynthetic material to the root. As a result aerial part of the shoot had lower share of photosynthetic materials and led to decrease plant height more than another treatment. Another researcher reported water stress led to decrease plant height and confirm result of current study (Nishi Mathur *et al.*, 2007; Tousi-Mojarrad and Ghannadha, 2012; Al-Kaisi and Yin, 2014; Davison *et al.*, 2016). Compare different level of SAP showed that the maximum and the minimum amount of plant height belonged to S_3 (185 cm) and control (165 cm) treatments (Table 3).

The reason for positive effect of SAP on plant height can be attributed to increased soil moisture content for the plant. Rafie *et al*. (2013) reported that super absorbent by water absorption and storage can alleviate dehydration and increase the plant height, which is consistent with findings of this research. Nazarli *et al*. (2010) reported the highest plant height was obtained from applicatin 300 kilogram per hectar of super absorbent polymer, but Memar and Mojaddam (2015) reported using 150 kg.ha^{-1} led to achieve maximum plant height.

Table 2. ANOVA result of measured traits

S.O.V	df	Plant height	Ear length	Ear diameter	Stem diameter
Replication	2	8.54^{ns}	2.86^{ns}	0.12^{ns}	0.24^{ns}
Irrigation regime (I)	2	503.6**	41.19*	3.24**	1.05**
Error I	4	35.06	5.72	0.08	0.09
Super absorbent polymer (S)	2	354.34**	24.52*	0.005^{ns}	0.017^{ns}
I × S	4	19.9^{ns}	0.013^{ns}	0.002^{ns}	0.015^{ns}
Error II	12	30.01	2.84	0.03	0.031
CV (%)	-	3.12	9.27	5.73	7.71

^{ns}, * and ** are non-significant and significant at 5 and 1% probability levels, respectively.

Continue Table 2.

S.O.V	df	Number of row per ear	Number of seed per row	Number of seeds per ear	1000-seed weight	Seed yield
Replication	2	0.75^{ns}	3.91^{ns}	1038.44^{ns}	94.7^{ns}	4666^{ns}
Irrigation regime (I)	2	0.2878^{ns}	148.85**	15160.3**	1024.9**	59896**
Error I	4	0.2539	6.88	210.6	82.15	641
Super absorbent polymer (S)	2	0.023^{ns}	61.23**	2524.7**	724.26**	12764**
I × S	4	0.26^{ns}	2.54^{ns}	1025.8*	52.04^{ns}	6278**
Error II	12	0.202	2.64	190.9	54.94	432.2
CV (%)	-	3.13	5.78	3.23	4.74	4.2

^{ns}, * and ** are non-significant and significant at 5 and 1% probability levels, respectively.

4.2. Ear length

Assessment result of analysis of variance indicated effect of different irrigation regime and SAP on ear length was significant at 5% probability level and but interaction effect of treatments was not significant (Table 2). According result of mean comparison of different irrigation regime maximum of ear length (20.11 cm) was obtained for I_1 and minimum of that (16.28 cm) was for I_3 treatment (Table 3). It seems in this research, the cause of reduction of ear length in I_2 treatment was due to reduced the photosynthesis under drought stress in the plant, which reduced the vegetative growth and plant growth. Also conventional irrigation due to non limitation of water and food resources, could achieve the highest ear length, this result which was consistent with the findings of Mohammadi *et al*. (2011).

Some researchers reported drought stress led to decrease water absorption, nutrient uptake and reduction transfer assimilation to aerial part, so it has negative effect on ear length (Sepasi *et al*., 2012; Valadabadi *et al*., 2014). Evaluation mean comparison result indicated in different level of SAP the maximum ear length (20.05 cm) was noted for S_3 and minimum of that (15.82 cm) belonged to control treatment (Table 3). It seems SAP by absorbing and maintaining water and releases it in droghut stress condition led to increase ear length. Some researcher such as Ghanbari and Miri (2013) and Moazzan Qamsari and Akbari (2006) confirm result of cuurent study.

Table 3. Mean comparison of morphological traits affected different irrigation regime and SAP

Treatments	Plant height (cm)	Ear length (cm)	Ear diameter (cm)	Stem diameter (cm)
Irrigation regime				
I_1	186^{a}	20.11^{a}	3.44^{a}	2.75^{a}
I_2	167^{c}	16.28^{c}	2.75^{b}	1.83^{c}
I_3	176^{b}	18.09^{b}	2.87^{ab}	2.17^{b}
Super absorbent polymer				
S_1	165^{c}	15.82^{c}	2.81^{a}	2.01^{a}
S_2	179^{b}	18.61^{b}	2.94^{a}	2.23^{a}
S_3	185^{a}	20.05^{a}	3.31^{a}	2.51^{a}

*Similar letters in each column show non-significant difference at 5% probability level in Duncan's multiple rang test. **I_1**: Conventional irrigation or control, **I_2**: Alternate furrow irrigation from 4 leaves stage until silk emergence and after conventional, **I_3**: Normal irrigation until silk emergence and after alternate furrow irrigation. **S_1**: non use of SAP or control, **S_2**: 25 $kg.ha^{-1}$, **S_3**: 50 $kg.ha^{-1}$ SAP.

4.3. Ear diameter

According result of analysis of variance effect of different irrigation regime on ear diameter was significant at 1% probability level but effect of SAP and interaction effect of treatments was not significant (Table 2). As for Duncan classification made with respect to different irrigation regime maximum and minimum amount of ear diameter belonged to I_1 (3.44 cm) and I_2 treatment (2.75 cm) (Table 3). It seems that providing the required moisture in normal irrigation treatment has the most impact on the growth of the ear and its diameter increase. Therefore, timely irrigation is effective in completing the growth of plant organs, especially reproductive organs such as ear. Result of current study similar to result of Soltanbeig (2009). On the other hand, the cause of the decrease in ear diameter (due to drought stress) can be attributed to the reduction in the ear growth rate, which is a strong sink for assimilates. Because supply of assimilates is reduced by drought stress (Yang *et al*., 1993). Rafie *et al*. (2013) by using SAP in 3 levels (0, 100 and 200 $kg.ha^{-1}$) on corn reported SAP increased seed yield significantly, but did not have significant effect on ear diameter, which was consisted with the results of this research.

4.4. Stem diameter

Result of analysis of variance showed effect of different irrigation regime on stem diameter was significant at 1% probability level but effect of SAP and interaction effect of treatments was not significant (Table 2). Between different irrigation regime the maximum stem diameter (2.75 cm) was observed in I_1 and the lowest one (1.83 cm) was found in I_2 treatment (Table 3).

4.5. Number of row per ear

Study result of analysis of variance indicated effect of different irrigation regime, SAP and interaction effect of treatments on number of row per ear was not significant (Table 2). The measurements showed that the number of rows per ear is very close to each other for different treatments, and the difference between treatments was not significant. Considering that the final determination of the number of rows per ear is done prior to the other components, it seems that there was not much competition among other components for the use of assimilates. As a result, mentioned result has a relative stability and strongly influenced by genetic factors (Ritchie and Hanway, 1997).

4.6. Number of seed per row

According result of analysis of variance effect of different irrigation regime and SAP on number of seed per row was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). Mean comparison result of different irrigation regime indicated the maximum and the minimum amount of number of seed per row belonged to I_1 (32.44 cm) and I_2 treatment (24.40 cm) (Table 4). Mohammadi *et al*. (2011) reported providing enough moisture two weeks before and after pollination is a critical period in corn farming. If the drought stress occurs before pollination and during the florlet production stage, the number of florets per ear decreased, even in acceptable pollination, number of seed per row and ear will be significantly reduced. If pollination occurs during drought stress, many pollen seeds will become infertile and ineffective. Drought stress at pollination stage causes pollen is abort and consequently the number of seeds decreases. Drought stress after pollination in seed filling period led to decrease seed weight. Mentioned result was similar to finding of current study. Samsamipour *et al*. (2015) reported that less irrigation before flowering in corn reduced ear diameter, number of seeds per row and increase of non-eared bushes in field, which was consistent with results of this research. Among different level of SAP maximum number of seed per row (31.01 cm) was obtained for S_3 and minimum of that (25.02 cm) was for control treatment (Table 4). It seems that reducing number of seeds per row in I_2 was due to lack of sufficient water during flowering, which is a critical stage during corn growth period. Its seems SAP provide enough moisture to tolerate heat and prevent abortion of flowers. S_3 treatment by water absorption and storage it can reduce dehydration and improve agronomic traits. Rafie *et al*. (2013) reported similar result.

4.7. Number of seed per ear

Study result of analysis of variance effect of different irrigation regime and SAP on number of seed per ear was significant at 1% probability level also interaction effect of treatments was significant at 5% probability level (Table 2). Mean comparison result of different different irrigation regime indicated the maximum number of seed per ear (460.22 cm) was obtained for I_1 and minimum of that (389.53 cm) was for I_2 treatment (Table 4). Ahmadpour *et al*. (2017) reported water shortage at flowering and pollination stages led to reduction in seed yield through abnormal growth of pollen and finally decrease in the number of fertilized seeds. The direct effect of drought stress on the number of seed is due to the reduction of ovary water potential and reduction of dry matter, due to reduction of target sink (ovary). On the other hand, the final amount of seed in maize has been largely dependent on the amount of storage assimilate before flowering. Compare different level of manganese Nano-chelate showed that the maximum and the minimum amount of number of seed per ear belonged to S_3 (457.34 cm) and control (390.30 cm) treatments (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum number of seed per ear (494.64 cm) was noted for I_1S_3 and lowest one (374.72 cm) belonged to I_2S_1 treatment (Table 5). It seems that SAP through water supply and nutrients in the critical phase of seed filling period has reduced abortion and, as a result, increased fertilization of seeds. Wu *et al.* (2008) stated with SAP consumption, 10.68% more water remained in the soil than to control.

Table 4. Mean comparison of seed yield and its components affected different irrigation regime and SAP

Treatments	Number of row per ear	Number of seed per row	Number of seed per ear	1000-seed weight (gr)	Seed yield ($kg.ha^{-1}$)
Irrigation regime					
I_1	14.5^a	32^a	460^a	166.51^a	5670^a
I_2	14.15^a	24^c	389^c	146.34^c	4210^c
I_3	14.41^a	27^b	429^b	156.22^b	4960^b
Super absorbent polymer					
S_1	14.3^a	25^c	390^c	149.55^c	4310^c
S_2	14.36^a	28^b	431^b	155.42^b	4960^b
S_3	14.4^a	31^a	457^a	164.11^a	5550^a

*Similar letters in each column show non-significant difference at 5% probability level in Duncan's multiple rang test. **I_1**: Conventional irrigation or control, **I_2**: Alternate furrow irrigation from 4 leaves stage until silk emergence and after conventional, **I_3**: Normal irrigation until silk emergence and after alternate furrow irrigation. **S_1**: non use of SAP or control, **S_2**: 25 $kg.ha^{-1}$, **S_3**: 50 $kg.ha^{-1}$ SAP.

In addition, the use of SAP significantly increased the seed yield and number of seed per ear, which was consistent with the results of this research. It can be expected that the application of SAP will improve the number of seeds per ear under drought stress conditions by increasing water absorbing capacity in the soil, reducing leaching nutrient, rapid growth of root and better aeration in the soil, which consisted with results of Kohestani *et al.* (2009).

4.8. 1000-Seed weight

Study result of analysis of variance effect of different irrigation regime and SAP on 1000-Seed weight was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). Evaluation mean comparison result revealed in different level of zinc Nano-chelate maximum 1000-Seed weight (166.51 gr) was noted for I_1 and minimum of that (146.34 gr) belonged to I_2 treatment (Table 4).

Reducing seed weight affected drought stress is due to premature aging of leaves and, consequently, reducing seed filling period. There is a significant correlation between water potential and stored assimilate of it, so increasing water potential of seed led to increase develope of cells and improve sink power (Larbi and Mekliche, 2004). Between different levels of manganese Nano-chelate the maximum 1000-Seed weight (164.11 gr) was observed in S_3 and the lowest one (149.55 gr) was found in control treatment (Table 4). 1000-Seed weight in I_2 treatment was significantly lower than other treatments, and post-stress irrigation failed to fully compensate for decrease in LAI, photosynthesis and reduction of assimilate stored in secondary sources, as a result seed weight decreased. It seems application SAP by imrove water storage capacity has been able to increase relative water content of plant, cells and sink power and as a result increase seed weight. Also Kohestani *et al.* (2009) reported effect of SAP application on seed weight has positively effect.

4.9. Seed yield

Evaluation result of analysis of variance effect of different irrigation regime, SAP and interaction effect of treatments on seed yield was significant at 1% probability level (Table 2). Mean comparison result of different different irrigation regime indicated the maximum seed yield (5670 $kg.ha^{-1}$) was obtained for I_1 and minimum of that (4210 $kg.ha^{-1}$) was for I_2 treatment (Table 4). Performing the deficit irrigation and limiting access to the moisture at reproductive stage will result in the reduction seed yield, which is due to high sensitivity of reproductive organ to drought stress. Drought stress by drcreasing the transfer of assimilate matter from leaves and other parts of the plant to the seeds led to reduce seed yield in cereals crop. These results were consistent with findings of some researcher (Valifar *et al.*, 2013). Mean comparison different level of manganese Nano-chelate showed that the maximum and minimum amount of seed yield belonged to the S_3 (5550 $kg.ha^{-1}$) and control treatment (4310 $kg.ha^{-1}$) treatments (Table 4). Evaluation the mean comparison result of interaction effect of treatments indicated the maximum seed yield (6300 $kg.ha^{-1}$) was for I_1S_3 and the lowest one (3870 $kg.ha^{-1}$) belonged to I_2S_1 treatment (Table 5).

Table 5. Mean comparison interaction effect of different irrigation regime and SAP on seed yield

Irrigation regime	Super absorbent polymer	Number of seed per ear	Seed yield ($kg.ha^{-1}$)
I_1	S_1	450^c	5060^d
	S_2	463^b	5710^b
	S_3	494^a	6300^a
I_2	S_1	374^g	3870^g
	S_2	392^e	4050^f
	S_3	414^d	4500^e
I_3	S_1	382^f	4550^e
	S_2	408^d	5060^d
	S_3	454^c	5340^c

*Similar letters in each column show non-significant difference at 5% probability level in Duncan's multiple rang test. **I_1**: Conventional irrigation or control, **I_2**: Alternate furrow irrigation from 4 leaves stage until silk emergence and after conventional, **I_3**: Normal irrigation until silk emergence and after alternate furrow irrigation. **S_1**: non use of SAP or control, **S_2**: 25 $kg.ha^{-1}$, **S_3**: 50 $kg.ha^{-1}$ SAP

Kang *et al*. (2000b) by compare conventional irrigation and variable furrow irrigation in corn planting, concluded alternate furrow irrigation, while increasing seed yield, saved 50% of water consumption, and introduced an effective way to reduce amount of water consumed in dry areas. It seems that the cause of increasing seed yield in 50 $kg.ha^{-1}$ SAP treatment is due to it able to increase the supply water, nutrient and pigments for crop and improve the growth and corn seed yield. Rafie *et al*. (2013) reported that superabsorbent significantly increased seed yield, 1000 seed weight, number of seed per ear, which was consistent with the results of this research. Kohestani *et al*. (2009) reported that under without drought stress, superabsorbent increased seed yield by reducing the leaching of nutrients in the soil and increasing root growth.

5. CONCLUSION

According result of current research I_3 treatment had lowest decrease in seed yield, its components and morphological characteristics, so in water resource limitation situation I_3 treatment with consume 50 $kg.ha^{-1}$ super absorbent polymer it can be advice to producers in studied region.

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FOOTNOTES

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