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Response of Yield and Morphophysiological Characteristics of Corn (SC 704) to Different Source of Potash Fertilizer under Deficient Irrigation Situation (at South West of Iran)

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ABSTRACT

BACKGROUND: Deficit irrigation strategies were effective in saving volume of water. Potassium is an essential nutrient that affects most of the biochemical and physiological processes are involved in plant resistance to biotic and a biotic stresses.

OBJECTIVES: This study was conducted to assess effect of different pattern of irrigation and several source of potassium on crop production and morphological traits of corn.

METHODS: This research was carried out via split plot experiment based on randomized complete blocks design with three replications along 2015 year. The main factor included three level of Irrigation regime (I_1: Conventional Irrigation or Control, I_2: Fix furrow irrigation, I_3: Alternate furrow irrigation) and three level of potassium (K_1: 100 kg.ha^{-1} Potassium sulfate base application or Control, K_2: 10 kg.ha^{-1} Solo potash with first irrigation, K_3: 100 gr.ha^{-1} PotaBARVAR-2 as a biofertilizer + 50 kg.ha^{-1} Potassium sulfate base application) belonged to sub factor.

RESULT: The results showed that in different irrigation patterns, application K_3 treatment with alternate furrow irrigation increased the seed yield and its components. Under deficient irrigation conditions, the plant height, length and diameter of ear were reduced and the application of K_3 treatment with alternate furrow irrigation led to increase above traits. The highest number of rows per ear (16.6) and number of seed per row (28) were obtained from the interaction effect of normal irrigation and K_3 treatment. The lowest number of row per ear (12.2) was due to the fix furrow irrigation and K_2 treatment. The highest (237.5 gr) and lowest (213.5 gr) amount of 1000-seed weight belonged to I_1K_3 and I_2K_2 treatments, respectively. Also the maximum (5463 kg.ha^{-1}) and minimum (2966 kg.ha^{-1}) amount of seed yield was achieved from I_1K_3 and I_2K_2 treatments, respectively.

CONCLUSION: Alternate furrow irrigation showed a significant advantage over the fix furrow irrigation after control with K_3 treatment had the highest seed yield. Generally use of 100 gr.ha^{-1} PotaBARVAR-2 as a biofertilizer + 50 kg.ha^{-1} Potassium sulfate base applications with alternate furrow irrigation can be advised to farmers.

KEYWORDS: *Alternate furrow irrigation, Nutrition, Maize, Potassium, Seed weight.*

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1. BACKGROUND

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 (English and James, 1990). The limitation of water resources in arid and semi-arid areas was the main reason that we considered water as the most important material in the production lines, although people often do not obey the irrigation water consumption rules and regulations (Cakir, 2004). Innovations for saving water in irrigated agriculture and thereby improving water use efficiency are of paramount importance in water-scarce regions. Conventional deficit irrigation is one approach that can reduce water use without causing significant yield reduction (Kirda *et al*., 2005). Deficit irrigation strategies were equally effective in saving irrigation water. Alternate furrow irrigation practice for rapeseed provides water use efficiency benefit compared to full irrigation. The value of benefits from water saving should be balanced with the value of yield reductions and the cost of implementing alternative irrigation system compared to conventional systems (Bahrani and Pourreza, 2016). Alternative furrow irrigation is commonly applied as part of a deficit irrigation program because it does not require the application of more than 50-70% of the water used in a fully irrigated program (Marshal *et al*., 2008). Alternate furrow irrigation was proposed as a method to increase water use efficiency and decrease chemical leaching compared to every-furrow irrigation and with small yield losses for different crops compared to a fixed furrow irrigation system (Abedi and Pakniyat, 2010). Tagheian-Aghdam *et al*. (2014) reported the alternative and fixed furrow irrigation treatments presented as the best solution for water saving in arid and semi-arid fields with 50% and 60% saving amount 6.9% and 14.22% reduction in corn biological yields. In some cases that a researcher has compared two methods of full irrigation and water deficit over some crops such as corn and shown that water deficit stress approximately increases the level of cultivated area and income up to 42% in comparison to full irrigation that is with reductions in water consumption, energy usage and other agricultural materials. The researcher has also found out the water deficit stress is a strategy to increase the economic efficiency (Kang *et al*., 2000). Many researchers have reported the effect of high temperature on the growth and yield of corn. Potassium (K) is an essential nutrient that affects most of the biochemical and physiological processes are involved in plant resistance to biotic and abiotic stresses (Ashfaq *et al*., 2015). Application of potash (70 kg $K.ha^{-1}$) as Potassium nitrate was better than potassium sulphate and potassium chloride for plant height, number of boll, boll weight, seed cotton yield, lint percentage and earliness in cotton (Armin and

Hajinezhad, 2016). Management of balanced fertilizer application according to plant growth requirements and soil testing is one of the strategies for improving the quality and quantity of agricultural products (Singh *et al*., 2015). Therefore, consideration of oil testing and application of elements required by plants are important strategies for increasing production of agricultural products (Pervez *et al*., 2004). Macro fertilizer has the pivotal role in increasing crop production. Besides N and P, use of K has been reported to influence productivity of seed yield and seed oil contents (Ghosh *et al*., 1995). Potassium plays a vital role in photosynthesis, translocation of photosynthesis, protein synthesis, control of ionic balance, regulation of plant stomata and water use, activation of plant enzymes and many other processes (Marschner, 1995). Potassium known to increase pest resistance, as well as resistance to diseases and other biotic and abiotic environmental stresses (Zafar and Athar, 2013). Recent studies in Iran have shown the rate of decline in soil potassium has increased, and the potassium balance in many wheat fields has become negative. The reasons are intensive cropping, use of cultivars with a high nutrient demand, excessive application of nitrogen and phosphorous fertilizers and negligible use of potassium fertilizers. These have increased rates of potassium removal from soils faster than the rate of its release from minerals (Olfati *et al*., 2010). Balasubramaniyan and Palaniappan (2001) reported when a soil is deficient in potassium, the crop yield reduced and had weak responses to nitrogen and phosphorus. The arable land under canola cultivation in Khuzestan province at south west of Iran has considerably increased in recent years. Therefore, the logical strategy for making canola cultivation profitable, and for increasing farmers' inclination to grow this crop, is to reduce the existing limitations. Conditions such as high lime content of soil, alkaline pH, heavy texture, unsuitable potassium status in soils under cultivation and lack of sufficient knowledge about the required amount of potassium for corn under the prevailing conditions in Khuzestan province are factors limited its production.

2. OBJECTIVES

The current study was conducted to assessment effect of different pattern of irrigation and several source of potassium seed yield, its components and morphological traits of corn.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was carried out to evaluate different level of irrigation pattern and potassium on crop production of corn via split plot experiment based on randomized complete blocks design with three replications along 2015 year. Place of research was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of Iran). The main factor included three level of Irrigation regime (I_1: Conventional Irrigation or Control, I_2: Fix furrow irrigation, I_3: Alternate furrow irrigation) and three level of potassium (K_1: 100 $kg.ha^{-1}$ Potassium sulfate base application or Control, K_2: 10 $kg.ha^{-1}$ Solo potash with first irrigation, K_3: 100 $gr.ha^{-1}$ PotaBARVAR-2 as a biofertilizer + 50 $kg.ha^{-1}$ Potassium sulfate base application) belonged to sub factor. This experiment had 36 plots. The size of each plot was 6×5 m² and each block has 9 treatments. For the experiment, the distance between rows to rows was 75 cm with six rows per treatment.

3.2. Farm Management

Plots were plowed and disked after winter wheat harvest in June. During the growth period, all plots were weeded manually. No serious incidence of insect or disease was observed and no pesticide or fungicide was applied. For control weeds by herbicide, before planting field was sprayed by Atrazine (1 kg) and Laso (4 lit) mix and after then the farm was discarded with the tractor.

3.3. Measured Traits

In order to measure total dry matter above the ground level, five crops within 0.5–0.6 m of a row section in each plot were cut at the ground level at ripening stage. Crop samples were dried at 65°C until constant weight was achieved. The final harvesting area was equal to 4.8 m^{-2} that was done from two middle lines of planting. The yield components including the seed weight, number of seed per row and number of seed per ear were measured separately from the final harvest plants per plot. Corn seed yields were determined by hand harvesting the 8 m sections of three center rows in each plot. Then, seed yield values were adjusted to 15.5% moisture content. Harvest index (HI) was calculated according to formula of Gardner *et al.* (1985) as follows: **Equ.1.** HI= (Seed yield/Biologic yield) ×100.

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done by SAS (Ver.8) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Plant height

According result of analysis of variance effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on plant height was significant at 5% probability level (Table 1). Mean comparison result of different level of irrigation pattern indicated that maximum plant height (179.4 cm) was noted for control or conventional irrigation pattern and minimum of that (163.5 cm) belonged to fix furrow irrigation (Table 2). The reduction of plant height as a result of low irrigation is due to the fact that under drought stress conditions, the cell turgence pressure of stem cells decreases, also the photosynthesis production decreases. So the length of the stem intermediates nodes decreased and thus the plant height is reduced (Abid *et al.*, 2016). As for Duncan classification made with respect to different level of potassium fertilizer maximum and minimum amount of plant height belonged to K_3 (175.7 cm) and K_2 treatment (157.3 cm) (Table 3).

Table 1. Result analysis of variance of measured traits

S.O.V	df	Plant height	Ear length	Ear diameter	Ear loss length	No. row per ear
Replication	2	78.9^{ns}	33.5^{ns}	7.2^{ns}	15.7^{ns}	3.70^{ns}
Irrigation Pattern (I)	2	907.5*	121.5*	212.4*	147.5*	92.50*
Error I	4	70.26	44.5	13.7	12.4	7.40
Potassium (P)	2	177.3*	111.5*	122.1*	129.2*	33.8*
I×P	4	756.5*	197.2*	119.3*	20.6*	62.8*
Error II	12	39.2	38.2	8.93	7.18	2.6
CV (%)	-	10.6	8.9	8.5	10.2	11.24

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Continue Table 1.

S.O.V	df	No. seed per row	1000-seed weight	Seed yield	Biologic yield	Harvest index
Replication	2	8.20^{ns}	36.5^{ns}	6211^{ns}	7726^{ns}	9.3^{ns}
Irrigation Pattern (I)	2	124.60*	1733.2**	47322*	66429*	377.9*
Error I	4	11.6	48.5	7459	8592	19.7
Potassium (P)	2	135.5*	1435.5**	138326*	52788*	180.4*
I×P	4	110.4*	988.7**	225724*	45691*	211.5*
Error II	12	6.30	28.3	4744	5372	12.2
CV (%)	-	6.88	7.9	10.22	13.4	9.7

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Farshad and Malakooti (2003) reported consumption of potassium sulfate under drought stress conditions led to increase the corn plant height. Evaluation mean comparison result of interaction effect of treatments indicated maximum plant height (179.1 cm) was noted for I_1K_3 and lowest one (165.1 cm) belonged to I_2K_2 treatment (Table 4). Some researchers reported same result (Farahmandfar *et al*., 2018; Majlesy and Gholinezhad, 2013).

4.2. Ear length

Result of analysis of variance showed effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on ear length was significant at 5% probability level (Table 1). Evaluation mean comparison result revealed in different level of irrigation pattern the maximum ear length (20.1 cm) was noted for control and minimum of that (16.5 cm) belonged to fix furrow irrigation (Table 2). 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). Between different level of potassium fertilizer the maximum ear length (21.3 cm) was observed in K_3 and the lowest one

(18.4 cm) was found in K_2 treatment (Table 3). Assessment mean comparison result of interaction effect of treatments indicated maximum plant height (21.7 cm) was noted for I_1K_3 and lowest one (17.85 cm) belonged to I_2K_2 treatment (Table 4).

Table 2. Mean comparison effect of different level of irrigation on measured traits

Treatments	Plant height (cm)	Ear length (cm)	Ear diameter (cm)	Ear loss length (cm)	No. row per ear
I_1	179.4^a	20.1^a	45.6^a	1.3^b	16.3^a
I_2	163.5^c	16.5^b	31.4^c	2.6^a	12.2^c
I_3	170.2^b	17.2^{ab}	38.5^b	1.7^b	14.5^b

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

I_1: Conventional Irrigation or Control, I_2: Fix furrow irrigation, I_3: Alternate furrow irrigation.

Continue Table 2.

Treatments	No. seed per row	1000-seed weight (gr)	Seed yield ($kg.ha^{-1}$)	Biologic yield ($kg.ha^{-1}$)	Harvest index (%)
I_1	26.5^a	231.4^a	5220^a	12258^a	42.5^a
I_2	17.3^c	203.5^c	3265^c	8893^c	36.7^c
I_3	20.5^b	215.6^b	4140^b	10304^b	40.2^b

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

I_1: Conventional Irrigation or Control, I_2: Fix furrow irrigation, I_3: Alternate furrow irrigation.

4.3. Ear diameter

According result of analysis of variance effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on ear diameter was significant at 5% probability level (Table 1). Mean comparison result of different level of irrigation pattern indicated the maximum and the minimum amount of ear diameter belonged to control (45.6 cm) and fix furrow irrigation treatment (31.4 cm) (Table 2). 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 the supply of assimilates is reduced by drought stress (Yang *et al.*, 1993). Among different level of potassium fertilizer maximum ear diameter (42 cm) was obtained for K_3 and minimum of that (35.7 cm) was for K_2 treatment (Table 3).

Table 3. Mean comparison effect of different level of potassium fertilizer on measured traits

Treatments	Plant height (cm)	Ear length (cm)	Ear diameter (cm)	Ear loss length (cm)	No. row per ear
K_1	162.5^{ab}	19.5^{b}	41.5^{a}	1.93^{b}	15^{ab}
K_2	157.3^{b}	18.4^{b}	35.7^{b}	2.03^{a}	14^{b}
K_3	175.7^{a}	21.3^{a}	42^{a}	1.63^{b}	16^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.
K_1: 100 kg.ha^{-1} Potassium sulfate base application or Control, K_2: 10 kg.ha^{-1} Solo potash with first irrigation, K_3: 100 gr.ha^{-1} PotaBARVAR-2 (biofertilizer) + 50 kg.ha^{-1} Potassium sulfate base application.

Continue Table 3.

Treatments	No. seed per row	1000-seed weight (gr)	Seed yield (kg.ha^{-1})	Biologic yield (kg.ha^{-1})	Harvest index (%)
K_1	24.2^{b}	223.5^{b}	5150^{b}	12610^{b}	40.5^{b}
K_2	21.3^{c}	212.4^{c}	4532^{c}	11445^{c}	39.4^{b}
K_3	27.5^{a}	235.6^{a}	5572^{a}	13050^{a}	42.8^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.
K_1: 100 kg.ha^{-1} Potassium sulfate base application or Control, K_2: 10 kg.ha^{-1} Solo potash with first irrigation, K_3: 100 gr.ha^{-1} PotaBARVAR-2 (biofertilizer)+50 kg.ha^{-1} Potassium sulfate base application.

Assess mean comparison result of interaction effect of treatments indicated maximum plant height (45 cm) was noted for I_1K_3 and lowest one (34.7 cm) belonged to I_2K_2 treatment (Table 4).

4.4. Ear loss length

According result of analysis of variance effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on ear loss length was significant at 5% probability level (Table 1). Mean comparison result of different level of irrigation pattern indicated the maximum ear loss length (2.6 cm) was obtained for I_2 and minimum of that (1.3cm) was for I_1 treatment (Table 2). Compare different level of potassium fertilizer showed that the maximum and the minimum amount of ear loss length belonged to K_2 (2.03 cm) and K_3 (1.63 cm) treatments (Table 3). Assess mean comparison result of interaction effect of treatments indicated maximum ear loss length (2.9 cm) was noted for I_2K_2 and lowest one (1.1 cm) belonged to I_1K_3 treatment (Table 4).

4.5. Number of row per ear

Result of analysis of variance revealed effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on number of row per ear was significant at 5% probability level (Table 1). According mean comparison result of different level of irrigation pattern the maximum number of row per ear (16.3) was observed in conventional irrigation and the lowest one (12.2) was found in fix furrow irrigation treatments (Table 2).

Table 4. Mean comparison interaction effect of treatments on measured traits

Treatments		Plant height (cm)	Ear length (cm)	Ear diameter (cm)	Ear loss length (cm)	No. row per ear
I_1	K_1	174.4^{ab}	20.7^{ab}	44.70^{ab}	1.5^{bc}	16.2^{a}
	K_2	172.9^{b}	20.2^{ab}	43.20^{ab}	1.3^{bc}	15.6^{ab}
	K_3	179.1^{a}	21.7^{a}	45.00^{a}	1.1^{c}	16.6^{a}
I_2	K_1	166.5^{c}	18.4^{b}	36.2^{bc}	2.6^{ab}	13.8^{bc}
	K_2	165.1^{d}	17.85^{c}	34.7^{c}	2.9^{a}	12.2^{d}
	K_3	170.2^{b}	19.3^{b}	39.5^{b}	2.3^{ab}	14.3^{b}
I_3	K_1	169.3^{b}	19.1^{b}	41.3^{b}	1.7^{bc}	15.2^{ab}
	K_2	167.8^{bc}	18.4^{b}	39.7^{b}	1.9^{b}	14.6^{b}
	K_3	172.8^{b}	19.9^{a}	41.5^{a}	1.5^{bc}	15.6^{ab}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

I_1: Conventional Irrigation or Control, I_2: Fix furrow irrigation, I_3: Alternate furrow irrigation.

K_1: 100 kg.ha^{-1} Potassium sulfate base application or Control, K_2: 10 kg.ha^{-1} Solo potash with first irrigation, K_3: 100 gr.ha^{-1} PotaBARVAR-2 (biofertilizer) + 50 kg.ha^{-1} Potassium sulfate base application.

Continue Table 4.

Treatments		No. seed per row	1000-seed weight (gr)	Seed yield (kg.ha^{-1})	Biologic yield (kg.ha^{-1})	Harvest index (%)
I_1	K_1	26.8^{ab}	229.9^{b}	5171^{b}	12695^{a}	40.7^{b}
	K_2	24.9^{b}	226.6^{b}	4839.5^{bc}	12061^{b}	40.1^{b}
	K_3	28^{a}	237.4^{a}	5463.6^{a}	12836^{a}	42.5^{a}
I_2	K_1	22.3^{c}	217.1^{d}	3363.5^{f}	9262.5^{e}	36.3^{d}
	K_2	20.3^{de}	213.7^{e}	2966.7^{g}	8630^{f}	34.2^{e}
	K_3	23.4^{bc}	223.1^{bc}	3486.4^{ef}	9404.5^{de}	37.1^{cd}
I_3	K_1	23.8^{bc}	221.5^{c}	4042.3^{d}	10518^{c}	38.4^{c}
	K_2	21.9^{cd}	218.1^{cd}	3644.5^{e}	9885^{d}	36.8^{d}
	K_3	25.2^{b}	227.5^{b}	4164.6^{d}	10659^{c}	39.06^{bc}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

I_1: Conventional Irrigation or Control, I_2: Fix furrow irrigation, I_3: Alternate furrow irrigation.

K_1: 100 kg.ha^{-1} Potassium sulfate base application or Control, K_2: 10 kg.ha^{-1} Solo potash with first irrigation, K_3: 100 gr.ha^{-1} PotaBARVAR-2 (biofertilizer)+50 kg.ha^{-1} Potassium sulfate base application.

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). Between different level of potassium fertilizer highest value of number of row per ear was belonged to K_3 (16) and the lowest one was found in the K_2 treatment as 14 (Table 3). Evaluation mean comparison result of interaction effect of treatments indicated maximum number of row per ear (16.6) was noted for I_1K_3 and lowest one (12.2) belonged to I_2K_2 treatment (Table 4).

4.6. Number of seed per row

According result of analysis of variance effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on number of seed per row was significant at 5% probability level (Table 1). According mean comparison result of different level of irrigation pattern the maximum number of seed per row (16.3) was observed in conventional irrigation and the lowest one (12.2) was found in fix furrow irrigation treatments (Table 2). 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, the 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 the pollination stage causes pollen is abort and consequently the number of seeds decreases. Drought stress after pollination in the 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 the field, which was consistent with the results of this research. Monneveux *et al*. (2006) reported that number of seeds per row affected more reducing yielded in compared with drought stress. Drought stress in flowering stage delayed tassels emergence. So tassels emerge when the pollination has done and no longer pollen has exists or reduced. Hence, no ovule, have fertilized and consequently no grain forms and this resulted in few grains formation at whole ear (Zenselmeier *et al.,* 1998). Between different level of potassium fertilizer highest value of number of seed per row was belonged to K_3 (16) and the lowest one was found in the K_2 treatment as 14 (Table 3). Assessment mean comparison result of interaction effect of treatments indicated maximum number of seed per row (28) was noted for I_1K_3 and lowest one (20.3) belonged to I_2K_2 treatment (Table 4).

4.7. 1000-seed weight

Result of analysis of variance showed effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on 1000-seed weight was significant at 1% probability level (Table 1). According mean comparison result of different level of irrigation pattern the maximum 1000-seed weight (231.4 gr) was observed in conventional irrigation and the lowest one (203.5 gr) was found in fix furrow irrigation treatments (Table 2). Sepaskhah and Khajehabdollahi (2005) reported that decrease in corn yield due to water stress in AFI was mainly due to the decrease in the number of kernels per cob and to a lesser extent to the decrease in1000-kernel weight. Naseri *et al.* (2013) stated water deficit would cause to reducing photosynthetic matters and decreasing leaf duration and producing less dry matter and as a result cause to fading grain and its weight.

Campos *et al*. (2004) reports showed that water deficit cause to decreasing stalk storage due to reducing photosynthesis content in maize and finally cause to reducing 1000-grains weight. Babaogli *et al*. (2012) Also suggested that, drought stress raising could led to dehydration stages faced with grain filling and resulted in less transmission of photosynthetic compounds to grains, that it decreased 100 grain weight. Between different level of potassium fertilizer highest value of 1000-seed weight was belonged to K_3 (235.6 gr) and the lowest one was found in the K_2 treatment as 212.4 gr (Table 3). Evaluation mean comparison result of interaction effect of treatments indicated maximum 1000-seed weight (237.4 gr) was noted for I_1K_3 and lowest one (213.7 gr) belonged to I_2K_2 treatment (Table 4).

4.8. Seed yield

According result of analysis of variance effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on seed yield was significant at 5% probability level (Table 1). Mean comparison result of different level of irrigation pattern indicated that maximum seed yield (5220 $kg.ha^{-1}$) was noted for control and minimum of that (3265 $kg.ha^{-1}$) belonged to fix furrow irrigation (Table 2). In general most attributes showed negative respond to water stress and seed yield affected by water stress more than other attributes due to sever decreasing number of seeds per row ear length and 1000-seed weight (Naseri *et al*., 2013). As for Duncan classification made with respect to different level of potassium fertilizer maximum and minimum amount of seed yield belonged to K_3 (5572 $kg.ha^{-1}$) and K_2 treatment (4532 $kg.ha^{-1}$) (Table 3). Assessment mean comparison result of interaction effect of treatments indicated maximum seed yield (5463.6 $kg.ha^{-1}$) was noted for I_1K_3 and lowest one (2966.7 $kg.ha^{-1}$) belonged to I_2K_2 treatment (Table 4). Savaghebi and Malakouti (1999) reported applying potassium has significant effects on canola yield, and use of potassium sulfates at the rate of 150 $Kg.ha^{-1}$ as the base fertilizer and 100 $Kg.ha^{-1}$ potassium chloride for topdressing led to achieve maximum yield. Moreover, application of potassium reduced zinc deficiency resulting from applying phosphorous (Mirzashahi *et al*., 2010). Tabatabaei *et al*. (2014) reported effect of potassium sulphate was significant on number of spike per m^2, number of grain per spike, number of spikelet per spike, protein content, biological yield, seed yield and straw yield also highest of seed yield (6523 $kg.ha^{-1}$) was obtained from 160 $kg.ha^{-1}$ potassium sulphate application.

4.9. Biologic yield

Result of analysis of variance showed effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on biologic yield was significant at 5% probability level (Table 1). According mean comparison result of different level of irrigation pattern the maximum biologic yield (12258 $kg.ha^{-1}$) was observed in conventional irrigation and the lowest one (8893 $kg.ha^{-1}$) was found in fix furrow irrigation treatments (Table 2).

Between different level of potassium fertilizer highest value of biologic yield was belonged to K_3 (13050 $kg.ha^{-1}$) and the lowest one was found in the K_2 treatment as 11445 $kg.ha^{-1}$ (Table 3). Evaluation mean comparison result of interaction effect of treatments indicated maximum biologic yield (12836 $kg.ha^{-1}$) was noted for I_1K_3 and lowest one (8630 $kg.ha^{-1}$) belonged to I_2K_2 treatment (Table 4).

4.10. Harvest index

According result of analysis of variance effect of different level of irrigation pattern, potassium fertilizer and interaction effect of treatments on harvest index was significant at 5% probability level (Table 1). Mean comparison result of different level of irrigation pattern indicated that maximum harvest index (42.5%) was noted for control and minimum of that (36.7%) belonged to fix furrow irrigation (Table 2). Another researcher such as Payero *et al*. (2009), Kashiani *et al*. (2011) and (El-Halim, 2013) reported same result. Sinclair *et al*. (1990) have concluded that plant's produced material decreases and it decreases in grain up to a ratio in the medium drought stress, although grain yield and harvest index have been significantly decreased in the severe drought stress. Pandey *et al*. (2000) have attributed the reduction of corn HI to the high sensitivity of generating growth rather than growing rate in severe drought stress. As for Duncan classification made with respect to different level of potassium fertilizer maximum and minimum amount of harvest index belonged to K_3 (42.8%) and K_2 treatment (39.4%) (Table 3). Assessment mean comparison result of interaction effect of treatments indicated maximum harvest index (42.5%) was noted for I_1K_3 and lowest one (34.2%) belonged to I_2K_2 treatment (Table 4).

5. CONCLUSION

According result of current alternate furrow irrigation showed a significant advantage over the fix furrow irrigation after control with K_3 treatment had the highest seed yield. Generally use of 100 $gr.ha^{-1}$ PotaBARVAR-2 as a biofertilizer + 50 $kg.ha^{-1}$ Potassium sulfate base application with alternate furrow irrigation it is useful for overcoming the negative effects of drought stress.

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FOOTNOTES

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