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ORIGINAL ARTICLE

Effect of Zeolite and Potassium on Yield and Yield components of Chickpea (*Cicer arietinum* L.) in the different Irrigation Regimes

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ABSTRACT
In order to study the effect of different Zeolite and Potassium amounts under different irrigation regimes on grain yield and yield components of chickpea cv. Azad, an experiment was conducted as split plot factorial arrangement based on Randomized Complete Block Design with three replications in Research Station of Agricultural and Natural Resources of Hamadan during 2014-15 cropping season. Irrigation regimes were considered as main plot (non-irrigation, irrigation at flowering, irrigation at flowering and pod setting and irrigation at pod setting), zeolite factor (0, 15 and 30 ton ha^{-1}) and potassium fertilizer (0, 150 and 250 kg ha^{-1}) were as subplots. The results showed that the effect of different irrigation regimes, zeolite and potassium fertilizer had significant effect on plant height, the number of pods per plant, the number of seeds per plant, seed weight per plant, 100- seed weight, seed yield, biological yield and harvest index. Interaction of irrigation × Zeolite on all traits and interaction of irrigation × potassium and Zeolite × potassium on seed yield was significant. In this study, the highest values of the traits were obtained under irrigations at both flowering and pod setting with 30 ton ha^{-1}. The flowering stage was the most sensitive stage to drought stress and in deficit water conditions, irrigation in this stage considerably increased yield of chickpea. Zeolite and potassium consumption with ameliorate damages due to water stress had more positive effect on seed.
Keywords: Irrigation regimes, Potassium, Yield, Zeolite

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INTRODUCTION

Climatic change in recent decades caused reduction of amount of rainfall in arid and semi-arid regions inthe world especially in Middle East [1]. Due to shortage of water resources and sequential cropping in many areas, it is necessary to regulate the irrigation water, because this would cause inadequate irrigation. Therefore, in order to achieve the maximum yield and efficient use of available water, prevention of waste of water is necessary [2]. The limited water supply makes it difficult to meet the food demand of the increasing population. Irrigation in the region accounts for 80% of the total fresh water consumption [3]. Drought is the most important environmental stress affecting agriculture worldwide [4]. Iran is located in arid and semi arid land and is one of the environmental stresses that cause temporary or permanent damage to a lot of the time. According to the country is facing a drought of 10 years, at least 2 times [5]. Therefore, considering change in drought stress patterns, change in appropriate strategies to reduce difference of actual yield and yield potential in such regions is necessary [1].studies have shown that the ability of plant cells to survive intensive water loss without experiencing nocuous damage is a core aspect of drought tolerance [6]. Chickpea (*Cicerarietinum*L.) is the third most important food legume grown in the world with 12 million ha is cultivated, producing a total grain yield of 11 million ton. Chickpea is grown in over 45 countries [7].In the Mediterranean countries, chickpea is one of the favourite legumes and an essential part of the diet in some countries such as Morocco, Tunisia, Lebanon and Syria[3]. Chickpea has received the attention of many researchers not only for being one of the primary legume crops but also because of its relatively high protein content [8, 9]. In regions where water scarcity is the principal limiting factor for cultivation, farmers are interested in using some methods to deduce injurious effects of water deficiency. One possible approach to reducing the effect of drought on plant productivity is through the addition of zeolite to soil [10].Zeolite is used as a soil additive, nutrient reservoir and super absorbent in soil. Application of some additives such as zeolite makes it possible to use infrequent rainfalls and limited water resources for preservation and storage of water in soil [11]. Zeolites are micro porous, crystalline aluminosilicates of alkali and alkaline materials that have a high internal surface area [12]. The unique cation exchange, adsorption, hydration-dehydration, and catalytic properties of natural zeolites have prompted slow release fertilizers and other materials [13]. Therefore such materials can reduce losing soil moisture in arid and semi-arid regions by soil physical improvement. These storage tanks absorb water provided by irrigation and rainfall and reduced permeability of soil. In drought stress condition, water saved in the polymer is gradually depleted and reduces need for re-irrigation. According to study, using zeolite can preserve soil moisture for a long time; consequently application of zeolite can decrease the effects of drought stress on crop plants [14]. However, some materials such as crop residuals, mulch plants, waste, litter, straw, stubble, and other synthetic materials like hydro plus zeolites could be used to save soil moisture [13]. Zeolites are highly hydrophilic due to low cross-links in their structure [11]. Zeolites may have great potential in restoration and reclamation of soil and storing water available for plant growth and production [15]. Chemical treatment and agronomical crop management practices have been tried to reduce the drought effects [16], but the application of zeolite to discharged plants attracted little attention. There are more than 50 known naturally occurring zeolites [17]. Natural zeolites are hydrated aluminosilicates with comprising silica and aluminum tetrahedral which result in a stable three-dimensional framework. This honeycomb structure is generally very open, containing channels and cavities, which are filled with cations and water molecules [18]. The cation is bound by weaker electrostatic bonds, increasing their mobility and the capability of being exchanged with cations present in solution [19, 20]. Studies showed that the increasing of zeolite and water stress have a significant effect on most of measured growth parameters Potassium is important as an element of high consumption, and although it is not a part of building the plant, but in doing of inside reaction has a key role that it called the quality element [21]. Potassium is involved in maintaining osmotic potential and water uptake. Plant with desirable of potassium; lose less water because potassium increases the osmotic potential [22]. Rabbani and Emam[23] reported that plant growth is controlled by some important factors which water has vital role in this regard Bukvice *et al*.[24] reported that adjustment of drought negative effects by maintaining of inflammation pressure, transpiration reduction and increase of water use efficiency has been through consumption of potassium [25]. Jagtap *et al*.[26] reported increase and improvement of seed yield, dry matter and harvest index with higher amounts usage of potassium under water stress condition. KhavariKhorasani [27] stated that irrigation in this plant should not be delayed because deficit of soil moisture causes leaves to wilt and to roll, also should not be allowed stress symptoms appear because corn damages physiologically before appearance of deficit symptoms and will not has enough growth due to non-growth of root and shoot cells. Sajedi *et al*.[28] have reported, many studies of researchers indicated that consumption of high-usage fertilizers can increase plants resistance to environmental stresses such as drought and salinity also Tabatabaii Ebrahimi *et al.*[29] concluded that application of appropriate amounts of potassium sulfate in water deficit condition can be partially prevented reduction of yield and yield components of maize. In Chikpea, application of zinc sulfate at flowering stage can compensate negative effects of water shortage partly [30].

With consideration to the importance of chickpea in nutrition of humans and weather conditions of arid and semi arid, supplementary irrigation is necessity for cultivation of this plant in Iran; with regard to role of zeolite and potassium in reducing sensitivity of plants to water deficit and Since there is limited published work about the effect of application of potassium sulphate combined with zeolite, this research was conducted to evaluate their effects on yield and yield components of chickpea.

MATERIALS AND METHODS

Site description

This research was undertaken in Ekbatan Research Station of Agricultural and Natural Resources of Hamadan (48°32_ E, 52°34_ N, 1730 m ASL, and Annual mean precipitation of this station is 295 mm; based on Koppen's classification, this region has cold, semi-arid climate) during 2014-15 cropping season.This area is part of cold semiarid regions.

Experimental design and treatments

In order to study the effect of different irrigation regimes and different Zeolite and Potassium amounts on grain yield and yield components of chickpea cv.Azad, an experiment was conducted as split plot factorial arrangement based on randomized complete block design with three replications. Main plot included irrigation regimes (check as non-irrigation, supplementary irrigation at 50% flowering, irrigations at both flowering and podding and irrigation at 50% podding stages) and subplot were three levels of zeolite (Z0=0, Z1=15 and Z2=30 ton/ha) and three levels of potassium fertilizer (K0=0 ,K1=100 and K2= 200 kg/ha K2SO4). The seeds were disinfected with Vitavax fungicide and sown in early December 2014.

Soil type

Before field preparation, soil samples were taken to determine the soil physical and chemical properties. Soil samples were collected at a depth of 0–30 cm. It was air-dried, crushed, and tested for physical and chemical properties. The research field had a sandy clay loam soil. Details of soil properties are shown in Table 1.

Table 1. soil and zeolite physical and chemical propertie

sample	EC(Ds/m^{-1})	pH	%T.N.V	P (ppm)	K (ppm)	% Sand	% silt	ó Clay
soil	2.22	8.1	7.5	5.6	230	48.1	26.6	25.3
zeolite	17.68	7.6	5.5	-	325	-	-	-

Management strategy and Sampling

Zeolite and chemical fertilizers (table 1) were applied and incorporated into the soil in depth of 15-30 cm.Also various rates of potassium from K2SO4 were distributed in the plots before the sowing. Weed control was done by hand. Each plot consisted of five rows of 5 m length with 30 cm spacing between the rows and 10 cm between plants and sowing depth was 5 cm. Data were recorded for characters such as plant height, number of pods per plant, number of seeds per plant, seed yield per plant, 100-seed weight, biological yield and seed yield per plot. To determine the volume of water for irrigation, a soil sample was taken from each plot in depth of root development region before irrigation. The samples were kept in oven 80°C for 24 hours. Weight of the soil moisture content was calculated and the volume of water needed for irrigation was determined by using equations1 and 2.To estimate moisture coefficient (FC) and nominal specific mass (BD), such parameters as soil texture and content of soil organic matter were employed, then the amount of net irrigating water at the stages of 50% flowering and pod-filling were estimated by using equation of moisture fraction.

$In = (FC - M) \times BD \times D$

Where BD, is nominal specific mass gcm-3; D is the depth of root extending (60 cm); M is weight of moisture pre-irrigation; and In is the depth of net irrigation water fraction.

The harvest index was accounted with follow: HI = (Economical yield / Biological yield).

Statistical Analysis

For statistical analyses used software SAS Ver. 9.1 and Duncan's test applied for comparison of mean at 0.05 level of significance.

RESULTS AND DISCUSSION

Plant height

Alterations of plant height are most noticeable variations caused by growth condition in majority of crop and plant height is affected by moisture in environment [31]. Delay in irrigation led to significant reduction in plant height. Irrigation and Zeolite had significant effect on plant height (Table 2).

Increase in drought tension caused reduction in plant height. The highest value for plant height (30.73 and 29.32 cm) was observed in two treatments of irrigation at flowering + pod setting and flowering stages. The lowest value for plant height (25.03 cm) was observed in non-irrigation (Table 3). Plant height decreased with increasing severity of water stress because of reduction in vegetative growth due to decrease of cell division and cells growth. The results of this study are in conformity with findings of Imanzade *et al.*[32]. Consequently, shortening in internodes distance caused a reduction in plant height [33].

With increasing in zeolite content, plant height increased from 25.38 cm (in non- Zeolite) to 30 cm (in 30 tons/ha Zeolite). Also, the positive effect of super absorbent on stem elongation is reported by Brar*et al*. [34]. This effect could be a result of high potential of super absorbent to absorb water and conserve water in the soil. Physical properties of soil were improved by super absorbent polymer [35].

Table 2- Analysis of variance (Mean Squares) of yield and yield components of chickpea under irrigation regimes, zeolite and potassium

S.O.V	Df	Plant height(cm)	pods per plant	seeds per plant	100- seed weight(g)	seed weight per plant(g)	seed yield(Kg/ha)	biological yield(Kg/ha)	Harvest index(%)
Block	2	12.07	4.36	4.296	38.98	26.84	11669	48265	17.06
Irrigation (I)	3	171.6**	642.6**	1010**	227**	87.55**	411319**	274706**	2012**
Error (1)	6	11.9	1.109	1.687	5.64	1.33	7983	7051	112.6
Zeolite (Z)	2	239.5**	241.4**	381.3**	620.1**	184.5**	590807**	488725**	3013**
Potassium (P)	2	25.44*	3.647	7.038	34.37*	4.65*	45553**	30896**	239.5**
Z× I	6	20.56*	37.45**	55.88**	22.98*	8.41**	75374**	37241**	362.9**
P× I	6	2.055	ns2.471	ns4.852	ns6.63	ns1.13	6702*	ns5299	66.57n.s
P× Z	4	ns3.313	ns3.318	ns4.171	ns8.91	ns0.44	8380*	ns4449	ns66.66
P× Z×I	12	ns1.332	ns3.089	ns4.19	ns7.01	ns1.17	ns2597	ns1883	24.55ns
Error (2)	64	6.764	1.896	2.883	9.76	1.24	2382	2694	40.68
CV (%)	-	9.28	12.94	12.75	12.34	14.55	12.30	7.16	12.18

*, **, and *ns* denotes significance at 5%, and 1% probability level and non-significance, respectively

Changes in plant height are usually the most obvious change in most crop plants. The maximum height was observed in irrigation at flowering + podding and stage and irrigation at flowering with use of 30 and 15 tons per hectare zeolite (33.24, 31.84, 31.33 and 31.41, respectively) and the lowest plant height in dry conditions (non-irrigation) and without the use of zeolite (22.72). When zeolite was used as soil amender, selective absorption and controlled release of food elements leads to development of plant growth [36]. Effect of zeolite could be a result of high potential of superabsorbent to absorb water and conserve water in the soil. These results are in agreement with findings by Alfie and Azizi [1].
Stem elongation depends on the amount of potassium [37]. K via osmotic adjustment, water potential for growth and consequently provides for cell division even in drought [38]. Nassiri*et al*. [39] showed that treatment of zeolite (10 tons/ha) under supplementary irrigation had the highest average of plant height.

Table 3-Comparison of effects of irrigation regimes, zeolite and potassium on yield and yield components of chickpea

Treatments	Plant height (cm)	pods per plant	seeds per plant	100- seed weight(g)	seed weight per plant(g)	seed yield (Kg/ha)	biological yield(Kg/ha)	harvest index(%)
Irrigation								
None irrigation	c25.03	5.133 d	d6.393	b5.56	c21.57	b263.8	c608.6	b43.14
Flowering stage	a29.32	b13.97	b17.51	a8.58	27.06 a	476.3 a	a793.1	a58.14
flowering and podding stage	a30.73	a15.44	a19.32	a9.27	28.06 a	523.6 a	a823.4	a61.09
podding stage	b27.00	c8.0	c10.05	b6.20	24.53 b	b322	673.4 b	46.98 b
Zeolite								
non- Zeolite	b25.11	b7.65	b9.57	b4.79	20.51 b	c250.9	597 c	b41.79
15 ton/ha	a28.94	a11.98	15.01a	a8.62	27.61 a	446.1 b	751.6 b	a57.02
30 ton/ha	a30.01	12.28 a	15.38a	a8.80	a27.79	a492.3	825.4 a	a58.20
Potassium								
Potassium								
non-Potassium	b27.26		b12.89	b7.09	24.45 b	c358.4	701.2 b	49.37 b
100 kg/ha	27.87 ab		13.29ab	ab7.33	25.08 ab	b402.1	715.3 b	a53.58
200 kg/ha	a28.93		13.77a	a7.79	26.37 a	a428.8	a757.5	a54.05

Means within each column with a letter in common are not significantly different at =0.05probability.

Number of pods per plant

The effect of different irrigation regimes and zeolite on number of pod per plant was significant at 1% level (Table 2). Interaction of irrigation × Zeolite on number of pod per plant was significant. The highest number of pods per plant belonged to irrigation at flowering + pod setting stages with 15.44. Number of pods per plant in None irrigation treatment was 5.133. 30 and 15 tons/ha zeolite produced the maximum pods per plant with 12.28 and 11.98, respectively. Irrigation at flowering + pod setting stages with 30 and 15 tons zeolite/ha and flowering stage with 30 tons zeolite/ha produced maximum pods per plant with 18.19, 17.89 and 17.56, respectively. The lowest number of pods per plant was produced in treatment of none irrigation and none application of zeolite with 3.86 (Table 4). Long periods of water deficit caused leaf-drying with subsequent reduction in plant yield. But high contents of zeolite and suitable treatments of irrigation provided enough environments for plant growth and increased number of pods per plant.

These results are in agreement with findings by Nasiri *et al*. [39] on rapeseed, Allahyari *et al*. [40] on pea, khurgami *et al*. [41] in chickpea and Mirakhori *et al*. [42] in soybean.

The number of seeds per plant

Results showed that irrigation, zeolite and interaction of irrigation and zeolite had significant effect on the number of seeds per plant (Table 2). Delay in irrigation led to significant reduction in number of seeds per plant. Irrigation at flowering stage in the presence of zeolite (30 ton/ha), the highest number of seeds per plant [16]. Non-irrigation without the presence of zeolite with (17.7) had the lowest number of seeds and difference with other irrigation levels (Table 4). Rezaeyanzadeh *et al*.[43] reported that increasing the humidity during reproductive growth stages, particularly at flowering and podding setting increased the number of seeds per pod.

100 seed weight

Results of variance analysis results showed that the effects different irrigation regimes, zeolite and potassium levels and interaction between irrigation and zeolite had significant effect on 100 seed weight (Table 2). The comparison of the mean values of the 100-grain weight (Table 3) shows that irrigation at flowering and podding stage treatment in the presence of zeolite 15 ton/ha had the highest (31.69 g) 100-grain weight and the non-irrigation without the presence of zeolite treatment had the lowest (17.65g) 100-grain weight. There was no significant difference between irrigation at flowering stage and irrigation at flowering and podding stage (Table 3).Whatever drought stress during seed filling stage become severe, seed weight and 100-seeds weight reduce and if field confronts with water deficit at seed filling stage, transmission of nutrients from leaves to seed reduces and 100-seeds weight decreases which is corresponded with the results of this research. High contents of zeolite and suitable treatments of irrigation provided enough environments for plant growth and increased leaf number (Table 4).Khadem *et al*. [44] also showed that the use of water absorbers can increase seed weight of corn. According to the results, the low seed weight in control treatment might be noted that generally Environmental stresses such as water shortages, especially in grain filling because of the reduced photosynthesis, reduced speed, and the weight of the seed filling period [45]. Drought stress imposed from flowering to maturity resulted in 100 grain weight as compared to non stress chickpea plants. Decrease in 100 grain weight under stress conditions might be due to lower photosynthetic translocation in the developing grain. Similar results were reported by Mansur *et al*. [46] and Rezaeyanzadeh *et al*. [43] in chickpea. zeolite application at both imposed drought stress conditions caused to significant increase on 100 seed weight [47]. In this study, zeolite application may be attributed to save as higher moisture and absorb more water from soil and therefore, it was caused to increasing water status of plant and leaf stomata conductance and seed weight, Probability.

Seed weight per plant

The highest average of seed weight per plant with amount of 11.26 g. was belonged to treatment of irrigation at flowering and podding stage and zeolite 30 ton/ha. The non-irrigation without the presence of zeolite treatment has the lowestseed weight per plant (3.71). Although between zeolite level 15 and 30 ton/ha, there was no significant difference. Karimi and Farnia[48] in chickpea reported that supplementary irrigation during reproductive growth stages significantly increase seed weight per plant during flowering and podding stage increased seed weight up to 50% compared to rainfed conditions. Tohidi Moghadam *et al*.[49] reported that Zeolite is able to store water in an effective way and under stress condition give it to the plant. According to their idea, these materials prevent water and nutrition materials washing, therefore increase seed weight. The comparison of the mean values of the seed weight per plant (Table 3) shows that application of 200 kg potassium sulphate with an average of 7.79 kg more than the non-potassium treatment, caused seed weight per plant was increased. With consideration to potassium role in maintenance of plant water and prevention of water wasting, therefore in stress condition which plant is facing with water deficit, existence of enough potassium caused to maintenance of photosynthesis activity and production of photosynthetic materials and with augmentation of stress intensity, potassium role is justifiable in prevention of reduction in seeds weight per plant. By taking consideration to potassium role in transmission of assimilate and nutrients, increase of seeds number weight per plant by using potassium is justifiable [50, 51].

Seed yield

The analysis of variance shows that the effects of irrigation, zeolite and potassium on seed yield were significant at 1% level of probability (Table 2). Increase of crop yield has been reported with consumption of potassium [28, 52]. Also the result present study showed that interaction of irrigation × Zeolite, irrigation × potassium and Zeolite × potassium were significant on seed yield (Table 2). The results of means comparison in irrigation regimes on seed yield indicated that the irrigation at flowering along with podding and flowering stages had higher and significant yield than check (Table

3).Sabaghpour [53] reported that flowering and podding stage are critical time for drought stress in chickpea. Shamsi *et al*. [54] reported that using supplemental irrigation in order to resolve stress at critical stages of plant growth had significant effect on increasing seed yield. Also many researchers have emphasized on the effect of water defect on reduction of yield throughout plant growth period, especially at the stages of grain formation and grain-filling in millet [55], in safflower [56] and in soybean Max [42].Allahyari *et al*. [40], Naseri*et al*. [31] reported that irrigation at flowering had positive effects on growth indices and, consequently, on yield of chickpea. Mousavi *et al*.[57] and Soltani *et al*., [58] stated that supplementary irrigation under rainfed condition had significant effect on increasing seed yield. Means comparison of present study in zeoliteand potassium treatment on seed yield indicated that 30 and 200 ton/ha produced higher and significant yield than check respectively (Table 3).

Means comparison of interaction of irrigation × Zeolite showed that the highest grain yield (682.42 kg) obtained from irrigation at both flowering and podding stage and with consumption of 30 ton/ha zeolite (Table 4).Drought stress lead to weak transfer of mineral nutrient from soil to plant [59] and causes significant reduction in dry weight in comparison with control plants [60]. High contents of zeolite with water supply, caused opening of stomata for a long time subsequently good fixation of CO_2 resulted an increase of dry matter and yield in crop plants [44]. Falkon *et al*.[61] who reported that water deficit caused reduction in grain yield of triticale by 54% on soils low in Zeolit and by only 16% with an adequate zeolite supply. Jaafarzadeh-Kenarsari and Postini [62] which found seed yield, biomass increases for a wide range of sorghum by applying zeolite when water supply was restricted.

Iran's location (latitude 25 to 38 degrees North), structure, climate and natural component of arid areas (65%) to semi-arid (25 %) is considered [63]. So the drought is one of the problems in many parts of the country in the production of crops, especially in the later stages of plants development (reproductive stage) even in plants such as millet, fox tail, and sorghum of nightingales in arid and semi-arid areas are reduced. Because the passing of the plant to the reproductive stage of vegetative stage, water limits leading to reduce photosynthesis compared with vegetative stage and considering that this time the number of grains and the weight is in the making, caused by accelerated aging reduce the grain filling period and grain weight that ultimatelyis result in reduced grain yield [64].Therefore, the use of one or two irrigation in critical stages of plant (flowering and pod-forming) and use 30 tons per hectare zeolite can produce acceptable yields. Effect of potassium fertilizer on seed yield was highly significant (Table 2). Bukvice*et al*.[24] have reported that consumption of zinc sulfate and potassium sulfate increases seed yield under drought stress. If plant at flowering stage and seed filling stage encounters with environmental stress (especially drought stress), share of assimilate increases in remobilization for seed filling. Interaction of Irrigation and potassium on seed yield were significant at the 5% level (Table 2), Jagtap*et al*. [26] reported increase and improvement of seed yield, dry matter and harvest index with higher amounts usage of potassium under water stress condition. Tabatabaii Ebrahimi *et al*.[29] concluded that application of appropriate amounts of potassium sulfate in water deficit condition can be partially prevented reduction of yield and yield components of maize. Therefore, proposed that zeolite and potassium application in dry land that exposed to drought stress could helpful to yield improvement and prevention of decreased yield. The results of Khodami *et al*.[22] indicate that consumption of potassium and zeolite increased seed yield in drought stress conditions amount of 70.33 percent in proportion to disuse of them.

The reason could be associated with the increase of seed yield in case of consumption of zeolite and consequently improvement of photosynthesis conditions and assimilates mobilization and lack of water deficit stress during the growth stage of plant in comparison to the treatment without application of superabsorbent. Quanchang and Cheng [65] who expressed Zeolite Consumption is increased Grain yield.

Biological yield

Irrigation, Zeolite and Irrigation × Zeolite had significant effect on biological yield (Table 2). High contents of zeolite with irrigation at flowering and podding stage had the highest biological yield, caused opening of stomata for a long time and subsequently good fixation of CO_2 resulted an increase of dry matter in chickpea. The treatment with one-time irrigation at flowering and pod-filling stage had the highest (823.44 kg/ha) and non-irrigation treatment had the lowest (608.63 kg/ha) biological yield (Table 3). Sharp reduction of shoots weight and photosynthetic products due to water limitation has been reported by Hosseini and *et al*.[66] and Allahyari*et al*.[40]. Edalatifar [50] and Imanzade *et al*. [32] reported that dry weight of shoots reduced significantly due to drought stress intensity. Mirzakhani *et al*.[67] reported that Stress causes a reduction in cell development through a deficiency in cell swelling and photosynthetic reduction and due to photosynthesis reduction growth reduces and finally stops. Irrigation in this plant should not be delayed because deficit of soil moisture causes leaves to wilt and to roll, also should not be allowed stress symptoms appear because chikpea damages physiologically before appearance of deficit symptoms and will not has enough growth due to non-growth of root and shoot cells. Drought stress during flowering and pod forming also reduces the amount of dry matter because of flowers, pods and seeds are not formed [68]. Results of Parsa*et al.*[69] show that the chickpea under drought stress reduced plant biomass.The effects of Potassium on biological yield was highly significant ($P < 0.01$) (Table 1).Potassium is involved in maintaining osmotic potential and water uptake. Plant with desirable of potassium; lose less water because potassium increases the osmotic potential. Application of K increases plant height, crop vigor and impart resistance against drought. Potassium increases leaf expansion particularly at early stages of growth, extends leaf area duration by delaying leaf shedding near maturity and increases the growth of shoot and increased dry matter [52]. It´s application activates number of enzymes involved in photosynthesis, carbohydrate metabolism and proteins and play an important role in the translocation of carbohydrates from leaves to tubers [70].Khodami *et al.*[22] reported that with normal irrigation and consumption of 150 kg/ha of potassium and 10 tons/ha zeolite maximum biological yield was obtained.

Table 4.Interaction effect of irrigation regimes and zeolite on yield and its components of chickpea

Irrigation treatment	Zeolite	Plant height (cm)	pods per plant	seeds per plant	seed weight per plant	100- seed weight (g)	seed yield (Kg/ha)	biological yield (Kg/ha)	Harvest Index (%)
Check	0	22.72^{e}	3.867^{h}	7.17^{k}	3.71^{k}	17.65^{i}	220.2^{l}	544.4^{k}	39.58^{k}
	15	25.14^{cde}	6.022^{fg}	8.18^{jk}	6.44^{gh}	22.21^{fgh}	277.2^{h-k}	601.5^{j}	46.18^{f-j}
	30	27.21^{bc}	5.511^{g}	9.61^{ghi}	6.52^{fg}	24.85^{def}	293.9^{g-k}	680^{e-h}	43.65^{h-k}
Flowering stage	0	24.59^{de}	9.511^{c}	10.21^{e-i}	5.36^{ij}	20.70^{h}	264.6^{jk}	604.8^{ij}	44.01^{g-k}
	15	31.41^{a}	14.84^{b}	14.42^{b}	10.35^{bc}	30.96^{a}	568^{d}	866.6^{c}	65.12^{c}
	30	31.33^{a}	17.56^{a}	16^{a}	10.04^{c}	29.51^{ab}	596.4^{cd}	907.8^{abc}	65.29^{bc}
flowering and pod setting	0	27.11^{bc}	10.27^{c}	9.87^{f-i}	5.45^{hij}	22.59^{e-h}	267.3^{ijk}	631.5^{g-j}	42.33^{ijk}
	15	31.84^{a}	17.89^{a}	12.92^{c}	11.10^{ab}	31.69^{a}	621.1^{bc}	888.1^{bc}	68.99^{abc}
	30	33.24^{a}	18.19^{a}	15.72^{ab}	11.26^{ab}	29.90^{a}	682.4^{a}	950.7^{a}	71.95^{a}
pod setting	0	26^{bcd}	6.956^{ef}	9.21^{ij}	4.65^{jk}	21.11^{gh}	251.6^{kl}	607.4^{hij}	41.26^{jk}
	15	26.81^{bcd}	9.156^{cd}	9.51^{hi}	6.58^{efg}	25.58^{cd}	318.1^{fgh}	650^{f-i}	47.78^{e-i}
	30	28.17^{b}	7.889^{ded}	11.18^{def}	7.38^{d-g}	26.90^{bcd}	396.3^{e}	763^{d}	51.90^{def}

In each column, values with similar letter(s) are not significantly different at the 5% level of probability

Harvest index

Harvest index, obtained from seed yield divided on biological yield. According to Table 2, this trait was affect under all of the simple effects and was significant at 1% level probability. Interaction comparison between irrigation× zeolite according to LSD test at 1% level showed that the maximum HI related to irrigation at flowering and podding stage with 30 ton/ha zeolite (71.95%) and the minimum related to Non-irrigation without using zeolite (39.58%). Having done an experiment on 25 chickpea genotypes under rain-fed and irrigation conditions in Syria, Singh and Saxena [71] concluded that grain size, grain yield, biological yield, and harvest index are improved by irrigation, which is in agreement with the result of the present experiment.Uses of zeolite can retain soil moisture longer and for plant therefore, use of the zeolite could improve crop plant adverse effects of drought stress [14]. The highest harvest index obtained with the highest amount of potassium (54.05%). Increased and improved seed yield, dry matter and harvest index with higher levels of potassium under water stress has been reported in sorghum and mustard [72]. Chimenti*et al.*[73] which express occurrence of water deficit stress has significant difference on total above ground biomass at end of flowering stage, But Zeolite Consumption prevented severe reduced total above ground biomass and HI. Naderi Darbaghshahi et al [74] stated HI is criterion of the performance remobilization produced in plant to the seeds. Fanaei *et al.*[72] during experiment on canola expressed that increased use potassium to 250 kg/ha, potassium sulfate in different levels of humidity increased seed yields. But increase the amount of the potassium fertilizer had light slope as if in stress condition, the effect of potassium in increase yield and decrease the negative effects of stress was higher compare to the moisture conditions. In a study Mirzakhani and Sibi[75] stated that 9 tons per hectare zeolite, could increase the harvest index and its positive role in reducing the damage from lack of water was proved.

CONCLUSION

Production in dry land farming systems in Iran is limited by deficiency of water. Chickpea has good potential to increase Production in dry land conditions. The highest values of the traits were obtained under irrigation at both flowering and pod setting stages with 30 ton zeolite ha^{-1}. The flowering stage was the most sensitive stage to drought stress and in deficit water conditions, irrigation in this stage considerably increased yield of chickpea. zeolite and potassium consumption with ameliorate damages due to water stress had more positive effect on seed. Zeolite application in lands which are exposure to late season drought stress can keep soil water content and improve plant growth and production. In general, zeolite as a soil amendment that improved water retention capacity, soil cation exchangeable capacity led to higher yield under drought stress conditions, and then it can be suggested for these lands in arid and semi-arid regions. Using zeolite in all irrigation regimes caused significant increase in yield. Findings in this study indicated that zeolite increased most of the quantitative traits in chickpea. Therefore, considering water shortage in drought area of the country, application of zeolite can be useful to save more water that leads to produce more yield. According to results of this study, under conditions water shortage consumption of potassium sulfate can be prevented to largely caused yield losses.

REFERENCES

1. Alfi SH, Azizi, F. (2015). Res. J. Recent Sciences. 4: 1-7.
2. Sasani S, Jahansooz MR, Ahmadi A.(2004) Proceeding of 4th International Crop Science Congress.
3. Hirich A, Omrani EL, Jacobsen H, et al. (2014).Aust. J. Crop Science. 8: 646-654.
4. Yang S, Vanderbeld B, Wan J, Huang Y. J. (2010). Molecular Plant.3: 469-490.
5. Zahedi H, Noormohammadi G, Shirani-Rad AH, et al. (2009). World Applied Sci. J. 7: 255-262.
6. Lessani H, Mojtahedi M. (2006). Introduction to Plant Physiology. Tehran University Press, Tehran.
7. FAO. (2012). Production year book. Food and Agriculture Organization of the United Nations FAO). Rome, Italy. http://apps. FAO Org.
8. Zia-Ul-Haq M, Iqbal S, Ahmad S, et al. (2007). Food Chemistry. 105:1357-1363.
9. Chang YW, Alli I, Konishi Y, Ziomek E . (2011). Food Res. Int. 44:3094-3104.
10. Najafinejad H, Tahmasebisarvestani Z, Moddaressanavy AM, Naghavi H. (2015). Agronomy And Soil Sci. J. 61: 891-906.
11. Ghazavi R. Int. J. Innovation and Applied Studies. 2015, 13: 172-177.
12. Szerment J, Ambrozewich-Nita A, Kedziora K, Piasek J. A Short review. 2014, UDC: 666.96:691.5.
13. Najafinejad H, Tahmasebisarvestani Z, Moddaressanavy AM, Naghavi H. ***Seed*** and Plant Production J. 2014, 2: 327-349.
14. Zamanian M. Iran Zeolite Conference, Amir Kabir Uni. 2008, 247-248.
15. Nazarli H, Zardashti MR, Darvishzadeh R, Najafi S. Not. Sci. Biology 2010, 2: 53-58.
16. Manivannan P, Jaleel CA, Kishorekumar A, et al. Colloids and Surfaces B: Biointerfaces. 2007, 57: 69-74.
17. Çoruh S. Desalination. 2008, 225: 41–57.
18. Karapinar N. J. of Hazardous Materials 2009, 170: 1186–1191.
19. Farkas A, Rozic M, Barbaric-Mikocevic Z. Hazardous Materials J. 2004, 117: 25–33.
20. Maranon E, Ulmanu M, Fernandez Y, Anger I, Castrillon L. Hazardous Materials J. 2006, 137: 1402–1409.
21. Gholizadeh A, Amin M, Anuar SM, Saberioon MM. Aus. J. of Basic and Applied Sci. 2010, 4: 5184-5190.
22. Khodami S, Shirani Rad AH, Delkhosh B, NoorMohamadiGh. Annals of Biological Res. 2013, 4:56-60.
23. Rabbani J, Emam Y. Product. and Processing of Agricultural and Horticultural Products. 2011, 1: 65-78.
24. Bukvice G, Antunovic M, Poovic S, Rastiya M. Plant Soil Environ.2003, 49: 505-510.
25. Cakir, R. Field Crop Research. 2004, 89: 1–16.
26. Jagtap V, Bhargava S, Stredo P, Feirabend J. (1998).Experimental Botany J. 49: 1715-1721.
27. KhavariKhorasani S. (2008). Applied science guide to the planting and harvesting of maize. Serva Press, 119.
28. Sajedi NM, Ardekani A, Naderi Madani H, Mashhadi Akbar Bojar M. (2009), Iranian J. Agri Res. 7: 493-503.
29. Tabatabaii Ebrahimi S, Yarnia M, Khorshidi Benam MB, et al. (2011). American-Eurasian J. Agri and Environ. Sci. 9: 415-421.
30. Barzabadi V, Farahani A. (2011).Crop and Weed Eco-physiology J. 20: 43- 52.
31. Naseri R, Rahimi MJ. Siyadat A, Mirzaee A. (2015). Iranian J. of Pulses Res. 2015, 6: 78-91.
32. Imanzadeh B. Yarnia M, RahimzadehKhoiy F. (2014).Biodiversity and Environmental Sci. J. 4: 92-100.
33. Yang X, Chen X, Ge Q, et al. (2006).Plant Sci. 171: 389–397.
34. Brar BS, Dhillon NS, Chhina HS. (2001).Ind. J. Agri. Sci. 71: 605-607.
35. PoormohammadKiani S, Grieu P, Maury P, et al. (2007). Theoretical and Applied Genetics. 114: 193-207.
36. Polat E, Karaca M, Demir H, Naci Onus A. Fruit Orna. Plant Res. J. 2004, 2, 183-189.
37. Kholdebarin B, Eslamzadeh T. (2005).Mineral nutrition of higher plants (translate). Dept of Biology, College of sciences, Shiraz, Iran.
38. Marschner H. (1995). Mineral nutrition of higher plants, 2nd Ed. Academic Press. London. Pp: 889.
39. Nasiri A, Delkhosh B, Shiranirad AH, Noormohammadi Gh. (2012).Crop production in environmental stress. 4: 49-57.
40. Allahyari S, Golchin A, Vaezi E. (2012).plant product. Res. J. 20: 125-140.
41. Khurgami A, Rafiee M. (2009). Drought stress, supplemental irrigation and plant densities in chickpea cultivars. African Crop Science Conference Proceedings, 141 – 143.
42. Mirakhori M, Paknejad F, Moradi F, et al. (2009). American J. Biochemistry and Biotechnology. 5 : 162-169.
43. Rezaeyanzadeh E, Parsa M, Ganjali A, Nazemi A. (2013). Soil and water J. 25 : 1080-1095.
44. Khadem SA, Galavi M, Ramrodi M, et al. (2010). Aus. J. Crop Science. 4: 642-647.
45. Hayati A, Ramroudi M, Galavi M.(2012). Crop Production and Processing J. 1: 35-44.

46. Mansur CPY, Palled B, Salimath PM, Halikatti SI. (2010).Agri.Sci. J. 23: 457-460.
47. Sibi M, Mirzakhani M, Gomarian M.(2011). New finding in agriculture J. 5: 275-290.
48. Karimi B, Farnia A. (2010). Modern agriculture J. 17: 83-90.
49. Tohidi-Moghadam HR, Shirani-Rad AH, NourMohammadi G, et al. (2009). Agropec. Trop. Goiania. 39: 243-250.
50. Edalatifar A. (2006). Study of morphological characteristics to drought tolerance in cotton, 9th Congress of Agronomy and Plant Breeding (abstracts), Iran, Tehran University, 121.
51. Frootan A, Yarnia M. (2015).Advances in Environmental Biology J. 9: 382-388.
52. Valadabadi SA, AliabadiFarahani RH, Khalvati MA. (2009). Asian J. Agricultural Sciences. 1: 19-24.
53. Sabaghpour, S.H. (2015). Strategic framework for food legume research, Nashar Entesharati Institute, 412 pages.
54. Shamsi K, Kobraee S, Haghparast R. (2010). African J. Biotechnology. 9: 4197-4203.
55. Seghatoleslami MJ, Kafi M, Majidi E. (2008). Botany J. 40: 1427-1432.
56. Nabipour M, Meskarbashee M, Yousefpour H. (2010). Biology Science J. 10: 421-426.
57. Mousavi SK, Pezeshkpoor P, Khoorgami A, Noori M.(2010). Agri. Res. J. 7: 657-672.
58. Soltani A, Khooie FR, Ghassemi- Golezani K, Moghaddam M. (2001). Agric. Water Management. 49: 225-237.
59. Hopkins WG. Introduction to plant physiology (3rd ed.). (2004). John Wiely& Sons. New York. PP: 557.
60. Igbal N, Ashraf MY, Ashraf M. (2005).Int. J. Environ. Sci. Tech. l2: 155-160.
61. Falkon P, Diatta JB, Grzebisz W. (2009)**.** Spring triticale reaction to simulated water deficit and zeolit. In: Proc. of the 14th Int. Symposium on Tropentage, September 13-14, Bern, Swaziland 205-209.
62. Jaafarzadeh-Kenarsari M, Postini K.(2009). Iranian J. Agri. Sci. 29:353-362.
63. Sibi M, Mirzakhani M, Gomarian M.(2012). Int. J. Agri and Crop Sci. 4: 151-156.
64. Moosavifar BE, Behdani MA, Jami Al-Ahmadi M, Hosaini MS. (2009).Agroecology J. 1: 41–51.
65. Quanchang HY, Cheng H. (2008). Cation exchange properties of natural zeolites and their applications. Science Press. Beijing. 228-232.
66. Hosseini NM, Palta JA, Berger JD, Siddique KH. (2009). Agric. Water Manage. 96: 1732-1736.
67. Mirzakhani M, Hemmati Z, Sajedi A. Iranian J. agronomy res. 2015, 13: 173-183.
68. AmiriDehahmad SR, Parsa M, Ganjali A. Iranian J. (2010). Field Crop Res. 8: 157-166.
69. Parsa M, Ganjali A, Rezaeeyanzadeh E, Nazemi A. Iranion J. (2013). Field Crops Res. 9: 310-321.
70. Imas P, Bansal SK. (1999).Potassium and integrated nutrient management in potato. Presented at the global conference on potato, New Delhi, India. 6-11,
71. Singh KB, Saxena MC.(1991). Annu. Rep. ICARDA.
72. Fanaie MR, Galavi M, Kafi M, et al. (2009).Agri.Sci. J. 3: 291-273.
73. Chimenti CA, Pearson J,Hall AJ. (2002).Field Crops Res. 75:235-246.
74. Naderi Darbaghshahi M, Noormohammadi R, ShiraniRad AH, Tamaddon C. (2005). Agri. Sci. J. 7: 225-212.
75. Mirzakhani M, Sibi M. (2010). Response to water stress and crop physiological traits zeolite. Proceedings of the second national conference on sustainable agriculture and development, opportunities and challenges ahead**,** Islamic Azad University of Shiraz, Shiraz. P 21.