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Full Length Research Paper

Plant growth and protein ratio of spring sown chickpea with various combinations of rhizobium inoculation, nitrogen fertilizer and irrigation under rainfed condition

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In the present study, it was aimed to determine the effects of different combination of rhizobium inoculation, nitrogen application and irrigation on nodule dry weight, protein ratio and seed yield of spring sown chickpea (*Cicer arietinum* L. cv ILC 482). The field experiment was carried out for two consecutive seasons in Van, Turkey in summer growing seasons of 1999 and 2000. All combinations influenced seed yield and yield components, therefore, there were highly significant differences in plant height (cm), number of branches per plant (plant^{-1}), number of pods per plant (pods plant^{-1}), number of seed per plant (seed plant^{-1}), seed yield (kg ha^{-1}), and protein ratio (%). The combination of nitrogen (60 kg N ha^{-1}) and irrigation had the highest seed yield. Moreover, this combination was followed by the combination of inoculation and nitrogen (20 kg N ha^{-1}) and irrigation (In_1+N_1+Ir_1). In contrast, the combination of uninoculation, no nitrogen application and nonirrigation (In_0+N_0+Ir_0) had the lowest seed yield. Moreover, the results obtained from the combination of inoculation, nitrogen (20 kg N ha^{-1}) and irrigation was comparable to that of the combination of nitrogen (60 kg N ha^{-1}) and irrigation for seed yield. Therefore, the combination of inoculation and nitrogen (20 kgN ha^{-1}) and irrigation treatment can be use instead of the combination of nitrogen (60 kg N ha^{-1}) and irrigation in chickpea production for achieving higher seed yield in rainfed condition. It is concluded, that nitrogen or inoculation has superior performance in seed yield and protein ratio under irrigation compared to those of nonirrigation conditions.

Key words: Chickpea (*Cicer arietinum* L.), irrigation, inoculation, nitrogen fertilizer.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an annual grain legume that is used extensively for human foods, as the primary source of nitrogen for many cropping systems and is widely grown in Turkey. Nitrogen, irrigation and inoculation are used as the most agronomic practice to achieving high seed yield in chickpea. Akdağ et al. (1995) reported that nitrogen fertilization increased seed yield. Furthermore, nitrogen fixation is more favourable than that of nitrogen fertilizer because of limitations and costs are not uncommon in many developing countries. Sharma et al. (1989) and Khan et al. (1992) showed that inoculation with rhizobium strains resulted in a significant increase in grain yield. In contrast, there are many factors (soil pH, soil moisture, organic mater, native strains, soil temperature etc.) that prevent nitrogen fixation. Soil moisture is known that the most factor that limits nitrogen fixation. Many researchers studied to determine effect of soil moisture on nitrogen fixation. Some of them such as Guerin et al. (1990), Pararjasingham and Knievel (1990) and Simpson and Daft (1991) reported that symbiotic nitrogen fixation of legumes was also highly sensitive to soil moisture deficiency. Legumes exhibit a reduction in nitrogen fixation when subjected to soil moisture deficit. Moreover, Albrecht et al. (1994) reported that nodule growth and activity are all more sensitive to water stress than plant metabolism in soybean. In addition, the

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response of nodulation and nitrogen fixation to water stress depends on the growth stage of the plants. Pena-Cabriales and Castellanos (1993) reported that water stress imposed during vegetative growth compared to reproduction stage was more detrimental to nodulation and nitrogen fixation. Moreover, Yağmur and Engin (1999) reported that effects of inoculation on all characters of chickpea plants were not significant under rainfed conditions. In addition, Parveen et al. (1999) stated that rhizobium inoculation performance was better under normal conditions than water stress conditions. Furthermore, chickpea is mostly produced under rainfed conditions but responds positively to irrigation (Zhang et al., 2000). Many researchers report that supplemental irrigation can significantly increase grain yield. Irrigations release the crop from soil moisture stress at critical stages and help to increase seed yield in chickpea (Sexana, 1980; Silim and Saxena, 1986). Therefore, number of irrigation is important as in case irrigation time and changed in different region. Zaman and Malik (1988) reported that maximum grain yield, dry matter, pods per plant, seeds per pod and 1000 grain weight were obtained with two irrigations. Pawar et al. (1992) reported that seed yield was the highest with irrigations at all 3 growth stages and the lowest with nonirrigations; seed protein content was the highest with 3 irrigations and the lowest with nonirrigations.

The main objective of this study was to determine the response of a chickpea variety to inoculation, irrigation, N fertilization and their different combinations.

MATERIALS AND METHODS

Study design and plant material

This study was carried out in field conditions in Van, eastern of Turkey (38°-55'N, 42°-05'E, 1725 m above sea level) in 1999 and 2000 in summer growing seasons. Chickpea variety of ILC-482 (C*icer arietinum* L.) was used as a seed material. The experimental design was a randomized complete blocks with four replications with a total number of 48 plots. Area of each plot was 7.5 m^2 (1. 50 m X 5 m each one).

The study contains the following treatments:

T1 = $Ino_0+N_0+Ir_0$ (no inoculation and 0 kg ha^{-1} N fertilizer and nonirrigation)

T2 = $Ino_0+N_0+Ir_1$ (no inoculation and 0 kg ha^{-1} N fertilizer and irrigation)

T3 = $Ino_1+N_0+Ir_0$ (inoculation and 0 kg ha^{-1} N fertilizer and nonirrigation)

T4 =$Ino_1+N_0+Ir_1$ (inoculation and 0 kg ha^{-1} N fertilizers and irrigation) T5=$Ino_1+N_1+Ir_0$ (inoculation and 20 kg ha^{-1} N fertilizers and nonirrigation)

T6=$Ino_1+N_1+Ir_1$ (inoculation and 20 kg ha^{-1} N fertilizer and irrigation)

T7 = N_1+Ir_0 (20 kg ha^{-1} N fertilizer and nonirrigation)

T8 = N_1+Ir_1 (20 kg ha^{-1} N fertilizer and irrigation)

T9 = N_2+Ir_0 (40 kg ha^{-1} nitrogen fertilizer and nonirrigation)

T10 = N_2+Ir_1 (40 kg ha^{-1} N fertilizer and irrigation)

T11= N_3+Ir_0 (60 kg ha^{-1} N fertilizer and nonirrigation)

T12 = N_3+Ir_1 (60 kg ha^{-1} N fertilizer and irrigation)

In this experiment, irrigation treatment was applied to plots at four different growth stages. The first irrigation was done after seed sown into plots. The second irrigation was done at pre flowering stage. The third one was done at flowering stage, and the fourth one was done at pod filling stage. These growth stages were selected as the reports of Rehman et al. (1983), Silim and Saxena (1986), Zaman and Malik (1988) and Pawar et al. (1992).

Fertilizers were applied with a hand and mixed into the top 1-5 cm of soil at seeding time. Seed inoculation was performed by thoroughly mixing a measured amount of peat inoculants containing *Rhizobium ciceri* and gum arabic solution as a sticker. Seeds were treated in black plastic bags immediately before seeding (Vincent, 1970). Peat material was provided by the Soil and Fertilizer Research Institute of Ankara. All plots fertilized with 40 kg ha^{-1} phosphorus. Phosphorus source was triple supper phosphates (42%) and nitrogen source was ammonium sulphates (21%) in this experiment.

In the first year, sowing date was on 28th April 1999 and in the second year; it was on 27th April, 2000. In this study, no fungicide seed treatment was used. Weeds were controlled by hand-hoeing during the growing season. No disease and insect problem was observed in this experiment.

Nodule and plant measurements

Nodule sampling was performed by excavating the roots of 10 random plants from the central rows of each plot at the flowering stage. A spade was used to collect an undisturbed soil sample (approximately 20 cm deep) containing the roots. Nodules were removed separately from the roots. The nodules dried in an oven at 60°C for 3 days and dry weights were determined (Vincent, 1970).

The sample unit consisted of 10 plants harvested from randomly selected samples from the two middle rows of each plot, at grain maturity. Some important yield and quality characters such as plant height (cm), branches $plant^{-1}$, pod plant $^{-1}$, seed plant $^{-1}$, protein ratio and seed yield were investigated in this experiment. Seed yield was obtained by removing all plants in there middle rows of each plot harvest, and that was standardized to 14% humidity. The micro Kjeldahl method was used to determine the seed nitrogen content which was multiplied by 6.25 to determine seed protein content (Nelson and Sommers, 1973).

Soil and climatic description

Soil analyses were determined as described by Kacar (1995). The experimental soil has sandy-clay loam texture and low organic matter and nitrogen, lime content medium phosphorus and soil is low alkaline (Table 1).

Temperate climatic condition is ruled in the region. During the course of experiment, from April to the end of July, total rainfall was 98.4 mm in 1999, 63.7 mm in 2000. Annual rainfall total was 322.8 mm in 1999 and 234.9 mm in 2000. In addition, the amount of rainfall in the second year of the trial was lower than that in the first year, both during the course of experiment and course of year (Anonymus, 2001).

Statistical analysis

The experimental design was a randomized complete block with four replications. The data obtained for the two years were analysed statistically (analysis of variance) for significant differences. These analyses were performed by the procedure of MSTATc statistical package. Means were grouped in Duncan Multiple Comparison Test (P<0.05).

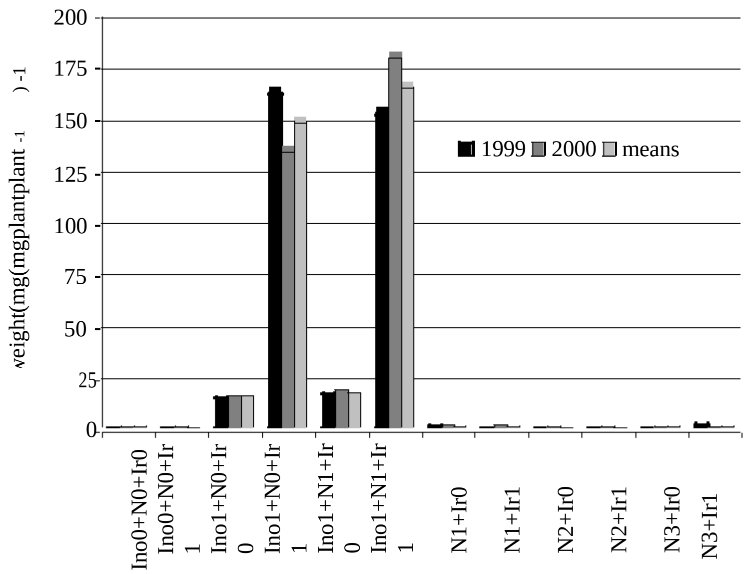

Figure 1. Effects of twelve treatments on nodule dry weight (mg plant^{-1}).

Table 1. Selected physical and chemical properties of the soil*.

Depth (cm)	pH	Organic matter (%)	Lime (%)	Salinity (%)	P (mg kg^{-1})	N (%)
0-20	7.41	1.05	31.5	0.49	5.48	0.15

*Soil analysis was done at the laboratories of The University of Yüzüncü Yıl.

RESULTS AND DISCUSSION

Nodule dry weight (mg plant^{-1})

It was found that the combination of inoculation, nitrogen and irrigation influenced significantly ($p<0.01$) on nodule dry weight of spring sown chickpea (*Cicer arietinum* L.) in two years (Figure 1). Nodule weight and count are used for specific determination of this activity, and therefore, to fixation (FAO, 1983). The combination of inoculation, and irrigation and low nitrogen significantly influenced the distribution of nodules on the root system. Therefore, inoculated seeds with irrigation had the highest nodule dry weight. Although, inoculated seed with rhizobium, nodulation was determined poor and ineffective under nonirrigated plots in spring sown chickpea. This may be attributed to the fact that moisture stress decreased nodulation and plant growth. Albrecht et al. (1994) reported that nodule growth was more sensitive to soil moisture. Especially, water stress imposed during vegetative growth was more detrimental to nodulation and nitrogen fixation than that imposed during the reproduction stage (Pena-Cabriales and Castellanos, 1993). Yağmur and Engin (1999) reported that poor and ineffective nodules were obtained under rainfed conditions.

Plant and pods characters

The statistical analysis revealed that the effect of 12 different treatments on plant height significantly different ($p<0.01$) in both years. Table 2 shows results of plant height were tested in variance analysis and means were grouped in Duncan Multiple Comparison Test. Plant height was similar in consecutive two years. Moreover, plant height was changed 19.7 to 27.5 in the average of two years. The highest plant height was determined by the treatments of T12, T10 and T6. The lowest plant height was obtained from the T1 ($Ino_0+N_0+Ir_0$) treatment as 19.7 cm.

Plant height and branches per plant ($p<0.01$) in chickpea tended to increase in inoculation with rhizobium, irrigation and mineral nitrogen fertilizer amended plots as compared to the unamended plots. Rhizobium inoculation performance in plant height or in branches was better under normal than that of water stress and it was reported by Parveen et al. (1999). Nitrogen uptake of

Table 2. Mean and compared values of the different treatments of inoculation, nitrogen fertilizers and irrigation on plant height (cm), number of branches per plant ($plant^{-1}$), number of pod per plant ($plant^{-1}$) in chickpea.

Treatment		Plant height (cm)			Number of branches (branches $plant^{-1}$)			Number of pod (pod $plant^{-1}$)		
		1999	2000	Means	1999	2000	Means	1999	2000	Means
T1	$Ino_0+N_0+Ir_0$	19.2 g*	20.2 e	19.7 f	9.0 d	8.5 f	8.7 e	10.5 f	10.2 c	10.3 f
T2	$Ino_0+N_0+Ir_1$	22.2 ef	22.7 c	22.5 d	12.2 b	11.2 de	11.7 c	13.5 c	12.7 b	13.1 c
T3	$Ino_1+N_0+Ir_0$	21.2 f	21.2 de	21.2 e	9.7 cd	9.7 ef	9.7 d	10.7 ef	11.5 bc	11.1 ef
T4	$Ino_1+N_0+Ir_1$	23.5 d	24.7 b	24.1 c	12.5 b	12.7 cd	12.7 b	13.7 bc	14.5 a	14.1 b
T5	$Ino_1+N_1+Ir_0$	23.0 de	21.7 cd	22.3 d	10.5 c	10.0 ef	10.2 d	11.7 de	12.0 b	11.8 de
T6	$Ino_1+N_1+Ir_1$	27.5 a	26.7 a	27.0 a	13.5 ab	14.5 ab	14.0 a	16.2 a	14.5 a	15.3 a
T7	N_1+Ir_0	22.7 de	22.5 cd	22.6 d	9.6 cd	10.0 ef	9.8 d	11.2 ef	11.5 bc	11.3 e
T8	N_1+Ir_1	25.5 b	24.7 b	25.0 b	12.5 b	13.0 bc	12.2 b	12.5 d	12.7 b	12.6 cd
T9	N_2+Ir_0	23.7 cd	22.7 c	23.2 cd	10.0 cd	10.5 e	10.2 d	11.5 def	11.2 bc	11.3 e
T10	N_2+Ir_1	27.2 a	26.5 a	26.5 a	14.0 a	14.0 abc	14.0 a	14.8 b	15.2 a	15.0 ab
T11	N_3+Ir_0	24.7 bc	23.0 c	23.5 c	10.5 c	10.7 e	10.5 d	11.0 ef	11.5 bc	11.2 ef
T12	N_3+Ir_1	27.5 a	27.7 a	27.6 a	13.0 ab	14.7 a	13.8 a	14.5 bc	15.0 a	14.7 ab
	Means	24.0 A	23.7 A		11.3 A	11.6 A		12.6 A	12.7 A	

*Difference indicated with same letter(s) are non-significant ($p<0.05$).

plant was increased by applications of inoculation and nitrogen fertilizers with irrigation supplies. Ammonium sulphate is water soluble or quick release nitrogen sources which was used in this experiment. Nitrogen becomes available as soon as water is applied to the chickpea. The high soil nitrogen levels from application of nitrogen fertilization and nitrogen fixation derivation from better nodulation cause excessive vegetative growth. Moreover, better availability of soil moisture and essential plant nutrients from organic and mineral sources resulted in better assimilation of photosyntheses and plant growth. All of these beneficial attributes might be effective on plant vegetative growth. Moreover, Bicer et al. (2004) reported that plant height was increased with irrigation application. Palled et al. (1985) reported that number of secondary branches per plant were increased due to irrigation. All of these inoculation and nitrogen fertilizers attributes might be affected on plant vegetative growth.

The number of pods per plant depends so much on the environment. According to Table 2, numbers of pod per plant were affected by all treatments significantly ($p<0.01$) and it was changed between 10.3 and 15.3 in average of two years results. The highest pods per plant (15.3 pod $plant^{-1}$) were determined from the combination of $Ino_1+N_1+Ir_1$ and the lowest one was obtained from the combination of $Ino_0+N_0+Ir_0$ (Table 2). Inoculated or nitrogen fertilized plots gave higher pods compared to no one amended plots. Moreover, inoculation and nitrogen fertilizer effects were superior with irrigated plots. Ullah et al. (2002) reported that irrigations had a significant effect on pods per plant. This may be inoculation was highly sensitive to soil moisture deficiency (Guerin et al., 1990; Pararjasingham and Knievel, 1990; Simpson and Daft, 1991). Parveen et al. (1999) reported rhizobium inoculation performance in pods number was better under normal than water stress. Deficient moisture in soil during the reproductive stage leads to flower abortion, poor pod set and formation of infertile pods in chickpea (Davies et al., 1999; Turner et al., 2001). Moreover, Nayvar et al., (2005) reported that the stressed plants of cultivated species in chickpea lost more number of flowers (62%) and pods (65%) when compared with the unstressed plants.

One of the yield components was number of seeds per plant relates closely that of pods per plant. In the present study, seeds per plant were changed 9.7 to 15.5 in average of two years. The highest number of seeds per plant was determined from the combination of $Ino_1+N_1+Ir_1$ or the combination of N_3+Ir_1. These two treatments had similar number of seeds per plant. The lowest number of seed per plant was determined from the combination of $Ino_0+N_0+Ir_0$ as 9.7 (Table 3). The combination of inoculation and nitrogen (20 kg N ha^{-1}) due to irrigation produced best results in number of seeds per plant. Equally, the combination of 60 kg N ha^{-1} with irrigation was superior applications on seeds per plant due to low soil nitrogen contents (Tables 3 and 1). In the current study, it was found that plant with higher pods resulted in higher seed per plant under better availability of soil moisture and nitrogen from nitrogen fixation and mineral sources. This was because of inoculation was highly sensitive to soil moisture deficiency (Guerin et al., 1990; Pararjasingham and Knievel, 1990; Simpson and Daft, 1991). Davies et al. (1999) and Turner et al. (2001)

Table 3. Mean and compared values of the different treatments of inoculation, nitrogen fertilizers and irrigation on the number of seed per plant (plant $^{-1}$) seed yield (kg ha^{-1}), protein ratio (%) in chickpea.

Treatment		Number of seed (Plant^{-1})			Seed yield (kg ha^{-1})			Protein ratio (%)		
		1999	2000	Means	1999	2000	Means	1999	2000	Means
T1	$Ino_0+N_0+Ir_0$	10.0 f *	9.5 f	9.7 g	530 h	452.5 f	534 h	19.0 d	19.0 f	19.0 d
T2	$Ino_0+N_0+Ir_1$	13.5 d	12.7 d	13.1 d	692 f	710.0 e	701 f	19.7 cd	19.7 ef	19.7 cd
T3	$Ino_1+N_0+Ir_0$	9.7 f	10.5 f	10.1 fg	605 g	695 e	650 g	19.0 d	19.7 ef	19.3 cd
T4	$Ino_1+N_0+Ir_1$	13.7 cd	14.2 cd	14.0 c	817 d	787 d	802 d	22.5 ab	21.2 cd	21.8 b
T5	$Ino_1+N_1+Ir_0$	11.2 e	11.0 e	11.1 e	740 e	710 e	726 ef	21.0 bc	19.2 ef	20.1 c
T6	$Ino_1+N_1+Ir_1$	16.2 a	15.5 a	15.5 a	1255 a	1335 a	1295 a	23.5 a	23.7 ab	23.6 a
T7	N_1+Ir_0	10.2 ef	11.0 e	10.5 ef	767 e	730d e	748 e	19.0 d	19.2 ef	19.1 cd
T8	N_1+Ir_1	13.0 d	12.5 cd	12.7 d	1000 c	900 c	950 c	22.0 ab	22.7 bc	22.3 b
T9	N_2+Ir_0	10.7 ef	10.5 ef	10.6 ef	840 d	745 de	792 d	20.0 cd	20.0 def	20.0 cd
T10	N_2+Ir_1	14.7 bc	15.2 ab	15.0 b	1125 b	1095 b	1110 b	23.2 a	23.2 ab	23.2 a
T11	N_3+Ir_0	10.5 ef	11.5 de	11.0 e	827 d	787 d	807 d	19.2 d	20.5 de	19.7 cd
T12	N_3+Ir_1	15.7 ab	15.2 ab	15.5 a	1292 a	1310 a	1301 a	23.0 a	24.0 a	23.5 a
	Means	12.4 A	12.4 A		868 A	855 A		20.9 A	21.0 A	

* Difference indicated with same letter(s) are non-significant ($p<0.05$).

reported deficient moisture in soil during the reproductive stage leads to impaired seed filling in chickpea. Biçer et al. (2004) reported that numbers of seed per plant were increased with irrigation application.

Seed yield (kg ha^{-1})

Twelve treatments of this study on seed yield of spring sown chickpea (*Cicer arietinum* L.) were significantly different ($p<0.01$) in both years (Table 3). The best effects were obtained on seed yield from the combination of N_3+Ir_1 and also from the combination of $Ino_1+N_1+Ir_1$ as 1301.0 and 1295.0 kg ha^{-1} respectively. Moreover, seed yield obtained from these two combinations were in same group as results of Duncan multiple comparison test. The lowest seed yield was determined from T1 treatment ($Ino_0+N_0+Ir_0$) as 534.0 kg ha^{-1}. This treatment was the number one (nitrogen, inoculation, irrigation) amended plots. These results indicated that inoculation or nitrogen fertilizer affects on spring sown chickpea significantly when plots were irrigated. Rhizobium inoculated or nitrogen fertilized plots without irrigation has small increases in seed yield as compared to results of no one (nitrogen, inoculation, irrigation) amended plots. Rainfall was low for achieving higher seed yield. Annual rainfall total was 322.8 mm in 1999 and 234.9 mm in 2000, moreover, during the course of experiment, from April to the end of July, total rainfall was 98.4 mm in 1999, 63.7 mm in 2000. Therefore, irrigated plots had higher seed yield compared to that of nonirrigated plots. It was concluded that N_3+Ir_1 and $Ino_1+N_1+Ir_1$ had 143 and 142% more seed yield than that of control treatment ($Ino_0+N_0+Ir_0$) respectively.

Seed yield had high depended upon plant height, secondary branches and pods per plant both under drought and normal field conditions (Parveen et al., 1999). Higher yield was determined from $Ino_1+N_1+Ir_1$ was a reflection of high N supply due to high nodulation, resulting in high nitrogen fixation. Sharma et al. (1989), and Khan et al. (1992) showed that inoculation with rhizobium strains resulted in a significant increase in grain yield. Other high yielding treatment (N_3+Ir_1) was a reflection of high supply nitrogen due to high nitrogen fertilization. This was because experimental soil has low nitrogen content. Saxena (1980) reported a positive response to nitrogen fertilization in soils with poor nodulation or low organic matter. It is concluded that seed yield obtained from the combination of inoculation and nitrogen (20 kgN ha^{-1}) and irrigation may be comparable to those of the combination of nitrogen (60 kg N ha^{-1}) and irrigation, because of these two treatments had similar seed yield. Therefore, the combination of inoculation and nitrogen (20 kgN ha^{-1}) and irrigation treatment can be use instead of the combination of nitrogen (60 kg N ha^{-1}) and irrigation in chickpea production for achieving higher seed yield in rainfed condition. Lower seed yield that obtained from the combination of no one amended (nitrogen, inoculation, irrigation) may be derived from poor nodulation, low soil nitrogen and moisture stress. Moreover, Parveen et al. (1999) reported that in winter growing season rhizobium inoculation enhanced yield under both normal and stressed conditions, but its performance was better under normal than under stress.

Protein ratio (%)

Chickpea (*Cicer arietinum* L.) is an annual grain legume that is used extensively for human foods, as the primary source of nitrogen for many cropping systems. The highest seed protein concentration was determined from T6 ($Ino_1+N_{1+}Ir_1$) treatment as 23.6% in average of two years results. Moreover, similar effects with T6 on protein ratio were obtained from T12 ($N_{3+}Ir_1$) and T10 ($N_{2+}Ir_1$). Treatment of T6 ($Ino_1+N_{1+}Ir_1$) was comparable to those of two treatments T12 and T10 ($N_{3+}Ir_1$ and $N_{2+}Ir_1$). The lowest protein ratio was determined from the combination of $Ino_0+N_0+Ir_0$ as 19% (Table 3). Moreover, $Ino_1+N_1+Ir_1$ N_3+Ir_1 and N_2+Ir_1 had 24.2, 23.6, 22.1% more protein than that of control ($Ino_0+N_0+Ir_0$) respectively. Rhizobium inoculated or nitrogen fertilized plots with irrigation increased seed protein ratio significantly as the results of no one amended plots. This significant increasing may be attributed to the fact that soil has small amount of nitrogen. According to Akçin and Işık (1995) nitrogen fertilization increased protein ratio.

Chickpea is a pulse crop thus it is rich in protein. Nitrogen occur primary in the plant as component of protein. Generally, the soil containing higher nitrogen increases seed protein ratios. Inoculation and nitrogen application which supplied together or separately to chickpea under irrigation increased seed protein contents in the present study. Moreover irrigated plots had high protein ratio. This may be attributed inorganic fertilizers needs water to be solved and this type inorganic fertilizer quick release nitrogen sources. Generally, nitrogen becomes available as soon as water is applied to crops. Kumpawat (1994) found out the effects of inoculation on seed protein content highly significant increase. Uptake of fertilizer N by plants depends on soil moisture (Nannipieri et al., 1990).

It can be concluded, inoculation practices were dwelled upon in developing country and organic agriculture system due to high nitrogen fertilizing takes more cost and contaminating nitrate to clear water. Therefore, the combination of inoculation, 20 kg N ha^{-1} application and irrigation (T6) would be applied to soil to improve spring sown chickpeas yield.

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