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The Effects of Bio, Mineral Nitrogen Fertilization and Foliar Zinc Spraying on Yield and Yield Components of Faba Bean

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Abstract: To study the effects of biological and mineral nitrogen fertilization and foliar zinc spraying on yield and yield components of faba bean, an experimental research in split plot format based on randomized complete block designed by three replications in Astaneh Ashrafiyeh Town (north of Iran) during 2010 was conducted. This consisted of 6 nitrogen fertilization levels as main plots (n_1: control, n_2: 30 kg/ha pure nitrogen, n_3: 60 kg/ha pure nitrogen, n_4: nitroxin inoculation, n_5: 15 kg/ha pure nitrogen + nitroxin inoculation, n_6: 30 kg/ha pure nitrogen + nitroxin inoculation) and 3 levels of foliar zinc spraying as sub-plots (z_1: control, z_2: 0.5 g/L, z_3: 1 g/L). During maturation; seed yield, straw yield, biological yield, harvest index, plant height, 100 seed weight, number of pods per plant and number of seeds per pod were measured. The results of the study showed that the effects of nitrogen fertilization and foliar zinc spraying on all studied traits were significant *($p<0.01$)*. On the other hand, there was a strong relationship among them and the yield indicators such as the straw yield, biological yield, harvest index, 100 seed weight, number of pods per plant and number of seed per pod *($p<0.01$)* and that them and the seed yield and plant height *($p<0.05$)*.

Key words: Faba bean · Nitrogen · Zinc · Iran

INTRODUCTION

Legumes are the major direct source of proteins for both man and livestock, especially in poor countries, where animal protein is expensive [1]. Faba bean (*Vicia faba* L.) is one of the major winter sown legume crops grown in the Mediterranean region and has considerable importance as a low cost food rich in proteins and carbohydrates [2]. Nitrogen (N) is required by plants in comparatively larger amounts than other elements [3]. Deficiency of N generally results in a stunted growth and chlorotic leaves caused by poor assimilate formation that leads to premature flowering and shortening of the growth cycle. The presence of N in excess promotes development of the above ground organs with abundant dark green (high chlorophyll) tissues of soft consistency and relatively poor root growth. This increases the risk of lodging and reduces the plants resistance to harsh climatic conditions and to foliar diseases [4]. N fertilizer use has played a significant role in increase of crop yield [5]. Daur *et al.* studying effects of different levels of nitrogen on dry matter and grain yield of faba bean reported that grain yield and shoot dry weight indicated significant quadratic relation with the increasing N rates between 0 and 200 kg/ ha [6]. Excessive application of chemical nitrogen fertilizers could result in a high soil nitrate concentration after crop harvest [7-9]. This situation can lead to an increase in the level of nitrate contamination of potable water, because nitrate remaining in the soil profile may leach to groundwater [10]. The best way to solve these problems is usage of biological nitrogen fixation. The utilization of biological nitrogen fixation method could decrease the use of the chemical nitrogen fertilizer (urea), prevent the depletion of soil organic matter and reduce environmental pollution to a considerable extent [11]. Several bacteria that are associated with the roots of crop plants could induce beneficial effects on their hosts and often are collectively referred to PGPR (Plant Growth Promoting Rhizobacteria) [21]. The biological fixation of the nitrogen produced by these organisms could constitute a significant and ecologically favorable cotribution to soil fertility [13]. Nitroxin is a biologic nitrogen fertilizer that containing *Azospirillum* and *Azotobacter*. *Azospirillum* belongs to family *Spirilaceae*, heterotrophic and associative in nature. In addition to their nitrogen fixing ability of about 20-40 kg/ha, they also produce growth regulating substances [14]. Although there are many species under

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the genus as *A. amazonense, A. halopraeferens, A. brasilense*, however, worldwide distribution and benefits of inoculation have been mainly proved by the *A. lipoferum, A. brasilense, Azotobacter* belonging to *Azotobacteriaceae* family, aerobic, free living and heterotrophic in nature. Azotobacters are present in neutral or alkaline soils and *A. chroococcum* is the most commonly occurring species in arable soils. *A. vinelandii, A. beijerinckii, A. insignis and A. macrocytogenes* are other reported species. The number of *Azotobacter* rarely exceeds of 10^4 to 10^5 g^{-1} of soil due to lack of organic matter and presence of antagonistic microorganisms in soil [15]. A bacterium produces anti-fungal antibiotics which inhibit the growth of several pathogenic fungi at the root zone, thereby, preventing seedling mortality to a certain extent [16]. Although micronutrients are required in small quantities by plants, the deficiency of the one of them could have the profound effects and may cause to the deficiencies of the major elements [17]. As 70 years ago, zinc was recognized as an essential micronutrient [18] and its deficiency in agricultural crops is one of the most common micronutrient deficiencies [19]. Zinc deficient soils have been widely found in India, USA, Canada, New Zealand, Africa, Europe and South America [20]. On the other hand, World Health Organization (WHO) reported that human population of developing countries faced with the deficiencies of zinc. Zn deficiency of human is the fifth major cause of diseases and deaths in these countries [21]. Plants usually absorb water and nutrients by their roots, therefore, fertilizers are traditionally applied into the soil [22]. While soil application can supply enough nutrients to improve plant production, it also causes world-wild anxiety about environmental contamination for nutrients leaching into ground water [23]. In recent years, increasing public concern and excessive nutrient loss from agricultural land have considerably encouraged the researchers to find more efficient ways to apply fertilizers [26]. The power of plant leaves absorbing the nutrient components has resulted in the fact that the foliar application of the nutrients becomes a recurrent method for the supplying nutrients to plants [25]. Therefore, foliar fertilization has the advantage of low application rates, the uniform distribution of fertilizer materials and the quick responses to applied nutrients. Moreover, hidden hungers can be easily managed [26]. Mahady (1990) found that foliar application of $ZnSO_4$ for faba bean plants increased the number of pods/plant and seed yield [27]. Ali and Mowafy (2003) also reported that application of foliar spray with Zn (2%) slightly improved groundnut yield and it's attributed as well as quality [28]. Thalooth *et al.* (2005) found that foliar spraying with Zn had a positive effect on yield and yield attributes of sunflower plants [29]. The aim of the study is to investigate the influences of foliar zinc application and the different bio, mineral nitrogen fertilization levels on yield and the yield components of faba bean.

MATERIALS AND METHODS

In order to study the effects of the biological and mineral nitrogen fertilization and foliar zinc spraying on yield and yield components of faba bean, during 2010 years, an experimental research in split plot format based on randomized complete block design (RCBD) with three replicates was done in Astaneh Ashrafiyeh Town located in 37°16' N latitude and 49°56' E longitude in the north of Iran. The climate of the area is mild as that of Mediterranean. Soil analyses results were showed in Table 1. The soil texture was sandy loam and pH 6.8. The experimental research was carried out by applying the six nitrogen fertilization levels as the main plots consisting of (n_1: control, n_2: 30 kg/ha pure nitrogen, n_3: 60 kg/ha pure nitrogen, n_4: nitroxin inoculation, n_5: 15 kg/ha pure nitrogen + nitroxin inoculation, n_6: 30 kg/ha pure nitrogen + nitroxin inoculation) and three levels of foliar zinc spraying as sub plots (z_1: control, z_2: 0.5 g/L, z_3: 1 g/L). For supplying pure nitrogen used from source of urea chemical fertilizer (46% pure N). For zinc spraying was used of zinc chelate (EDTA). Foliar application with zinc was carried out twice at vegetative stage (30 days after sowing) and blooming period. Inoculation seeds with nitroxin biofertilizer in a dish contain water and nitroxin bio-fertilizer before cultivation to main field was carried out. Seeds of faba bean were planted on 25 November.

Table 1: The results of soil analysis at the experimental sites

Depth (cm)	0-30	Soil texture	Sandy loam
Organic carbon %	3.2	pH	6.8
Clay (%)	14.7	Total nitrogen (%)	0.196
Silt (%)	25.3	Available P (mg/kg)	14.7
Sand (%)	60	Available K (mg/kg)	286
EC (ds/m)	1.073	Available Zn (mg/kg)	0.72

Plant spacing of 20×40 cm was used and seeds were planted in depth of 4-5 cm. The normal agricultural practices required for control of weeds and pests were applied as commonly followed in the farm. In maturity time, Seed yield, straw yield, biological yield, harvest index, plant height, 100 seed weight, number of pods per plant and number of seeds per pod were measured. The yield and yield components were analyzed by using MSTATC software. The Duncan's multiple range tests was used to compare the means at 5% of significant.

RESULTS AND DISCUSSION

Effect of Nitrogen Fertilization: Results of variance analysis show that, the effect of nitrogen fertilization on all studied traits had significant differences in 1% probability level (Table 2). Comparison of mean between nitrogen fertilization levels show that (Table 3), the highest grain yield with 5369 kg/ha, plant height with 140.1 cm, harvest index with 34.45%, 100 seed weight with 254.4 g, number of pods per plant with 19.33 and number of seeds per pod with 6.65 was obtained by n_6 treatment (30 kg/ha pure nitrogen + nitroxin inoculation). The lowest grain yield, plant height, harvest index, 100 seed weight, number of pods per plant and number of seeds per plant was found from n_1 treatment (without nitrogen fertilizer + without nitroxin inoculation) respectively with 2729 kg/ha, 120.7 cm, 26.13%, 227.7 g, 10.93 pods and 4.42 seeds. The maximum straw yield with 10520 kg/ha and biological yield with 15670kg/ha was obtained by n_3 treatment (60 kg/ha pure nitrogen). On the other hand, the lowest amounts of these traits were found as n_1 (without nitrogen fertilizer + without nitroxin inoculation) treatment with 7682 kg/ha straw and 10410 kg/ha biological yield, respectively. Similar results were reported by EL-Habbak and Naggar (1993), Pizto *et al.* (1991), Salah *et al.* (2000) and Soheir (2001) [30-33].

Effect of Foliar Zinc Spraying: The effects of foliar zinc spraying on all measured traits had significant differences ($p<0.01$) in Table 2. The comparisons of the means among fertilization levels with zinc showed that an increasing of zinc spraying rate caused to the increases of all studied traits (Table 3). The highest grain yield, straw yield, biological yield, harvest index, plant height, 100 seed weight, the number of pods per plant and the number of seeds per pod with 4535 kg/ha, 9843 kg/ha, 14380 kg/ha, 31.23%, 133.4 cm, 247.7 g, 18.19 pods and 6.09 seeds, respectively, was obtained from z_3 level (1 g/L foliar zinc spraying). On the other hand, the lowest grain yield with 3837 kg/ha, straw yield with 9132 kg/ha, biological yield with 12970 kg/ha, harvest index with 29.13%, plant height with 128.1 cm, 100 seed weight with 238.9 g, the number of pods per plant with 14.56 and the number of seeds per pod with 4.70 were found at z_1 treatment level (without zinc spraying). The similar results were reported by El-Gizawy and Mehasen (2009), EL- Fouly *et al.* (2010), EL-Masri *et al.*(2002), Rashed and Ahmed (1997), Rizk and Abdo (2001), [34-38].

Interaction Effect: The results of the study also showed that nitrogen fertilization and foliar zinc spraying had the interaction effects on straw yield, biological yield, harvest index, 100 seed weight, the number of pods per plant and the number of seeds per pod had significant differences at 1% probability level. On the other hand, that on grain yield and plant height was significant at 5% probability level (Table 2). The comparisons of the means among the interaction effect treatment showed that the highest grain yield with 5658 kg/ha, harvest index with 35.16%, plant height with 143.3 cm, 100 seed weight with 256.8 g, the number of pods per plant with 21.30, the number of seeds per pod with 7.96 were obtained from n_6z_3 treatment (30 kg/ha pure nitrogen + nitroxin inoculation along with 1 g/L zinc foliar spraying) (Table 4). In contrary of this, thelowest grain yield, harvest index, plant height, 100 seed weight, the number of pods per plant and the number of seed per pod with 2368 kg/ha, 24.76%, 118 cm, 216.3 g, 6.91 pods and 3.97 seeds, respectively, were obtained from n_1z_1 treatment levels (no nitrogen fertilizer, no nitroxin

Table 2: Analysis of variance related to the traits of faba bean under different levels of bio, mineral nitrogen fertilization and foliar zinc spraying

Source of variance	df	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Plant height (cm)	100 seed weight (g)	No.of pods per plant	No.of seeds per pod
				MS					
Nitrogen fertilization (N)	5	9185127.289**	11723515.322**	40262815.778**	81.076**	428.503**	862.565**	96.046**	5.630**
Error (N)	10	30039.611	32445.011	66178.678	0.977	4.818	5.114	1.995	0.094
Foliar zinc spraying (Z)	2	2206940.056**	2284772.167**	8928890.722**	20.943**	125.608**	349.387**	59.088**	8.953**
N×Z	10	20710.211*	69428.322**	85063.567**	1.128**	4.155*	28.293**	3.467**	0.237**
Error (Z)	24	8672.352	9592.019	18981.426	0.309	1.739	7.538	0.377	0.072

Ns, ** and * respectively: non significant, significant in 1% and 5% area

Table 3: Comparison of the mean of the effects of bio, mineral nitrogen fertilization and foliar zinc spraying

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Plant height (cm)	100 seed weight (g)	No.of pods per plant	No.of seeds per pod
Nitrogen fertilization								
Control	2729 f	7682 e	10410 d	26.13 e	120.7 e	227.7 f	10.93 d	4.42 e
30 kg/ha nitrogen	4121 d	10040 bc	14160 b	29.04 d	131 c	242.5 d	17 b	5.06 cd
60 kg/ha nitrogen	5154 b	10520 a	15670 a	32.86 b	136 b	251.4 b	19.19 a	5.79 b
Nitroxin inoculation	3420 e	8422 d	11840 c	28.82 d	126 d	238 e	14.12 c	4.81 d
15 kg/ha nitrogen+ nitroxin inoculation	4418 c	9967 c	14380 b	30.67 c	130.4 c	247.2 c	17.61 b	5.20 c
30 kg/ha nitrogen+ nitroxin inoculation	5369 a	10210 b	15580 a	34.45 a	140.1 a	254.4 a	19.33 a	6.65 a
Foliar zinc spraying								
Control	3837 c	9132 c	12970 c	29.13 c	128.1 c	238.9 c	14.56 c	4.70 c
0.5 g/L	4234 b	9443 b	13680 b	30.63 b	130.6 b	243.9 b	16.34 b	5.18 b
1g/L	4535 a	9843 a	14380 a	31.23 a	133.4 a	247.7 a	18.19 a	6.09 a

Within each column, means followed by the same letter do not differ significantly at $P<0.05$

Table 4: the interaction effect of bio, mineral nitrogen fertilization and foliar zinc spraying on studied traits

Treatment	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Plant height (cm)	100 seed weight (g)	No.of pods per plant	No. of seeds per pod
n_1z_1	2368 L	7193 k	9561 n	24.76 i	118 j	216.3 j	6.91 j	3.97 h
n_1z_2	2762 k	7553 j	10310 m	26.75 h	120.6 i	231.6 i	11.64 i	4.32 gh
n_1z_3	3057 j	8299 h	11360 k	26.89 h	123.4 h	235 hi	14.23 h	4.97 def
n_2z_1	3608 i	9816 ef	13420 h	26.87 h	129.7 ef	239.2 gh	15.74 g	4.58 fg
n_2z_2	4232 g	10070 cd	14300 f	29.59 g	130.6 def	242.7 fg	17.01 f	4.97 def
n_2z_3	4521 f	10220 c	14740 e	30.67 ef	132.8 d	245.5 ef	18.25 bcde	5.62 c
n_3z_1	4805 e	10111 cd	14910 de	32.22 cd	131.9 de	248.3 cde	17.85 cdef	5.04 def
n_3z_2	5181 cd	10460 b	15640 c	33.11 bc	136.7 c	251.5 bcd	18.89 bc	5.61 c
n_3z_3	5475 b	11000 a	16470 a	33.24 b	139.4 b	254.4 ab	20.82 a	6.71 b
n_4z_1	3015 j	8075 i	11090 L	27.18 h	121.9 hi	235.6 hi	12.07 i	4.41 gh
n_4z_2	3453 i	8305 h	11760 j	29.36 g	127 g	236 hi	14.44 h	4.66 efg
n_4z_3	3793 h	8885 g	12680 i	29.92 fg	129.1 fg	242.3 fg	15.84 g	5.38 cd
n_5z_1	4083 g	9662 f	13750 g	29.68 g	128.8 fg	242.4 fg	17.14 ef	4.61 efg
n_5z_2	4467 f	10020 d	14480 f	30.83 ef	130.2 ef	246.8 def	17 f	5.10 de
n_5z_3	4704 e	10221 c	14930 de	31.50 de	132.2 de	252.5 abc	18.68 bcd	5.88 c
n_6z_1	5141 d	9940 de	15080 d	34.09 b	138.1 bc	251.8 abcd	17.67 def	5.58 c
n_6z_2	5308 c	10250 c	15560 c	34.12 b	138.7 bc	254.7 ab	19.03 b	6.40 b
n_6z_3	5658 a	10430 b	16090 b	35.16 a	143.3 a	256.8 a	21.30 a	7.96 a

Within each column, treatments that carry the same superscript letter are not significantly different at $P<0.05$

inoculation and no zinc spraying) (Table 4). The highest straw yield and biological yield were recorded by n_3z_3 treatment level (60 kg/ha pure nitrogen along with 1 g/L zinc foliar spraying) with 11000 kg/ha and 16470 kg/ha, respectively. However, the lowest straw yield with 7193 kg/ha and biological yield 9561 kg/ha were found at n_1z_1 treatment level (no nitrogen fertilizer, no nitroxin inoculation and no zinc spraying). Similar results were reported by EL-Habbasha *et al.* (2007), Mohammadian Roshan *et al. (2010),* Mokhtar Soheir (2001), Sakr *et al. (1996) and* Van Hoorn *et al.* (2001), [39-43].

CONCLUSION

As a whole, results of the present study suggested that foliar zinc spraying and bio, mineral nitrogen fertilization affect all the measured traits of faba bean. Among foliar zinc spraying levels, the treatment of 1g/L zinc spraying in all studied traits was superior. In the other hand, among nitrogen fertilization levels, the n6 treatment (30 kg/ha pure nitrogen + nitroxin inoculation) was recorded the highest grain yield, plant height, harvest index, 100 seed weight, number of pods per plant and number of seeds per pod. The obtained Results in this study suggested 1g/L foliar zinc spraying and 30 kg/ha pure nitrogen + nitroxin inoculation as the most suitable fertilizer management for faba bean grown under the region's conditions.

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