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Effect of Supplemental Irrigation, Nitrogen Chemical Fertilizer, and Inoculation with Rhizobium Bacteria on Grain Yield and Its Components of Chickpea (*Cicer arietinum* L.) Under Rainfed Conditions

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***Abstract*—**In order to study the effects of supplemental irrigation, different levels of nitrogen chemical fertilizer and inoculation with rhizobium bacteria on the grain yield of chickpea, an experiment was carried out using split plot arrangement in randomize complete block design with three replication in agricultural researches station of Zanjan, Iran during 2009-2010 cropping season. The factors of experiment consisted of irritation (without irrigation (I1), irrigation at flowering stage (I2), irrigation at flowering and grain filling stages (I3) and full irrigation (I4)) and different levels of nitrogen fertilizer (without using of nitrogen fertilizer (N0), 75 $kg.ha^{-1}$ (N75), 150 $kg.ha^{-1}$ (N150) and inoculation with rhizobium bacteria (N4). The results of the analysis of variance showed that the effects of irrigation, nitrogen fertilizer levels and bacterial inoculation, were significant affect on number of pods per plant, number grains per plant, grain weight, grain yield, biological yield and harvest index at 1% probability level. Also Results showed that the grain yield in full irrigation treatment and inoculated with rhizobium bacteria was significantly higher than the other treatments.

***Keywords*—**Chickpea, Nitrogen, Supplemental irrigation.

I. Introduction

CURRENTLY, the population growth and low protein content of cereals, has attracted the attention of people to legumes consumption as an important source of required protein of people [1]. The legumes because of presence the nitrogen fixing bacteria in their roots, are effective on soil fertility and after harvest of these products, large amounts of nitrogen will be added to the soil [2]. Among legumes, chickpeas with cultivated area about 11 millions ha and production of 650 $kg.ha^{-1}$ [3], has more adaptations than the climatic conditions of the country, especially with the most dry farming areas of Iran compared to other legumes [4]**.** In general, drought stress is the second a biotic stress, that has negative effects on chickpea grain function. That with applying of supplemental irrigation in stage that plant has maximum requirement water can be significantly increases the yield compared to in drought and rainfed conditions. On the other hand considering with nitrogen is a key element for the plant growth, nitrogen fixation by legumes including chickpea, could obviate plant requirement to this element and it replaces by chemical fertilizers. Such replacement in terms of economically and environmentally has been welcomed in sustainable agricultural programs. Pawar et al. [5] in investigate the irrigation effect at critical stages growth of chickpea reported that highest grain yield be obtained with three irrigations at branching, flowering and pods stages. Singh [6] expressed that because the lack of water, vegetative and reproductive growth of chickpea accelerated and in result decreases the duration of these stages. Bagheri et al. [4] introduced the initial growth stage of pea pods as the most sensitive to drought stress. Saxsena [7] about response of Chickpea to supplemental irrigation in different regions expressed that supplemental irrigation has serious effects on increasing yield**.** Providing the humidity is one of important factors of nitrogen accumulation in grain and nitrate of soil is one of the most limiting factors of legume rhizobium symbiosis. In experiments [8]-[10], rhizobium inoculation significantly increased yield and nitrogen content in grain of chickpea. Unfortunately, in Iran farmers use excessive of nitrogen fertilizers regardless of good potential of fields for nitrogen fixation and because of the very low prices of nitrogen fertilizers. For this purpose, one can have opposed with water scarcity crisis and environmental pollution (by reducing the use of chemical fertilizers) by useful programs and also products propose with suitable quality to agricultural**.** Thus, the present study was carried out to enhance the yield and optimize the use of nitrogen fertilizers in the area.

II. Materials and Methods

In order to study the effects of supplemental irrigation, different levels of nitrogen chemical fertilizer and inoculation with rhizobium bacteria on the grain yield of chickpea varieties, an experiment was carried out using split plot arrangement in randomize complete block design with three replication in agricultural researches station of Zanjan, Iran during 2009-2010 cropping season. The factors of experiment consisted of irritation (without irrigation (I1), irrigation at flowering stage (I2), irrigation at flowering and grain filling

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stages (I3) and full irrigation (I4)) and different levels of nitrogen fertilizer (without using of nitrogen fertilizer (N0), 75 kg.ha^{-1} (N75), 150 kg.ha^{-1} (N150) and inoculation with rhizobium bacteria (N4). Properties of the soil and water location experiment in studied region are observed in Tables I and II.

TABLE I
RESULTS OF ANALYSIS OF SOIL EXPERIMENT BEFORE PLANTING

(Absorbable)		
Zn	2.8	Mg.kg^{-1} soil
Mg	228	Mg.kg^{-1} soil
Mn	10.1	Mg.kg^{-1} soil
Fe	8.9	Mg.kg^{-1} soil
K	850	Mg.kg^{-1} soil
P	235	Mg.kg^{-1} soil
N	10	(%)
O.C	0.54	(%)
EC	0.68	(ds.m^{-1})

TABLE II
CHARACTERISTICS OF WATER LOCATION EXPERIMENT (CHEMICAL ANALYSIS OF WATER PROPERTIES)

Mg + Ca	1.76	MEq per liter
Na	1.11	MEq per liter
Sulfate	0.31	MEq per liter
Cl	0.4	MEq per liter
Bicarbonate	2	MEq per liter
Carbonate	0.16	MEq per liter
PH	8.08	
EC ×10^{6}	360	μ mho/cm

According to the results obtained of soil analysis, 100kg.ha^{-1} triple super phosphate was added to the experiment field. All seeds were disinfected using pesticide Benomyl except seeds were coated with bacteria. For treatments were inoculated with bacteria, the sugar solution 20% was prepared due to sticking bacteria to seeds and then seeds soaked with sugar solution and bacteria in three replications. Then seeds immediately planted after become dry in shade. Nitrogen is required for each treatment was calculated and before planting and added to the ground. In treatment I4 (full irrigation) soil moisture and its required water were calculated using A Class evaporation pan and the relevant formulas and then plants was irrigated. The total consumed water in each of the treatments I4, I3, I2 were measured by the contour. Measured traits were including the number of pods per plant, number of grains per plant, seed weight, grain yield per unit area, biological yield per unit area and harvest index. At the end, analysis of variance (ANOVA) was done using SAS 9.1 statistical software and means were compared using Duncan's test.

III. RESULTS AND DISCUSSION

According to the results of analysis variance (Table III), the effect of Irrigation, nitrogen fertilizer levels and inoculation on the number of pods per plant, number of grains per plant, seed weight, grain yield, biological yield and harvest index was significant at 0.01% level of probability.

TABLE III
VARIANCE ANALYSIS (MEAN SQUARE) FOR STUDIED TRAITS IN CHICKPEA

S.O.V	d.f	Number of pods per plant	Number of grains per plant	Grain weight	Grain yield	Biological yield	Harvest index
Replication	2	1.988 ns	1.2 ns	0.71ns	429.8ns	7677.5ns	10.6 ns
Irrigation	3	753.08**	451.7**	47.2**	2997630.1**	10776260.7**	117.29**
Error	6	2.5	2.9	0.3	4958.5	33644.3	4.5
Nitrogen	3	38.1**	16.7**	38.2**	215433.5**	84617.6**	38.02**
Irrigation × nitrogen	9	8.3**	4.7ns	1.7**	29886.4**	67859.8	15.6**
Error	24	2.3	2.3	0.2	796.5	46556.2	2.5
CV	-	6.7	11.6	2.8	10.2	12.3	3.2

ns, * and **: Non – significant at 5% and 1% probability levels, respectively

A. The Number of Pods per Plant

Means comparison obtained from the data showed that the lowest the number of pods per plant was obtained from plants that only at flowering were irrigated (Table IV). In full irrigation, due to prolong the flowering period and the optimum use of plants of available resources, flowers and pods production are being done in the more range time. Effects of water deficit and reduce the number of pods in chickpea have also been reported by Ghasemzadeh Ganjei et al. [9], Pandy [11], Siddique and Sedgley [12]. Also Means comparison showed that the Maximum (17.6 pods) and lowest (13.5 pods) number of pods per plant was obtained from plants that were inoculated with bacteria and treatment without nitrogen respectively. Since the number pods per plant is the most important traits relating to yield, any factor that increases this component also because will increases yield the deficiency of nitrogen decreases the number of flowers and pods in legumes. Interaction effect irrigation treatments, nitrogen fertilizer levels and inoculation on the number of pods per plant were significant. The plants grown under full irrigation and inoculation with bacteria generated highest the number of pods per plant (32.2 pods).

TABLE IV
INTERACTION EFFECTS OF IRRIGATIONS AND NITROGEN FERTILIZER AND INOCULATION ON THE NUMBER OF PODS PER PLANT

Irrigation / Nitrogen	No irrigation	one irrigation at flowering	irrigation at flowering and grain filling	full irrigation	Mean
No nitrogen	9.3d	9.02d	11.1cd	24.8b	13.5c
75 kg.ha^{-1}	11.4cd	12.6cd	13.8c	29.3a	16.8ab
150 kg.ha^{-1}	13.08cd	11.7cd	13cd	24.6b	15.6b
Inoculation	12.8cd	12.6cd	12.9cd	32.2a	17.6a
Mean	11.6b	11.5b	12.7b	27.7a	

Means, in each column, followed by similar letter(s) are not significantly different at the %5 probability level- using Duncan's Multiple Range Test.

B. The Number of Grains per Plant

Regarding to analysis variance of data (Table III), the effect of Irrigation, nitrogen fertilizer levels and inoculation on the number of grains per plant was significant at 1% level of probability. The results showed that the highest (22.3 grains) and lowest (9.8 grains) number of grains per plant was calculated from plants grown under full irrigation and non irrigation (Table V). Drought stress reduces the number of pods per plant; result decreases the number of grains per plant**.** Similar results on chickpea have been reported by Ghasemzadeh Ganjei et al. [9] and Pawar et al. [5]. Also results show that seed inoculation with the stabilizer bacteria increasing the number grains per plant chickpea. Interaction effects of different treatments on the number of grains per plant were not significant.

TABLE V
INTERACTION EFFECTS OF IRRIGATION, NITROGEN FERTILIZER AND INOCULATION ON NUMBER OF GRAIN IN PLANT

Irrigation / Nitrogen	No irrigation	one irrigation at flowering	irrigation at flowering and grain filling	full irrigation	Mean
No nitrogen	7.8c	8.2c	9.2c	20.8b	11.5
75 kg.ha^{-1}	10.3c	11.2c	11.7c	22.3ab	13.9
150 kg.ha^{-1}	10.7c	10.1c	10.6c	20.4b	12.9ab
Inoculation	10.3c	9.7c	10.6c	25.7a	14.1a
Mean	9.8b	9.8b	10.5b	22.3a	

Means, in each column, followed by similar letter(s) are not significantly different at the %5 probability level- using Duncan's Multiple Range Test.

C. Grain Weight

Results of analysis of variance showed that the effect of irrigation and nitrogen fertilizer levels was significant on hundred grain weight at 1% level of probability. Means comparison of the data showed that the highest grain weight (21.7g) was obtained from plants that were grown under full irrigation. Low grain weight in moisture deficiency condition could attribute to decrease photosynthetic rate and shortening effective grain filling period. Negative effect of No irrigation in different stages of plant growth, especially in the grain filling stage on grain weight reported on chickpea by Ghasemzadeh Ganjei et al. [9], on bean by Singh [6], in soybean by Foroud et al. [13]. Investigate the interaction effects showed that the highest value (24.3g) was obtained by using the 150 kg.ha^{-1} of N fertilizer and full irrigation. It can be seen that plants have adequate nitrogen and moisture, thus have higher hundred grain weight than other treatments (Table VI).

D. Grain Yield

The results of analysis data indicated that the effect of different levels of irrigation, nitrogen fertilizer and inoculation was significant on grain yield at 1% level of probability (Table III). The plants that grown under full irrigation generated the highest grain yield (1615 kg.ha^{-1})**.** The better grain yield on full irrigation treatment is due to, most yield components especially the number of pods per plant and hundred grain weight in comparison with limited irrigation**.** The results showed that seed inoculation with bacteria and nitrogen provide lead to the production the highest yield (Table VII). Effective symbiosis of rhizobium bacteria with legumes plants in addition to molecular nitrogen fixation will be followed reducing consumption of nitrogen fertilizer and also increasing grain yield. The Interaction effect of different treatments was significant on grain yield at 1% level of probability (Table III) and the highest grain yield (1911 kg.ha^{-1}) obtained of the full treatment and inoculation. (Table VII).

TABLE VI
INTERACTION EFFECTS OF IRRIGATION, NITROGEN FERTILIZER AND INOCULATION ON GRAIN WEIGHT (G)

Irrigation / Nitrogen	No irrigation	one irrigation at flowering	irrigation at flowering and grain filling	full irrigation	Mean
No nitrogen	15.7j	16.03ij	17.1ghi	18.3efgh	16.8c
75 kg.ha^{-1}	17ij	17.3gh	18.3efgh	21bc	18.4b
150 kg.ha^{-1}	18.03	18.9def	19.8cd	24.3a	20.3a
Inoculation	18.4efg	19.4de	21.3b	23.4a	20.6a
Mean	17.2c	17.9c	19.1b	21.7	

Means, in each column, followed by similar letter(s) are not significantly different at the %5 probability level- using Duncan's Multiple Range Test.

TABLE VII
INTERACTION EFFECTS OF IRRIGATION, NITROGEN FERTILIZER AND INOCULATION ON GRAIN YIELD (KG.HA^{-1})

Irrigation / Nitrogen	No irrigation	one irrigation at flowering	irrigation at flowering and grain filling	full irrigation	Mean
No nitrogen	412.3f	441.3ef	530ef	1270c	678.4b
75 kg.ha^{-1}	584def	654de	715.7d	1557b	875.3a
150 kg.ha^{-1}	648.1de	640.7de	739.3d	1732ab	937.7a
Inoculation	621ef	666.3de	730.7d	1911a	982.1a
Mean	566.4b	615.6b	675.5b	1615a	

Means, in each column, followed by similar letter(s) are not significantly different at the %5 probability level- using Duncan's Multiple Range Test.

E. Biological Yield

The results of the analysis of variance indicated that the effect of different levels of irrigation and nitrogen fertilization on biological yield was significant (Table III). The highest and lowest biological yield indicated in control irrigation (3163 kg.ha^{-1}) and irrigation in flowering stage (1213 kg.ha^{-1}), respectively. In Nitrogen fertilizer treatments, highest and lowest yield showed in treatment with 150 kg.ha^{-1} nitrogen using (1990 kg.ha^{-1}) and no fertilizer using (1375 kg.ha^{-1}), respectively (Table IX). Interaction of different nitrogen fertilization level and different levels of irrigation on biological yield was significant (Table III). Highest biological yield showed in control irrigation treatment (3670 kg.ha^{-1}) and using 150 kg.ha^{-1} nitrogen. Lowest biological yield showed in no using fertilizer and no irrigation (Table VIII).

TABLE VIII
INTERACTION EFFECTS OF IRRIGATION, NITROGEN FERTILIZER AND INOCULATION ON BIOLOGICAL YIELD (KG.HA^{-1})

Irrigation / Nitrogen	No irrigation	one irrigation at flowering	irrigation at flowering and grain filling	full irrigation	Mean
No nitrogen	979.8e	999.2de	930.9e	2589c	1375b
75 kg.ha^{-1}	1323.3de	1207de	1409de	3038bc	1744a
150 kg.ha^{-1}	1425de	1314de	1551d	3670a	1990a
Inoculation	1347de	1332de	1427de	3356ab	1865a
Mean	1269b	1213b	1329b	3163a	

Means, in each column, followed by similar letter(s) are not significantly different at the %5 probability level- using Duncan's Multiple Range Test.

F. Harvest Index

The results show that the effect of different levels of irrigation and nitrogen fertilizer and inoculation on harvest index was significant (Table III). Mean comparison treatments showed that the highest harvest index gained in control irrigation condition (Table IX). Increasing moisture treatment did not increase grain yield. Highest harvest index showed in inoculation (51.1%) and lowest showed in using 150 kg.ha^{-1} nitrogen fertilizers (47.41%). The interaction effect of studied treatments on harvest index was significant at 1% probability level (Table IX). Highest harvest index showed in control irrigation and inoculation condition (59.67 %).

TABLE IX
INTERACTION EFFECTS OF IRRIGATION, NITROGEN FERTILIZER AND INOCULATION ON HARVEST INDEX (%)

Irrigation / Nitrogen	No irrigation	one irrigation at flowering	irrigation at flowering and grain filling	full irrigation	Mean
No nitrogen	42.09g	50.27bc	49.6cd	49.8cde	47.7b
75 kg.ha^{-1}	44.1fg	54.1ab	50.8b	51.01bc	50.04a
150 kg.ha^{-1}	45.9efg	48.9cde	47.8cdef	47.2cdef	47.41b
Inoculation	46.1def	50.1bcd	51.2bc	56.9a	51.1a
Mean	46.4b	50.8a	49.9a	51.08a	

Means, in each column, followed by similar letter(s) are not significantly different at the %5 probability level- using Duncan's Multiple Range Test.

IV. CONCLUSION

As regards the most function of seed grain obtained from the level of inoculation with bacteria which it doesn't have a significant difference with two levels of nitrogen fertilizer uses and providing of moisture soil is one of the most important factors in being effective inoculation. It appears in dry farming of chickpea using of chemical fertilizer is more effective than inoculation method. It is suggested that in this state, do many studies for a product of this area and determine the rate of decline of products function per difference low degrees of irrigation, until it's applied the maximum using of water by optimize consumption of water, efficiency or consumption.

REFERENCES

[1] Q. Bateni, "Chickpea production in Zanjan, Jihad University press of Zanjan University. Iran. Chickpea", *Ann. Agric. Res.* 1: 136-140. 1983.
[2] N. Majnoon Hosseini, "Effect of different strains of rhizobium strains of lentil yield", *Proceedings of the Third National conference biological materials application development and optimal use of fertilizers and pesticides in agriculture*. 1993.
[3] Kochaki and M. Banaiyan, "Agricultural crops", *University Jihad published by, Ferdowsi University, Mashhad.* 1994.
[4] A. Bagheri, Nezami, A. Ganj and M. Parsa, "Agronomy and Breeding of chickpeas", *Publishing of the University Jihad by Ferdowsi University of Mashhad. Iran*. 1997.
[5] V.S. Pawar, P.O. Patit, S.D. Dahiwalkker and S.S. Magar, "Effect of irrigation Schedule based on critical growth stages on yield, quality and water use of chickpea (C*icer arietinum* L.) on Vertisoil", *Indian J. of Agric. Sci.* 62(6): 402-404. 1992.
[6] S.P. Singh, "Selection for water stress tolerance in interracial population of common bean", *Crop Sci*. 35: 118-128. 1995.
[7] M.C. Saxsena, "Recent advances in chickpea agronomy", *In proceedings of the International Workshop on chickpea Improvement, ICRISAT, Patancheru. India*. 96-98. 1980.
[8] M.C. Saxsena, "Agronomic studies on winter chickpeas", In proceeding of the workshop on Ascochyta Blight and Winter Sowing of chickpeas". *ICARDA. Publications. Aleppo*. 123-137. 1984.
[9] M. Ghasemzadeh Ganjei, A. Asgharzadih and M. Afshari, "Effect of rhizobial inoculant on chickpeas yield in the Khorasan province", *Proceedings of the Third National Conference on Application of biological materials and efficient use of fertilizers and pesticides in agriculture*. 2003.
[10] N. Majnoon Hosseini, "Legumes in Iran", Published by Jihad Tehran. Iran. 1993.
[11] R.K. Pandey, "Influence of source and sink removal on seed yield of chickpea (Cicer arietinum L.)", *Field Crops Res*. 8:159-168. 1984.
[12] K.H.M. Siddique and R.H. Sedgley, "Chickpea a Potential grain legume for southwestern Australia: Seasonal growth and yield", *Aust. J. Agric. Res*. 37:245-261. 1986.
[13] N. Foroud , H.H. Mundel, G. Saindon and T. Entz, "Effect of level and timing of moisture stress on soybean yield, protein and oil response", *Field Crops Res*. 31:195-209. 1993.