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INFLUENCES OF MICRO-NUTRIENTS (ZINC AND IRON) AND BIO-FERTILIZER ON YIELD AND YIELD COMPONENTS OF CHICKPEA (CICER ARIETINUM L.) CULTIVARS

SUMMARY

Nutrients deficiency in the soils is one of the key factors limiting pulses production in arid and semi-arid regions. Responses of chickpea (*Cicer arietinum*) cultivars (Jam from Kabuli type and Pirooz from Desi type) to Biosuper (The mixture of *Azospirillum*, *Azotobacter*, *Basillus subtilis* and *Pseudomonas fluorescens*) inoculation as bio-fertilizer and micro-nutrient (FeEDDHA and $ZnSO_4$) fertilization were studied under field condition. Result revealed that micro-nutrient application could significantly improve plant height, chlorophyll index, number of primary and secondary branches, plants fresh weight and biological yield. Positive effects of micro-nutrients application on morphological traits were more predominant than bio-fertilizer inoculation. Grain yield and yield components were notably affected by investigated treatments. Micro-nutrient and bio-fertilizer had significant positive effect on number of pods, seed number per plant, number of filled and empty pods, 100-grain weight and grain yield. Nevertheless the best result was achieved through $ZnSO_4$ application concomitant with bio-fertilizer inoculation. Future more results obtained from current study indicated that Kabuli type of chickpea was more responsive than Desi type against bio-fertilizer inoculation and micro-nutrients application. The results of the present study coincided with the conclusion that combined application of iron, zinc and bio-fertilizer can significantly improved chickpea yield in alkaline soils of semi-arid regions.

Keywords: chickpea, FeEDDHA, nutrients, semi arid region, $ZnSO_4$

INTRODUCTION

Chickpea (*Cicer arietinum*) is one of the most important cool-season legumes of the family Fabaceae which is grown in the semi arid and Mediterranean regions like as Turkey, Iran, India (FAO, 2003). Chickpea is one of the earliest cultivated crops and is considered as the third most consumed food legume (Saxena et al., 1996). Chickpea provides a high quality protein to the

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people in developing countries and it can play a key role to alleviate protein-energy malnutrition (Manjunatha, 2007). World population is growing rapidly and it has nearly doubled over the last century (UNFPA, 2008), on the other part progress in the pulse production is not sufficient to meet the requirements of an ever increasing market demand. Hence, it can bring a serious challenge on the food security, especially in the developing countries.

Chickpea production under semi arid conditions frequently is restricted via moisture scarcity and low nutrients availability in the soil (Kumar and Abbo, 2001). In order to achieve a reasonable grain yield in chickpea, supplying of micro and macro nutrients are essentials. Plants nutrition and agricultural resources management should be based on preservation of natural recourses and abstain from environmental degradation. Although micro-nutrients are required in very low amount for plants, but their positive effects on crop yield and nutritional quality are important (Singh et al., 2004). However the beneficial effect of micronutrients on chickpea only is attainable after adequate providing of macro-nutrients such as nitrogen, phosphorus and potassium (Barker and Pilbeam, 2007). In this context provide of macro-nutrients in environmentally friendly way could be a matter of great concern.

Bio-fertilizers refer to preparations containing living cells or efficient strains of symbiotic and non-symbiotic microorganisms. They are advantageous bacterial or fungal inoculants that facilitate uptake of nutrients by crop roots via their interactions in the rhizosphere when applied through seed or soil (Tilak et al., 2005). They could increase plant growth by various mechanisms such as fixation of atmospheric nitrogen, production of siderophores that chelate metal elements and make them available to the plant root, solubilization of minerals such as phosphorus, and synthesis of phytohormones (Glick, 1995). Microorganisms that are present in bio-fertilizers may indirectly improve plant growth through control of plant's pathogens. This could be achieved by different methods like as siderophores producing and making iron unavailable to pathogens, synthesize of anti-fungal metabolites, synthesize of fungal cell wall-lysing enzymes, or hydrogen cyanide, which inhibit the growth of fungal pathogens, successful competing with pathogens for nutrients or specific niches on the crop's root and inducing the systemic resistance (Glick, 1995; Bloemberg and Lugtenberg, 2001).

Iron is one the most essential micro-nutrient in plants and is a component of some antioxidant enzymes which are involved in the protection of chloroplasts from free radicals. Also, iron could be considered as a constituent of the heme group that is a precursor of chlorophyll (Marschner, 1995; Barker and Pilbeam, 2007). In the semiarid regions, calcium carbonate ($CaCO_3$) builds up in soils because of insufficient precipitation to wash or leach them, which in turn induce pH increase soil (Kumar and Abbo, 2001). In this high pH environment, Fe solubility is minimized. Iron fertilizers founded on FeEDDHA (iron ethylene diamine di-o-hydroxy phenyl acetic acid) chelates through gradual release of Fe for plants may be the most efficient in preventing and remedying iron deficiency in soil-grown plants (Troeh and Thompson, 2005).

Furthermore, zinc (Zn) is an important micro-nutrient for plant growth and development. The soil of dry regions is often poor in plant-available Zn (Waraich et al., 2011). Zinc is involved in a wide variety of metabolic processes, including carbohydrate, lipid, protein and nucleic acid synthesis and degradation. As well it can substantially improve seed germination and seedling vigour (Auld, 2001).

Although some researchers have separately studied various aspects of micro-nutrients and bio-fertilizers (Bloemberg and Lugtenberg, 2001; Singh et al., 2004; Tilak et al., 2005), the interaction of bio-fertilizer and micro-nutrient remain less understood. The objective of this research was to investigate the responses of chickpea cultivars to seed inoculation and foliar application of micro-nutrients (Fe and Zn) and bio-fertilizer.

MATERIAL AND METHODS

A field experiment was carried out to study the effect of bio-fertilizer and micro-nutrients (iron and zinc) application on yield and yield component of chickpea under irrigated conditions during 2010 growing season at experimental farm of the university of Tabriz. Experimental farm is situated at latitude of 38° 5′ N, a longitude of 46° 17′ E and an attitude of 1360 meters above mean sea level. Tabriz is located in North West of Iran and has a mean annual temperature of 13°C and annual rainfall of 271.3 mm. The total rainfall for during growing season was 85.5 mm. The field was ploughed once and harrowed twice during February to bring the soil to fine tillage. The soil samples were collected at random from the top 0–30 cm soil depth before sowing and soil properties are presented in Table 1.

Table 1. Physical and chemical properties of the soil of experimental area

Texture	Sandy-loam
Clay (%)	12
Silt (%)	21
Sand (%)	67
Available N (ppm)	1.214
Available P (ppm)	41.7
Available K (ppm)	540
Iron (ppm)	1.43
Zinc (ppm)	0.46
Organic carbon %	2.24
pH	7.78
EC (dS/m)	1.84

The experiment was laid out as factorial based on randomized block design with three replications. The experiment included three factors: bio-fertilizer (with two levels: control and Biosuper), micro-nutrient (with three levels: control, iron and zinc) and cultivar (with two levels: Pirouz as a Desi chickpea and Jam as a Kabuli chickpea). Kabuli is a large seeded white chickpea used in salad bars. Kabuli have a fragile, thin seed coat which requires careful handling. Desi is a small seeded chickpea which is split or ground into flour for use in a variety of ethnic foods. The seeds were sown in experimental plots of 3.0 m (length) × 4.0 m (width), with 8 rows 0.5 m apart from one another, with small terraces of 1.5 m in the interspaces to prevent contamination by surface run-off containing bacteria or fertilizer. The crop was given protective irrigations as and when required. Seven irrigations were given at an interval of 7 to 15 days up to the maturity stage. Irrigation scheduling was done using the daily water balance computed from rainfall and pan evaporation data. The seeds were sown in rows on April 14, 2010. Seeds were placed at 5 cm depth in each row. Two hand weeding were carried out during crop growth. Nitrogen fertilizer in the form of urea, was applied about 70 kg ha^{-1} in the line opened at 4 cm deep and about 5 cm away from the seed at 10 days after sowing as starter fertilizer.

Zinc and iron were given as seed and foliar application in the form of zinc sulphate and FeEDDHA (iron ethylene diamine di-o-hydroxy phenyl acetic acid) respectively. A day before sowing chickpea seeds were, initially, soaked in 1% FeEDDHA or zinc sulfate solutions for three hours and seeds were dried under shade and used for sowing. For foliar application leaves were sprayed separately with 5% FeEDDHA or zinc sulfate solutions during early bloom stage (R1). Bio-fertilizer was applied in form of seed inoculation with 1.5 liters of Biosuper (The mixture of *Azospirillum* and *Azotobacter* as free-living diazotrophic bacteria; *Basillus subtilis* and *Pseudomonas fluorescens* as crop root protective against parasitic fungi and phytophagous nematodes).

Some important triats including plant fresh weight, biological yield per plant, seed yield as well as harvest index were measured from a 2.0 m^2 harvest area from the central four rows of each plot when the crop reached physiological maturity. Ten plants from each treatment were selected at random in the harvested 2.0 m^2 sample and traits like as plant height (cm), canopy spread (cm), pods per plant, seeds per pod, seed number per plant, number of filled and unfilled pods, 100 seed weight (g), number of primary and secondary branches were measured. Chlorophyll index was measured on ten leaves of a plant at each plot, using a portable chlorophyll meter (SPAD) at full bloom stage (R2). Data were analyzed using ANOVA procedure with the statistical program SPSS 15.0 and Duncan's test applied for comparison of means.

RESULTS AND DISCUSSION

The main effects of micro-nutrients and bio-fertilizer inoculation were significant, and a significant variety × micro-nutrient interaction was obtained for chlorophyll index (Table 2). The highest chlorophyll index was recorded in plants that had been received Fe, as their chlorophyll index was 26 % higher over control. Inoculation with bio-fertilizer could also increase the chlorophyll index by 15 %. Evaluation of cultivars response to micro-nutrients utilization showed that application of Zn or Fe in cv. Jam caused a greater increase in chlorophyll index when compared with cv. Pirouz. However, the lowest chlorophyll index was recorded in cv. Pirouz under no-applied micro-nutrient condition (Figure 1 D).

Table 2. Effect of micro-nutrients and bio-fertilizer on some morphological traits of chickpea varieties

indicator	PH (cm)	CS (cm)	CHL	NPB per plant	NSB per plant	FW (kg ha^{-1})	BY (kg ha^{-1})
Varieties (V)							
Pirouz	21.51 b	9.90 b	52.64 a	5.48 b	10.52 b	2695 b	2238 b
Jam	31.81 a	14.47 a	59.21 a	8.05 a	15.63 a	40733 a	3662 a
	Micro-nutrient (M)						
Control	25.04 b	9.85 b	47.78 c	4.71 b	10.77 b	2758 c	2350 c
Fe	27.06 a	13.07 a	60.32 a	7.66 a	13.76 a	3506 ab	3096 b
Zn	27.92 a	13.65 a	55.74 ab	7.93 a	14.76 a	3888 a	3404 a
	Bio-fertilizer application (B)						
Non	26.12 a	1.86 b	50.35 b	5.77 a	12.54 a	3077 b	2495 b
With	27.20 a	2.79 a	57.81 a	5.19 a	13.65 a	3698 a	3405 a
Interactions	Significance level						
V × M	NS	NS	**	NS	NS	*	NS
V × B	NS	NS	NS	**	NS	**	**
M × B	*	NS	NS	NS	NS	NS	NS
V × M × B	*	NS	NS	*	NS	NS	NS

Notes. PH = plant height, CS = canopy spread, CHL = chlorophyll index, NPB = number of primary branches, NSB = number of secondary branches, FW = plants fresh weight, BY = biological yield per plant, V = variety, M = micro-nutrient and B = bio-fertilizer. Mean values of the same category followed by different letters are significant at $p \leq 0.05$ level.

In the case of plants fresh weight and biological yield, results showed that the all investigated factors significantly affected these traits (Table 2). Plant fresh weight and biological yield in cv. Jam significantly were higher than cv. Pirouz. Furthermore, micro-nutrient application in cv. Jam induced a greater increase of plant fresh weight in comparison with cv. Pirouz (Figure 1 C). Bio-fertilizer consumption could considerably increase both fresh weight and biological yield in Desi and Kabuli types of chickpea (Figures 2 D and 2 E). However this increase was more prominent in cv. Jam.

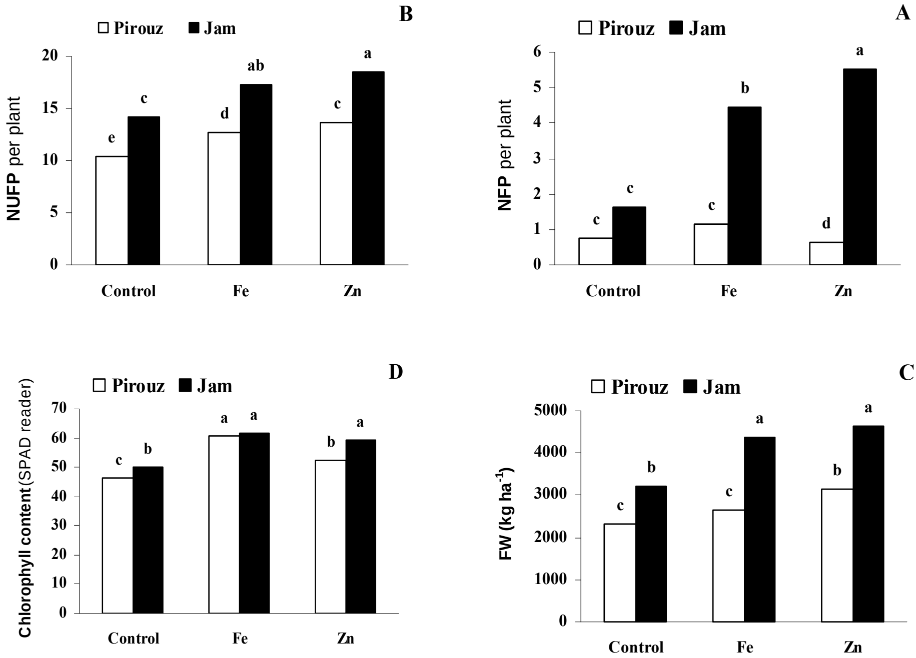

Figure 1. Effect of micro nutrient (Zn and Fe) application on number of filled pods (NFP) (A), number of unfilled pods (NUFP) (B), plant fresh weight (FW) (C) and chlorophyll index (D) of Desi (Pirouz) and Kabuli (Jam) chickpea cultivars. Values with the same letter were not significantly different

Number of primary and secondary branches per plant increased with application of the both type of micro-nutrient fertilizers (Table 1). Number of the both primary and secondary branches in Kabuli chickpea significantly was higher than Desi type. Although the micro-nutrients fertilizer increased the number of primary branches in both cultivars, bio-fertilizer inoculation accompanied with micro-nutrient utilization could significantly increase its positive effects, particularly in Kabuli type of chickpea (Figure 3 B).

Results showed that application of Zn and Fe has significant effect on plant height, so that the lowest height was recorded for control plants (Table 2). The maximum height was observed in cv. Jam and the average height of Desi cultivar was 32.5 % less than Kabuli cultivar. Inoculation with Biosuper showed no effects on this trait. A similar state was confirmed by examining the spread of the canopy. Evaluation plant height under different micro-nutrients application and bio-fertilizer inoculation in different cultivars showed that the highest plants were obtained from cv. Jam with micro-nutrients application. Conversely the smallest plants produced by cv. Pirouz without fertilizer application (Figure 3 C).

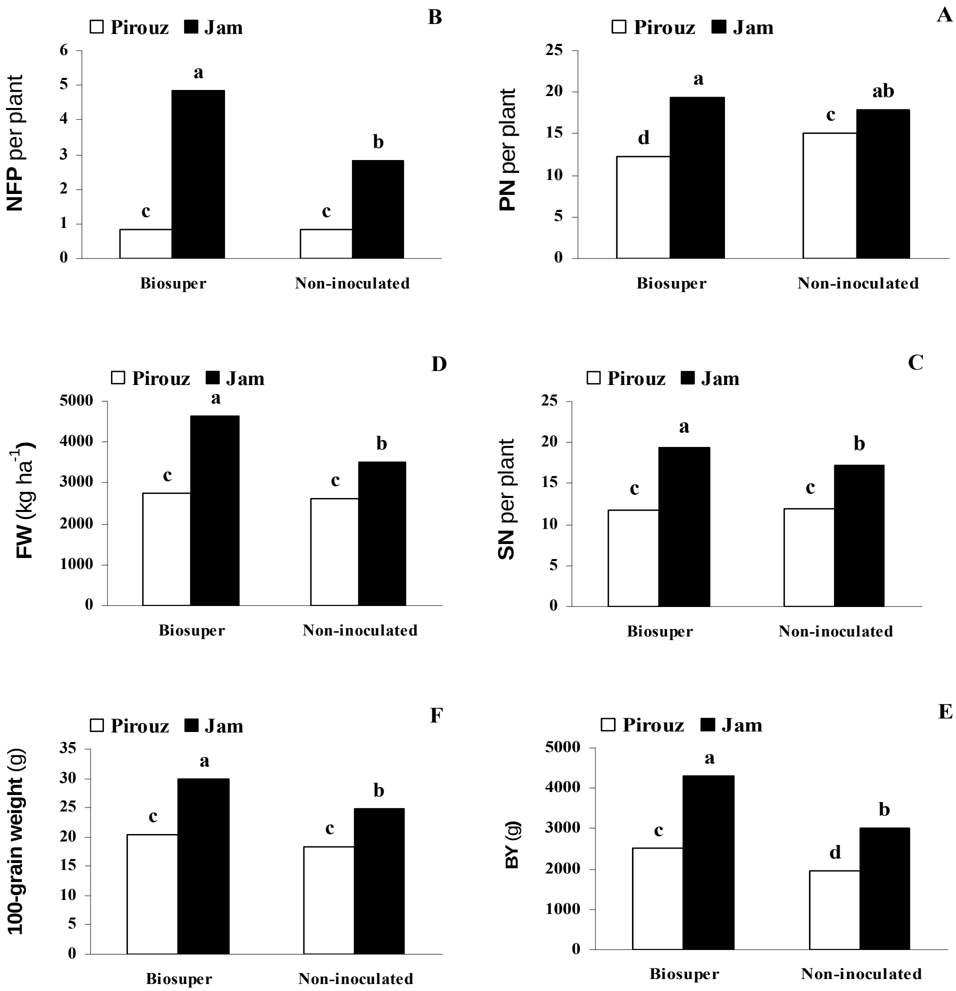

Figure 2. Effect of Biosuper inoculation on pod number (A), number of filled pods (B), seed number per plant (C), plant fresh weight (D), biological yield (E) and 100-grain weight (F) of Desi (Pirouz) and Kabuli (Jam) chickpea cultivars. Values with the same letter were not significantly different

Micro-nutrient and cultivar had significant effect on number of pods per plant. However bio-fertilizer consumption could not affect this yield component (Table 3). Pod number in cv. Jam was about 21.54 % higher over the cv. Pirouz. Application of zinc and iron in comparison with control could increase pod number about 25 % and 12%, respectively. Analysis of variance showed that interaction of Biosuper inoculation and cultivar has significant effect on pod number per plant, so that the largest number was obtained in cv. Jam by bio-fertilizer inoculation, whereas the lowest number of pods was recorded in inoculated plants of cv. Pirouz (Figure 2 A).

Result revealed that the seed number per plant increased by application of micro-nutrient fertilizer. Comparison of means showed that seed number in plants which had received iron and zinc fertilizer respectively was 16 % and 24 % higher over the control (Table 3). Investigation of interaction of cultivar by bio-fertilizer indicated that the maximum seed number was produced in inoculated plants of cv. Jam, whereas the lowest seed number recorded in non-inoculated or inoculated plants of cv. Pirouz (Figure 2 C). The data regarding number of filled pods (NFP), number of unfilled pods (NUFP) and number of empty pods (NEP) showed significant effects of micro-nutrient and bio-fertilizer inoculation (Table 3).

Table 3. Effect of micro-nutrients and bio-fertilizer on yield components of chickpea varieties

indicator	PN per plant	SN per plant	NFP	NUFP	NEP	100-GW (g)	GY (kg ha^{-1})
Pirouz	14.64 b	12.81 b	0.846 b	13.55 a	4.89 a	19.46 b	937.12 b
Jam	18.41 a	19.28 a	3.85 a	10.49 b	5.26 a	27.81 a	1397.41 a
	Micro-nutrient						
control	14.01 c	14.19 b	1.06 c	12.16 c	3.10 c	22.11 b	881.62 c
Fe	16.55 ab	16.47 a	2.87 ab	14.23 ab	5.85 b	23.76 ab	1213.54 b
Zn	17.52 a	17.47 a	3.29 a	15.69 a	6.91 a	25.03 a	1407.45 a
	Bio-fertilizer application						
non	15.83 a	15.60 ab	1.86 b	13.07 b	4.41 b	23.10 a	994.30 b
with	16.22 a	16.48 a	2.79 a	15.24 a	5.91 a	27.07 a	1340.76 a
interactions	Significance level						
V × M	NS	NS	**	*	NS	NS	**
V × B	**	**	**	NS	NS	*	*
M × B	NS	NS	NS	NS	**	NS	**
V × M × B	NS	NS	NS	NS	NS	NS	**

Notes. PN = pod number, SN = seed number, NFP = number of filled pod (with two seeds per pod) per plant, NUFP = number of unfilled pod (with one seeds per pod) per plant, NEP = number of empty pod per plant, 100-GW = 100-grain weight, GY = grain yield, V = variety, M = micro-nutrient, B = bio-fertilizer. Mean values of the same category followed by different letters are significant at $p \leq 0.05$ level.

In addition, the effect of cultivar was significant on NFP and NUFP, so in cv. Pirouz proportion of unfilled pods notably was higher than cv. Jam. Only 7% of total produced pods in cv. Pirouz were entirely filled. Micro-nutrient fertilizers increased the total number of pods per plant and consequently NFP, NUFP and NEP were increased. However, the effect of Zn was more noticeable than Fe on these components, especially in cv. Jam (Figures 1 A and 1 B). On the other hand, bio-fertilizer inoculation could appreciably increase NFP in cv. Jam (Figure 1 B). However, bio-fertilizer inoculation under Fe applied and micro-nutrient free conditions significantly enhanced proportion of empty pods number per plant (Figure 4).

100-grain weight was affected by micro-nutrient and chickpea type (Table 3). Although application of Zn and Fe fertilizers increased the weight of 100 grains in both type of chickpea, bio-fertilizer inoculation only could increase this trait in cv. Jam (Figure 2 F). Data presented in Table 2 revealed that all three studied experimental factors (cultivars, micro-nutrient and bio-fertilizer) had significant effects on grain yield. Application of Fe and Zn increased grain yield by 37.68% and 59.59% respectively, compared to the control plants. Furthermore, grain yield of inoculated plants was 35% higher than non-inoculated plants. Evaluating the cultivar ×micro-nutrient × bio-fertilizer interaction revealed that the highest grain yield was produced by Zn and Biosupe application in plants of cv. Jam, whereas the lowest grain yield was recorded in non-inoculated plants of cv. Pirouz under micro-nutrients free conditions (Figure 3 C). Generally it seems that cv. Jam is more responsible than cv. Pirouz against the use of the micro-nutrients and bio-fertilizer.

In neutral to alkaline soils of semi arid region (where chickpea is usually grown), Zn and Fe deficiencies can be encountered. Sustaining soil fertility and utilization of plant nutrient in sufficient and reasonable amount is one of important components to improve crop yield (Caliskan et al., 2008). Application of both micro-nutrients significantly improves morphological traits in both types of chickpea when compared with control condition, though the Kabuli type was more affected than Desi type. The similar status was evident for yield and yield components. However, few numbers of morphological traits had been influenced by bio-fertilizer whereas yield components were considerably responsive against to Biosuper inoculation.

Pre-sowing seed treatments, which during those seeds hydration are done outside of field and under control condition, can accelerate seed germination, improve the seedling establishment and increase water and nutrients absorption by roots (Anuradha and Rao, 2007). In current experiment micro-nutrients has been applied on both seed and leaves. Hence, it possible that some beneficial effects of micro-nutrients application on growth and yield may be caused from seeds priming influence on early vegetative growth.

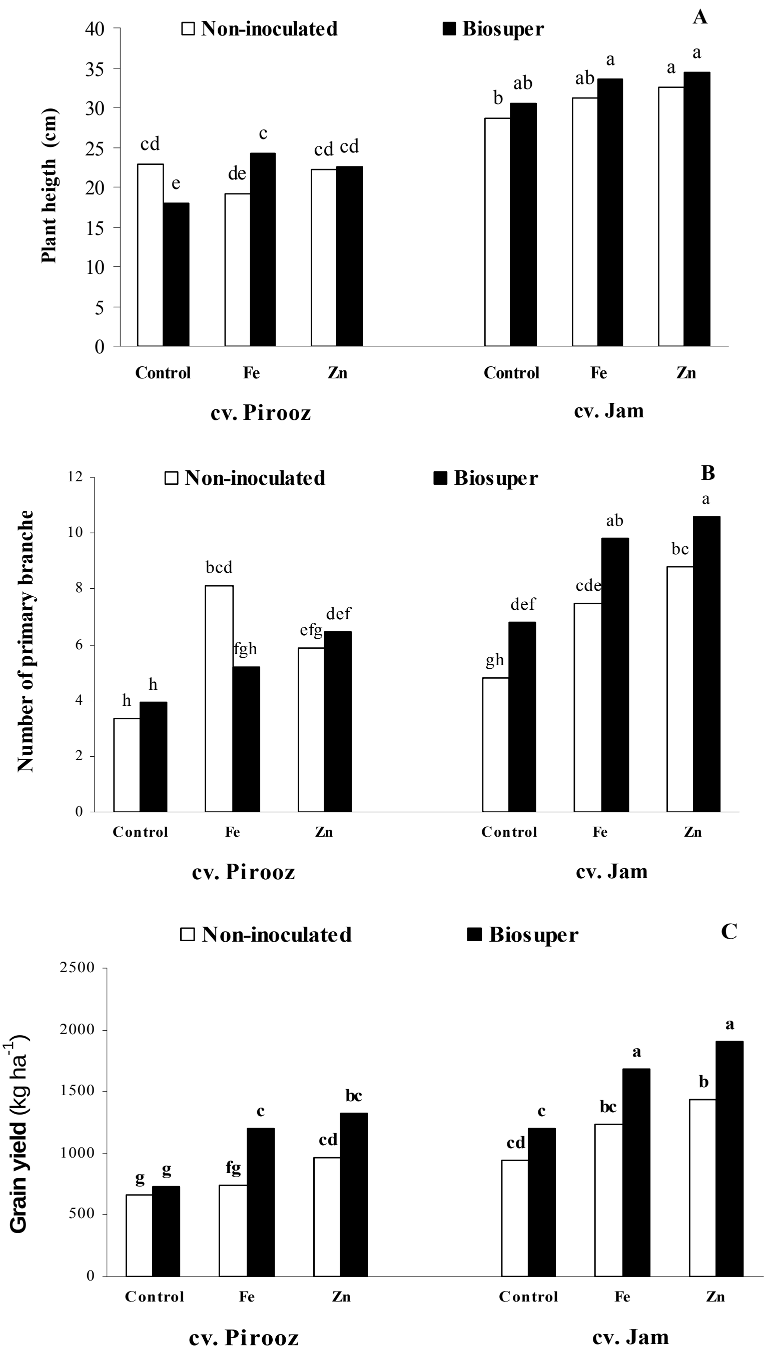

Figure 3. Effect of micro nutrient (Zn and Fe) application under Biosuper inoculation and non-inoculation on plant height (A), number of primary braches (B) and grain yield (C) in Desi (Pirouz) and Kabuli (Jam) chickpea cultivars. Values with the same letter were not significantly different

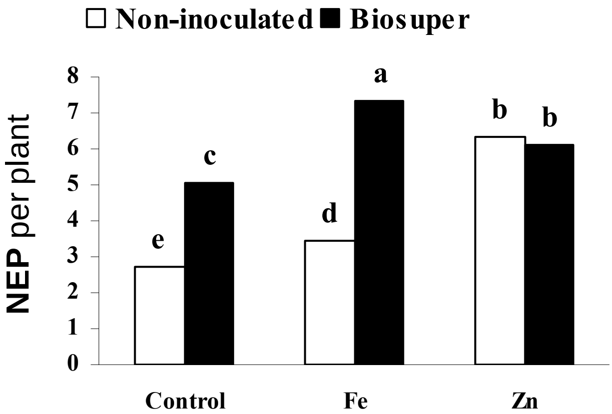

Figure 4. Effect of micro nutrient (Zn and Fe) application under Biosuper inoculation and non-inoculation on number of empty pods. Values with the same letter were not significantly different

Much research regarding the application of micro-nutrients has been recently done on the invigoration of seeds to increase rate of germination, accelerate seedling emergence, and improve the uniformity of seedling growth in some field crops (Imran et al., 2008; Mirshekari et al., 2010). This case earlier has been reported by Arshad Ullah et al. (2002) on peela raya (*Brassica carianata* L.), Harris et al. (2007) on chickpea, and Johnson et al. (2005) on chickpea, lentil, rice and wheat.

The increase in growth and yield parameters of chickpea by Biosuper inoculation recorded here can be resulted from collaborative effects of *Azospirillum*, *Azotobacter*, *Basillus subtilis* and *Pseudomonas fluorescens*, such as increased supply of N and P to the crop aside from growth promoting substances generated by these organisms. Seed inoculation of maize with *Azospirillum* could increase root surface area and consequently increase absorption of N, P, K, other nutrients, and water and thereby improved above-ground biomass (Meshram and Shende, 1993). Seed inoculation by bio-fertilizer could induce and activate nitrogen-fixing symbiotic bacteria in roots of pulse crop and consequently higher rates of atmospheric nitrogen fixation can enhance vegetative growth and yield (El-Desuki et al., 2010).

Results obtained in this study were consistent with finding of Namvar and Seyd Sharify (2011) who reported that inoculation of chickpea seeds with mentioned bacterium could hasten plants growth and improve grain yield. Also Singh et al. (2004) reported that best growth and maximum nutritional quality of grain was observed with the combined application of all micronutrients (Fe, Zn and Mo) with *Rhizobium* inoculation.

Zinc and iron have imperative roles in normal growth. Zn is an important component of lots of enzymes and plays an important role in metabolism of nitrogen, synthesizing proteins, nucleic acids and precursor of auxin (Marschner, 1995). Also iron has an important role in the synthesis of chlorophyll and also helps in the absorption of other nutrients. It is a constituent of chlorophyll and it regulates respiration, photosynthesis, nitrogen fixation, reduction of nitrates and sulphates (Imsande, 1998). It seems that existence of nitrogen fixing bacteria along with micro-nutrients application due to more availability of nutrients and existence of *Pseudomonas fluorescens* and *Basillus subtilis* bacteria due to decrease of pathogens and stress factors, have increased fertile pod number and grain yield under bio-fertilizer inoculation conditions.

Our results are in line with findings of Rabieyan et al. (2011) who reported that both vegetative and grain yield of chickpea increased by application of nitrogen fertilizer and bio-fertilizer inoculation. Moreover, they reported that the response may be varied in different cultivars. In current experiment difference in response between the Kabuli and Desi chickpea may be resulted from the different appropriate micro-nutrient fertilizer rates to optimize yields according to chickpea type. The differential response between the two chickpea types is not surprising, especially considering the remarkable phenotypic and genotypic diversity (Muehlbauer 1987), together with noticeable differences in phenological development. However, study of a single Desi variety and a single Kabuli variety, cannot be enough to assume that all Desi or Kabuli chickpea varieties will respond in a dissimilar manner. Our findings about the response of different chickpea type to fertilizers was consistent with findings of Bonfil and Pinthus (1995) who reported that Desi chickpea (cv. Bulgarit) did not respond to nitrogen fertilizer.

CONCLUSIONS

These results elucidated that Kabuli chickpea is a highly responsive crop to micro-nutrient fertilizers in general and Zn and Fe in particular and their scarcities may be one of the major reason of poor yield under semi arid region due to high bicarbonate and pH in soils. Utilization of micro-nutrient fertilizers in the appropriated amount and time along with the application of bio-fertilizers can be considered as a reasonable solution to improve performance of chickpea under semi arid condition.

REFERENCES

Anuradha, S. & Rao, S. R. (2007): The effect of brassinosteroids on radish (*Raphanus sativus* L.) seedlings growing under cadmium stress. *Plant Soil and Environment.,* 53: 465-472.

Arshad Ullah, M. Sarfraz, M. & Sadiq, M. (2002): Effects of pre-sowing seed treatments with micronutrients on growth parameters of Raya. *Asian Journal of Plant Sciences*., 1: 22-25.

Auld, D. S. (2001): Zinc coordination sphere in biochemical zinc sites. *Biometals*. 14: 271-313.

Barker, A. V. & Pilbeam, D. J. (2007): *Handbook of Plant Nutrition* (eds.). – New York, USA, 613 pp.

Bloemberg, G. V. & Lugtenberg, B. J. (2001): Molecular basis of plant growth promotion and biocontrol by rhizobacteria. *Current Opinion in Plant Biology*., 4: 343-350.

Bonfil, D. J. & Pinthus, M. J. (1995): Response of chickpea to nitrogen, and a comparison of the factors affecting chickpea seed yield with those affecting wheat grain yield. *Journal of Experimental Agriculture*., 31: 39–47.

Caliskan, S. Ozkaya, I. & Caliskan, M. E. (2008): The effects of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in a Mediterranean-type soil. *Field Crops Research*., 108: 126-132.

El-Desuki, M. Hafez, M. & Mahmoud, A. R. (2010): Effect of organic and biofertilizer on the plant growth, green pod yield, quality of pea. *International Journal of Academic Research*., 2: 87-92.

FAO. (2002): *Production Year Book*, Food and Agriculture Organization of the United Nations (FAO). Rome, Italy, 377 pp.

Glick, B. R. (1995): The enhancement of plant growth by free-living bacteria. *Canadian Journal of Microbiology*., 41: 109-117.

Harris, D., Rashid, A. & Miraj, G. (2007): On-farm seed priming with zinc in chickpea and wheat in Pakistan. *Plant and Soil*., 306: 3-10.

Imran, M. Neumann, G. & Romheld, V. (2008): *Nutrient seed priming improves germination rate and seedling growth under submergence stress at low temperature*: Competition for Resources in a Changing World: New Drive for Rural Development. Hohenheim, Germany, pp. 181.

Imsande,J.(1998): Iron, sulfate and chlorophyll deficiencies: A need for an integrative approach in plant physiol. *Physiologia Plantarum*., 103:139-144.

Johnson, S. E. Lauren, J. G. Welch, R. M. (2005): A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicerarietinum*), lentil (*Lens culinaris*), rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Nepal. *Journal of Experimental Agriculture*., 41: 427-448.

Kumar, J. & Abbo, S. (2001): Genetics of flowering time in chickpea and its bearing on productivity in semiarid environ. *Advances in Agronomy*., 72: 107–138.

Manjunatha, B. L. (2007): Physiological basis of seed hardening in chickpea (*Cicer arietinum* L.). M.Sc. Agrculturei University of Agricultural Sciences. Dharwad, 2007, 94 pp.

Marschner, H. (1995): *Mineral Nutrition of Higher Plants*.London, 889 pp.

Meshram, S. U. & Shende, S. T. (1993): Total nitrogen uptake by maize with *Azotobacter* inoculation. *Plant and Soil*., 69: 275-280.

Mirshekari, B. Asadi Rahmani, H. & Mirmozaffari A. (2010): Effect of seed inoculation with *Azospirillum* strains and coating with microelements on seed yield and essence of cumin (*Cuminum cyminum* L.). *Iran Journal of Medicinal and Aromatic Plant*., 25: 470-481.

Muehlbauer, F. J. & Singh, K. B. (1987): *Genetics of chickpea* .M. C. Saxena, K. B. Singh (eds). The chickpea. Wallingford, UK, 99 pp.

Namvar, A. & Seyed Sharifi, R. (2011): Phonological and morphological response of chickpea (*Cicer arietinum* L.) to symbiotic and mineral nitrogen fertilization. *Žemdirbystė-Agriculture*., 98: 121-130.

Rabieyan, Z. Yarnia, M. & Kazemi-e-Arbat, H. (2011): Effects of biofertilizers on yield and yield components of chickpea (*Cicer arietinum* L.) under different irrigation levels. *Australian Journal of Basic and Applied Sciences.,* 5: 3139-3145.

Saxena, N. P. Saxena, M. C. & Johansen C. (1996): *Adaptation of chickpea in West Asia and North Africa region*. ICARDA. Aleppo, Syria, 263 pp.

Singh, M. Chaudhary, S. R. Sharma, S. R.(2004): Effect of some micronutrients on content and uptake by chickpea (*Cicer arletinum*). *Agricultural Science Digest*., 24: 268–270.

Tilak, K. Ranganayaki, N.& Pal, K. (2005): Diversity of plant growth and soil health supporting bacteria. *Current Sciences*., 98: 136-150.

Troeh, F. R. & Thompson, L. M. (2005): *Soils and Soil Fertility*, 6th ed. Ames, USA,293 pp.

UNFPA (2008): World population prospects: the 2006 revision and world urbanization prospects.. <http://esa.un.org/unpp>

Waraich, E. A. Ahmad, R. & Saifullah, A. (2011): Role of mineral nutrition in alleviation of drought stress in plants. *Australian Journal of Crop Sciences*., 5: 764-777.

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UTICAJ MIKRONUTRIJENATA (CINKA I GVOŽĐA) I BIOĐUBRIVA NA PRINOS I KOMPONENTE PRINOSA KULTIVARA SLANUTKA (CICER ARIETINUM L.)

SAŽETAK

Deficit nutrijenata u zemljištu jedan je od ključnih faktora koji ograničava proizvodnju mahunarki u aridnim i poluaridnim područjima. Proučavan je odgovor kultivara (Jam Kabuli tipa i Pirooz Desi tipa) slanutka na inokulaciju Biosuperom (mješavina *Azospirillum*, *Azotobacter*, *Basillus subtilis* i *Pseudomonas fluorescens*) kao biođubrivom i đubrenje mikronutrijentima (FeEDDHA i $ZnSO_4$) u terenskim uslovima. Rezultati su pokazali da je primjena mikronutrijenata mogla značajno povećati visinu biljke, indeks hlorofila, broj primarnih i sekundarnih grana, svježu masu biljke i biološki prinos. Pozitivni efekti primjene mikronutrijenata na morfološke karakteristike bile su dominantnije nego kod inokulacije biođubrivom. Ispitivani tretmani značajno su uticali na prinos zrna i komponente prinosa. Mikronutrijenti i biođubrivo imali su značajan pozitivan efekat na broj mahuna, broj sjemenki po biljci, broj punih i praznih mahuna, masu 100 zrna i prinos zrna. Ipak, najbolji rezultat ostvaren je primjenom $ZnSO_4$ uz istovremenu inokulaciju biođubrivom. Dalji rezultati dobijeni ovom studijom ukazuju da je Kabuli tip slanutka bio prijemčiviji za inokulaciju biođubrivom i primjenu mikronutrijenata nego Desi tip. Rezultati ove studije podudarili su se sa zaključkom da kombinovana primjena gvožđa, cinka i biođubriva može značajno poboljšati prinos slanutka u baznim zemljištima poluaridnih područja.

Ključne riječi: slanutak, FeEDDHA, nutrijenti, poluaridno područje, $ZnSO_4$