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Response of Faba Bean (*Vicia faba L.*) To Different Planting Densities and Bio-Mineral Fertilization Systems.

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Abstract: Two field experiments were conducted during two winter seasons (2010/2011 and 2011/2012) in the Experimental farm of Faculty of Agriculture, Cairo University, Giza, Egypt to study the response of faba bean to two planting densities (25 or 33 plants/m^2) and different fertilization systems (100% mineral NP normal levels i.e, 70% (NP)+ seed inoculation with *Rhyzobium leguminosarum*, 70% (NP)+ compost as an organic fertilizer and 70%(NP)+ seed inoculation + compost on growth and productivity of Giza 40 cultivar. Planting density, fertilization treatments and their interactions had a significant effect in all characters under study. Use of 25 plants/m^2 (105,000 plants/faddan) increased number of branches / plant, number of pods /plant, 100-seed weight, seed weight/plant, straw,seed yield/ faddan, nitrogen and protein percentage. Use of 70% NP + Rhizobium + compost resulted in significant increased in number of branches and pods / plant and hence seed yield/plant, per faddan, nitrogen and protein percentage. Planting 25 plants /m^2 with 70% NP+ Rhizobium + compost gave the highest number of branches / plant, number of pods/ plant, 100- seed weight and hence the straw and seed yields / fed. as well as recorded the highest average of nitrogen and protein percentage.

Key words: Faba bean · Planting densities · Bio-mineral fertilization

INTRODUCTION

Faba bean is an important legume crop contains a high protein content compared to other legumes amounting to 33 % [1]. Increasing faba bean production is one of the major targets of the agricultural policy. That target may be achieved through the use of high yielding varieties and adaption of the proper agronomic practices. Several studies have been paid regarding planting density and NP fertilization.

Faba bean is one of the major winter-sown legume crops and considerable importance as a low-cost food rich in proteins and carbohydrates [2]. Nitrogen is essential component of many compounds of plant, such as chlorophyll, nucleotides, protein, alkaloids, enzymes, hormones and vitamins [3].

Due to pollution caused by the excessive use of mineral fertilizer, biofertilization has been practiced in legume and non legume crops to minimize this adverse effect. Biofertilizers are products containing living cells of different types of micro organisms, which have an ability to convert nutritionally important elements from unavailable to available form through biological processes [4-6]. Claims are made that these products stimulate plant growth through an hormonal effect [5].

Antoun *et al*. [7] found that Rhizobia stimulate plant growth mainly by modifying root development, which, in turn improved macro and micronutrients and water uptake in the early stages of plant development. Moreover, Dileep Kumar [8], Dileep-Kumar *et al.* [9] *and* Talaat and Abdallah [6] reported that, the plant host organisms may be affected by one or more mechanisms such as nitrogen fixation, production of plant growth promoting substances, phytohormons, enhancing nutrient uptake and organic acids.

Concerning planting density, El-Metwally [10], El-Douby *et al*. [11], Metwally [12], Ashmawy *et al*. [13], Abdel-Aziz and Shalaby [14], Mokhtar [15] and El-Murshedy *et al*. [16], revealed that, the highest faba bean seed yields were obtained by using high planting density (33 plants /m^2). Irrespective of the decrease of number of pods/plant, number of branches/plant, number of seeds/ plant, 100-seeds weight and seed yield per plant.

Crop productivity can be increased by application of chemical, organic and biological fertilizers [17].

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The importance of legumes is that they can fix nitrogen in symbiotic association with rhizobia and so they increase the soil nitrogen content [18, 19]. Rugheim and Abdelgani [20] suggested the use of, microbial fertilization with compatible effective strains to compensate the chemicals fertilizers, to decrease the expenses of chemical fertilizers and to protect the environment from pollution hazards.

The objective of this study was to determine the effects of biological, organic and mineral nitrogen fertilization and plant densities on growth and productivity of faba bean cultivar (Giza 40).

MATERIALS AND METHODS

Two field experiments were carried out in the Experimental Farm of Faculty of Agric., Cairo University, at Giza, Egypt, during two winter seasons (2010/2011 and 2011/2012) to study the response of faba bean cultivar (Giza 40) to two planting densities and different fertilization treatment as follows.

Planting density of 25 plants/m^2 was obtained from seeding three seeds on one side of ridges in hills spaced 30 cm apart, the 33 plants/ m^2 was obtained by seeding two seeds on two sides of ridges in hill spaced 20 cm apart.

The Fertilizations Treatments Were as Follows: 100% NP as control (recommended doses), 70% NP+ seed inoculation with Rhizobium, 70% NP+ organic fertilizer (compost at rate of 4 ton /fad.) was soil incorporated before planting and 70% NP+ seed inoculation seeds with Rhizobium + organic fertilizer (compost).

Seed of faba bean cultivar namely Giza 40 was obtained from Agronomy Res. Institute Agric. Res. Centre, Ministry of Agric. Giza Egypt. The experimental soil was clay loam. Rhizobium seed inoculation was done by using effective Rhizobium leguminosarum which was provided from Dept. of Agric. Microbiol., Agric. Res. Center, Giza inoculation technique. The inoculants was (200 g./50 Kg. seeds) mixed with moistened seeds in presence of Arabic gum.

The recommended fertilizer treatment was as follows: nitrogen was applied at the rate of 15 kg.N/fad as ammonium sulphate (20.5%N), phosphorus was applied at the rate of 150 kg/fad. super phosphate (15.5% P_2O_5) and 50 kg/fad. potassium sulphate (48% K_2O). These additions were applied at time of planting.

Mechanical and chemical properties of the experimental soil sites in the two seasons are shown in Table (1).

The treatments were arranged in a split plot design with four replicates where planting densities were distributed in the main plots and fertilizers treatments were allocated in the sub-plots. The experimental unit consisted of five ridges four meter long and 60 cm apart (plot area = 12 m^2). Seeds were planted on 15 November in both seasons. All normal cultural practices were followed as usual at the recommended levels. The preceding crop was maize *(Zea mays*, *L.*) in both seasons.

At harvest, ten plants were randomly taken from sub plot to determine the plant height, number of branches/ plant, number of pods/plant, number of seeds/plant, 100-seed weight and seed yield/plant. Seed yield (ton/fad) was determined from the three middle ridges of each sub plot and calculated in ton /fed. Total nitrogen percentage (N%) in seeds was determined according to the modified Micro -keldahl method [21]. Crud protein content in seeds was determined by multiplying the nitrogen percentage by 6.25.

Data were statistically analyzed according to Snedecor and Cochran [22]. Combined analysis was done for the two growing seasons, which indicate that the results of the two seasons followed similar trend. For comparison between means, LSD test at 5% level was used [23].

Table 1: Soil mechanical and chemical analysis of upper 50 cm depth of the experimental soil sites in 2010/2011and 2011 /2012 seasons.

Mechanical analysis			Chemical analysis		
	2010	2011		2010	2011
Clay (%)	38.90	39.10	Available N (ppm)	25.39	29.71
Silt (%)	23.11	22.25	Available P (ppm)	6.70	8.20
Sand (%)	37.99	38.65	Available K (ppm)	297.3	256.7
Texture	Clay loam	Clay loam	pH	7.6	7.8
-------	-------	-------	Organic matter %	1.6	1.9
-------	-------	-------	Ec mmohs/cm 25^{o}C	0.97	0.86

RESULTS AND DISCUSSION

Effect of Planting Density: Data in Tables (2, 3, 4 and 5) indicated that, planting density had a significant effect on all characters under study as average of both seasons, the increase of planting density from 25 to 33 plant/ m^2 increased plant height while decreased number of branches /plant, number of pods / plant, number of seeds/plant, 100- seed weight, seed yield/plant, straw and seed yield/fad. This result may be due to, increasing planting density decreased dry matter due to increased inter and intra-plant competition for growth factors such as light, water and nutrients uptake.Similar results were obtained by Shams El-din [24], Mohamed [25] and Mokhtar [15].

Use of 25 plants /m^2 recorded the highest average of nitrogen and protein percentage compared with using of 33 plants/m^2.

Effect of Fertilization System: The results in Table 2, 3, 4 and 5 show that, fertilization treatments had a significant effect on all characters under study. The number of branches/plant, number of pods/plant, number of seeds/ plant, 100-seed weight, straw and seed yield/ fad were increased by using of 70% (NP)+ Rhizobium + Compost.This may be due to enhancement of plant growth as rhizobium might have had augmented plant growth by providing products of dinitrogen fixation, either by a direct bacterium-plant transport of fixed nitrogen or by a slow transfer due to a gradual death of

Table 2: Faba bean plant height and number of branches and pods/plant as influenced by planting density and fertilization systems (Average of the two seasons).

Planting density(A) / Fertilization systems (B)	Plant height (cm)			No. of branches / plant			No. of pods / plant		
	25 Plant/ m^2	33 Plant/ m^2	Mean(B)	25 Plant/m^2	33 Plant/ m^2	Mean (B)	25 Plant/ m^2	33 Plant/ m^2	Mean(B)
100% (NP)) Control	110.91	125.11	118.01	2.81	2.50	2.65	22.04	19.65	20.84
70% (NP)+ Rhizobium	129.32	137.73	133.52	4.28	3.95	4.11	23.71	23.51	24.61
70% (NP)+ Compost	107.71	109.52	108.61	3.91	3.36	3.63	29.32	20.11	19.71
70% (NP)+ Rhizobium+ Compost	135.93	139.44	137.68	5.53	4.01	4.77	26.62	25.81	26.21
Mean (A)	120.96	127.95		4.13	3.45		25.42	22.27	
L.S.D. 0.05	(A) = 3.11 (B) = 5.79 (AXB) = 11.36			(A) = 0.43 (B) = 1.20 (AXB)= 1.67			(A) = 0.07 (B) = 4.21 (AXB)= 5.62		

Table 3: Faba bean seed weight /plant and its components as influenced by planting density and fertilization systems (Average of the two seasons).

Planting density(A) / Fertilization systems (B)	No. of seeds/ plant			100-seed weight			Seed weight/plant (g)		
	25 plant/m^2	33 plant/m^2	Mean B	25 plant/ m^2	33 plant/ m^2	Mean B	25 plant/ m^2	33 plant/ m^2	Mean B
100% (NP) Control	72.11	69.20	70.65	79.92	68.47	73.19	49.31	42.55	45.93
70% (NP)+ Rhizobium	92.78	91.51	92.14	93.29	81.56	87.42	70.45	66.72	68.58
70% (NP)+ Compost	83.96	76.39	80.17	85.10	74.93	80.01	62.97	59.81	61.39
70% (NP) + Rhizobium + Compost	103.31	100.44	101.87	96.03	89.88	92.95	75.29	69.98	72.63
Mean (A)	88.04	84.38		88.08	78.71		64.50	59.76	
L.S.D. 0.05	(A) = 3.01 (B) =13.65 (AXB) = 19.13			(A) = 2.50 (B) = 6.11 (AXB)= 10.09			(A) = 4.43 (B) = 18.61 (AXB)= 23.18		

Table 4: Faba bean straw and seed yields/fad. as influenced by planting density and fertilization systems (Average of the two seasons).

Planting density(A) / Fertilization systems (B)	Straw yield (ton/fad.)			Seed yield (ton /fad.)		
	25plant/ m^2	33 plant/ m^2	Mean B	25plant/ m^2	33 plant/ m^2	Mean B
100% (NP) Control	1.81	1.80	1.81	1.54	1.01	1.27
70% (NP)+ Rhizobium	1.89	1.84	1.86	1.70	1.34	1.52
70% (NP)+ Compost	1.69	1.57	1.63	1.58	1.20	1.39
70% (NP)+ Rhizobium+ Compost	1.98	1.99	1.98	2.19	2.00	2.09
Mean (A)	1.84	1.80		1.75	1.38	
L.S.D. 0.05	(A) = 0.08 (B) =0.22 (AXB) = 0.13			(A) = 0.10 (B) = 0.24 (AXB)= 0.29		

Table 5: Faba bean nitrogen and protein percentage as influenced by planting density and fertilization systems (Average of the two seasons).

Planting density(A) / Fertilization systems (B)	Nitrogen (%)			Protein (%)		
	25plant/ m^2	33 plant/ m^2	Mean B	25plant/ m^2	33 plant/ m^2	Mean B
100% (NP)) Control	4.70	4.50	4.60	29.37	28.12	28.74
70% (NP)+ Rhizobium	4.52	4.36	4.44	28.25	27.25	27.75
70% (NP)+ Compost	4.23	3.99	4.11	26.43	24.93	25.68
70% (NP)+ Rhizobium+ Compost	4.93	4.89	4.91	30.81	30.56	30.68
Mean (A)	4.59	4.43		28.71	27.71	
L.S.D. 0.05	(A) = 0.20 (B) =0.82 (AXB) = 0.45			(A) = 0.89 (B) = 3.20 (AXB)= 3.52		

bacteria and hence the subsequent mineralization of insoluble nutrients particularly nitrogen, followed by an enhancement of uptake by plant a possible and production of plant growth regulators that stimulate plant growth [26, 7, 9, 6]. The possible more availability of phosphorus cannot be neglected in this respect.

EL-Habbasha *et al.* [27] found that, increasing phosphorous levels from zero to 45 Kg P_2O_5/fad. in combination with rhizobium, Nitrobein or rhizobium + Nitrobein significantly increased faba bean yield components and hence yield compared with control treatment. Also, El-Gizawy and Mehasen [28] reported that,adding 30 Kg.P_2O_5 mixed with phosphorus dissolving bacteria (PDB) increased faba bean plant height, number of branches and pods/plant, 100-seed weight, seed yield /plant, seed and straw yields /fad.

Data in Table (5) indicated that application of 70% NP with Rhizobium and compost resulted in considerable increase in nitrogen and protein percentage. The result obtained by Abd-Alla and Omar [29] cleared that, inoculation of Rhizobium increased crude protein content in faba bean seeds compared with un inoculated control plants. This finding prove the results by Lucas-Garcia *et al*. [30] and Rugheim and Abdelgani [20].

Effect of Interactions: The interaction between planting density and fertilization treatments had a significant effect on most traits under study. Use of 25 plants/m^2 and 70% NP+ Rhizobia + Compost recorded the highest average of number of seeds /plant, 100-seed weight, seed yield/plant, straw, seed yields /fad. nitrogen and protein percentage.

It can be concluded that the significant interaction effect between planting density and fertilization system, it was quite evident that the main effects of these factors played a complementally roles i.e. the decrease of planting density afforded faba bean plants a safe competition where the decrease of plant height (Table 2) provided plants with better light penetration. This in turn,might have had increase photosynthesis and made larger amounts of photosynthates available for more plant branching. These larger number of branches could set larger number of flowers which could set larger number of pods/plant (Table 2). The increase in number of pods/plant was not on the expense of the number of seeds/plant or on the expense of seed index when both were increased due to the use of the proper planting density (25 plants/m^2). These favorable effects were enhanced by the combination of mineral-organic-bio fertilization where the use of 70% of NP+ seed inoculation + compost played compensating roles for the decrease of the complete mineral fertilization possibly due to direct atmospheric nitrogen fixation and/or more availability of plant nutrients due to compost fertilization. The positive favorable interaction between the 25 plants/m^2 density and the mineral-organic and bio fertilizer treatments could be recommended in order to maximize the production of faba bean.

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