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Original article

Effect of irrigation regime and plant density on yield and yield components of chickpea (*Cicer arietinum* L.)

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Extended abstract

Introduction

Maize is the third most important agricultural crop in the world in terms of production, That production and demand has increased by 45% in 2020 compared to 1997. Abiotic stresses in many cultivated areas of this plant have a negative impact on its production and these effects are expected to intensify in the near future.Inefficient use of water in agricultural production in arid and semi-arid regions is one of the most important factors in exacerbating the water crisis and water shortage is a serious limiting factor in agricultural production. The use of technologies to improve water use efficiency in crops is very important for sustainable crop production and food security. Deficit irrigation is a water-saving strategy that is commonly used in arid and semi-arid regions and leads to increased water efficiency. According to studies, Deficit irrigation can save irrigation water, maintain or increase crop production and improve its quality. One of the methods for optimizing water consumption in agriculture is the addition of moisture absorbent such as Zeolite, which by gradually providing absorbed water and nutrients to the soil, play an important role in fertility and preventing water loss. The use of zeolite, especially in sandy soils that exposed to drought stress, can improve growth and final yield by absorbing and controlling moisture release and increasing soil moisture capacity. Because of low rainfall and also limitation of water resources in Birjand region, efficient use of water in agriculture, especially in the production of important cereals such as Miaze, is very important. The aim of this study was to investigate the application of zeolite and deficit irrigation methods for optimal use of water and achieving optimum yield in Maize in this region.

Materials and methods

In order to investigate the effect of irrigation and Zeolite on maize, a field experiment was conducted on two planting dates in 2017, factorial based on a randomized complete block design with three replications. The factors including Zeolite in two levels and deficit irrigation in eight levels include: 100% water requirement, 75% water requirement in vegetative stage with: conventional irrigation, Fixed alternate partial root-zone irrigation, nonfixed alternate partial root-zone irrigation, and 75% water requirement in total growth with Fixed alternate partial root-zone irrigation, 50% water requirement in vegetative stage with: conventional irrigation, Fixed alternate partial root-zone irrigation, nonfixed alternate partial root-zone irrigation.

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Results and discussion

Traits measured on the second date of planting had the highest value compared to the first date. Deficit Irrigation reduced the total dry weight and grain yield, but the use of zeolite improved these indicators. Total dry weight, number of grains per ear, grain yield, harvest index and water use efficiency had the highest value in irrigation control treatment and decreased with deficit irrigation, so that the lowest value in conventional irrigation treatment The basis of 50% of water requirement in the growing season was observed with 23, 26, 38, 27 and 19% reduction, respectively. Zeolite application had a favorable effect on all traits, but the effectiveness of some traits was different during planting dates, so that the rate of yield increase on the second planting date (37%) was higher than the first date (27%). The highest water use efficiency was obtained on the second planting date and Fixed alternate partial root-zone irrigation based on 75% of water requirements during the growing season and total growth with 0.7 and 7.6 due to the increase in observation, had the highest Were the amount. Although the yield decreased in deficit irrigation treatments, but due to the increase in harvest index and water use efficiency, excess water due to under-irrigation can be spent on irrigating more lands and increasing production.

Conclusion

One of the important goals of production in areas with water constraints is to increase the yield per unit of water. According to the results, after the control treatment, the highest harvest index was related to 75% water requirement in vegetative stage with Fixed alternate partial root-zone irrigation treatment. Also, based on water use efficiency, to 75% water requirement in vegetative stage with Fixed alternate partial root-zone irrigation and 75% water requirement in total growth with Fixed alternate partial root-zone irrigation treatments were better than other treatments with a superiority of 0.69 and 7.59% compared to the control treatment. Despite saving 19.84% of water consumption in low irrigation treatments, 50% of water requirement in the growing period, but did not get an acceptable result from this treatment (33.74% reduction in yield and 13.79% efficiency). Water consumption). It seems that the relatively severe lack of water during vegetative growth has caused serious damage to the roots of the plant, which in the later stages of growth, despite the optimal irrigation of the plant could not use the water in the root environment well. Regardless of the reduction in yield and considering the water use efficiency that was obtained in 75 water requirements treatments in the form of atmospheres and constant intermediate stacks in the vegetative period and the whole growth period, it seems that these two treatments for Execution in Birjand region should be more appropriate.

***Keywords*:** Deficit irrigation, Grain yield, Harvest index, Water use efficiency, Zeolite

Table 1. Water consumption in irrigation treatments (m^3 ha^{-1})

First planting date (May 12)															
PRD50 V†		FPRD50 V		CI50 V		FPRD75 T		PRD75 V		FPRD75 V		CI75 V		FI100	
R††	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V
3575	7250	2681.25	7250	2681.25	7250	2681.25	7250	2681.25	5437.5	1787.5	7250	1787.5	7250	1787.5	7250
9037.5		9037.5		9037.5		8118.75		9931.25		9931.25		9931.25		10826.0	

Second planting date (July 12)															
PRD50 V		FPRD50 V		CI50 V		FPRD75 T		PRD75 V		FPRD75 V		CI75 V		FI100	
R	V	R	V	R	V	R	V	R	V	R	V	R	V	R	V
3968	4219	2976	4219	2976	4219	2976	4219	2976	3164.25	1984	4219	1984	4219	1984	4219
6203		6203		6203		6140.25		7195		7195		7195		8187	

† FI100: convectional irrigation with 100% water requirement; CI75 V: conventional irrigation with 75% water requirement in vegetative stage; FPRD75 V: fixed alternate partial root-zone irrigation with 75% water requirement in vegetative stage; PRD75 V: nonfixed alternate partial root-zone irrigation with 75% water requirement in vegetative stage; FPRD75 T: fixed alternate partial root-zone irrigation with 75% water requirement in total growth; CI50 V: conventional irrigation with 50% water requirement in vegetative stage; FPRD50 V: fixed alternate partial root-zone irrigation with 50% water requirement in vegetative stage; PRD50 V: nonfixed alternate partial root-zone irrigation with 50% water requirement in vegetative stage).
†† V: Vegetative stage; R: Reproductive stage

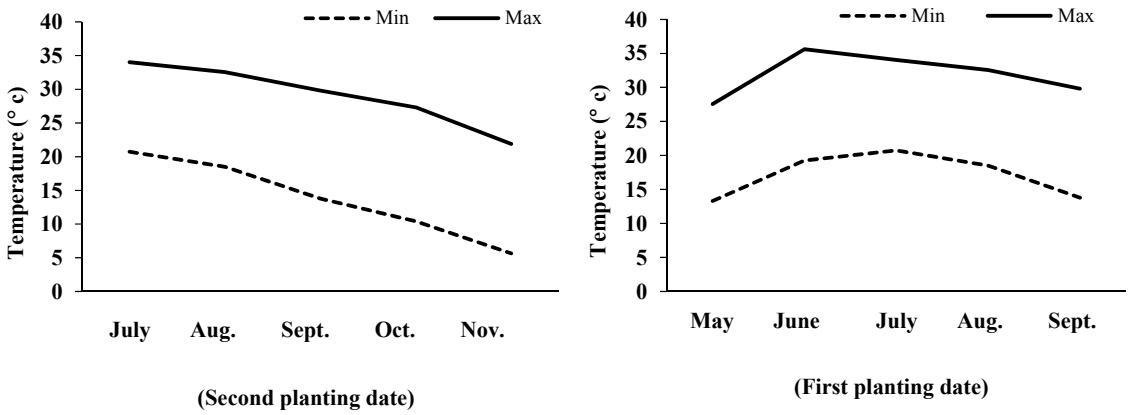

Fig. 1. Average of minimum and maximum degree in two planting date

Table 2. Mean squares from the analysis of variance for yield and yield components of maize

S.O.V	df	Leaf area index	Dry matter yield	Number of seeds per ear
Planting Date (PD)	1	14.11 **	693.76 **	820105.51 **
Error	4	0.63	31.36	3544.7
Zeolite (Z)	1	4.23 **	76.62 **	131498.01 **
Deficit Irrigation (D)	7	0.14 ns	14.06 **	19694.01 **
PD*Z	1	2.71 **	50.47 ns	21663.18 *
PD*D	7	0.02 ns	14.40 ns	200.61 ns
Z*D	7	0.04 ns	1.08 ns	401.49 ns
PD*Z*D	7	0.006 ns	0.47 ns	697.49 ns
Error	60	0.27	8.47	3651.5
CV%	-	*11.45*	*10.96*	*16.77*

Table 2. Continued

S.O.V	df	Thousand seed weight	Grain yield	Water Use Efficiency	Harvest Index
Planting Date (PD)	1	40950.19 **	1082.86 **	38.91 **	7495.42 **
Error	4	1422.55	4.52	0.06	77.88
Zeolite (Z)	1	11007.1 **	208.31 **	3.97 **	1529.62 **
Deficit Irrigation (D)	7	2646.74 **	31.88 **	0.18 *	165.36 **
PD*Z	1	695.90 ns	41.04 **	1.30 **	142.06 ns
PD*D	7	118.95 ns	0.56 ns	0.03 ns	24.07 ns
Z*D	7	212.26 ns	0.52 ns	0.02 ns	3.797 ns
PD*Z*D	7	153.32 ns	0.69 ns	0.02 ns	5.17 ns
Error	60	574.01	3.83	0.07	37.58
CV%	-	9.01	19.09	19.09	16.36

*,** and ns means significant at 0.05 and 0.01 probability levels, and non-significant, respectively

Table 3. Comparison of the mean effect of planting date, application of zeolite and deficit irrigation on yield and yield components of maize

Treatments	Leaf area index ††	Dry matter yield	Number of seeds per ear
	$m^2 m^{-2}$	t ha^{-1}	
First planting date	4.00 b	23.87 b	267.81 b
Second planting date	4.77 a	29.24 a	452.67 a
Non zeolite	4.18 b	25.66 b	323.23 b
With zeolite	4.60 a	27.45 a	397.25 a
FI100 †	5.12 a	29.23 a	420.17 a
CI75 V	4.29 cd	26.81 bc	360 bc
FPRD75 V	4.76 ab	28.1 ab	392.75 ab
PRD75 V	4.52 bc	27.99 ab	375.17 ab
FPRD75 T	4.71 abc	27.65 ab	391.92 ab
CI50 V	3.68 e	23.81 d	298.92 d
FPRD50 V	4.03 de	24.46 cd	321.92 cd
PRD50 V	4.00 de	24.39 d	321.08 cd

Table 3. Continued

Treatments	Thousand seed weight ††	Grain yield	Water Use Efficiency	Harvest Index
	g	t ha^{-1}	Kg m^{-3}	%
First planting date	245.17 b	6.90 b	0.72 b	28.63 b
Second planting date	286.48 a	13.61 a	2 a	46.30 a
Non zeolite	255.12 b	8.78 b	1.16 b	33.47 b
With zeolite	276.54 a	11.73 a	1.56 a	41.45 a
FI100 †	291.81 a	13.04 a	1.45 ab	44.17 a
CI75 V	267.17 bc	10.19 bc	1.29 bc	36.81 bcd
FPRD75 V	276.45 ab	11.61 ab	1.46 ab	40.93 ab
PRD75 V	275.95 ab	10.98 b	1.38 abc	38.51 bc
FPRD75 T	247.18 d	10.38 bc	1.56 a	36.89 bcd
CI50 V	252.79 cd	8.1 d	1.18 c	32.45 d
FPRD50 V	257.80 bcd	8.93 cd	1.29 bc	35.09 cd
PRD50 V	257.48 bcd	8.89 cd	1.28 bc	34.85 cd

† FI100: convectional irrigation with 100% water requirement; CI75 V: conventional irrigation with 75% water requirement in vegetative stage; FPRD75 V: fixed alternate partial root-zone irrigation with 75% water requirement in vegetative stage; PRD75 V: nonfixed alternate partial root-zone irrigation with 75% water requirement in vegetative stage; FPRD75 T: fixed alternate partial root-zone irrigation with 75% water requirement in total growth; CI50 V: conventional irrigation with 50% water requirement in vegetative stage; FPRD50 V: fixed alternate partial root-zone irrigation with 50% water requirement in vegetative stage; PRD50 V: nonfixed alternate partial root-zone irrigation with 50% water requirement in vegetative stage).

†† Means within each column in each section, followed by the same letters are not significantly different based on FLSD test ($p \leq 0.05$)

Table 4. Effect of planting date and Zeolite on yield and water use efficiency

Zeolite	planting date	Number of seeds per ear	Grain yield	Water Use Efficiency
			t ha^{-1}	kg m^{-3}
Non zeolite	**First date**	252.12 d	6.08 d	0.64 d
	Second date	401.33 b	11.49 b	1.68 b
With Zeolite	**First date**	293.62 c	7.72 c	0.81 c
	Second date	504 a	15.74 a	2.32 a

Means within each column followed by the same letters are not significantly different based on FLSD test ($p \leq 0.05$)

Table 5. The pearson correlation coefficient between yield and yield components in Maize

	Measured traits	1	2	3	4	5	6	7	8	9
1	**Leaf area index**	1								
2	**Dry matter yield**	0.635**	1							
3	**Number of seeds per ear**	0.668**	0.818**	1						
4	**Number of rows per ear**	0.556**	0.695**	0.738**	1					
5	**Number of seeds per row**	0.635**	0.772**	0.963**	0.540**	1				
6	**Thousand seed weight**	0.540**	0.556**	0.651**	0.554**	0.600**	1			
7	**Grain yield**	0.674**	0.785**	0.970**	0.739**	0.922**	0.804**	1		
8	**Water Use Efficiency**	0.596**	0.742**	0.943**	0.649**	0.922**	0.728**	0.952**	1	
9	**Harvest Index**	0.623**	0.593**	0.909**	0.660**	0.875**	0.817**	0.958**	0.914**	1

**, * Correlation is significant at the 0.01 and 0.05 levels (2-tailed)