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Effect of different intercropping patterns and fertilizers on some growth characteristics of faba bean (*Vicia faba* L.)

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Key words: Intercropping, Organic fertilizer, Azotobarvar, Barvar 2, Vermicompost.

Abstract

In order to evaluate the effect of different intercropping patterns and fertilizers on some growth characteristics and biomass of faba bean (*Vicia faba* L.) an experiment was conducted as factorial based on randomized complete block design with 12 treatments and three replications at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran in 2014. The first factor was four cropping systems including monoculture of faba bean; row intercropping of faba bean with cumin (*Cuminum cyminum* L.) at three patterns (1 row faba bean-1 row cumin; 2 rows faba bean-2 row cumin; 4 rows faba bean-4 row cumin and the second factor was three levels of fertilizers including 100% chemical fertilizer, 50% chemical fertilizer + biofertilizer (Azoto barvar + Barvar 2) and vermicompost. Results showed that the fertilizer had significant effect on plant height of faba bean. The greatest faba bean height was observed in 100% chemical fertilizer that was not significantly different with 50% chemical fertilizer +bio-fertilizer. The interaction effect of fertilizer and cropping pattern was significant on leaf number of faba bean. The highest chlorophyll content index was observed in 100% chemical fertilizer. The biomass of faba bean was significantly affected by fertilizer and cropping patterns. The highest biomass (3887.5 kg/h) was observed in 100% chemical fertilizer and the lowest was observed at vermicompost treatment. In comparison of intercropping patterns the 1-1 and 4-4 faba bean-cumin patterns could be recommended to growers for higher faba bean growth and production.

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Introduction

Production of high yielding varieties, use of fertilizers and pesticides caused a significant increase in world crop production (Sullivan, 2003). On the other hand the reduction of genetic diversity, deterioration of soil and water resources as well as consume more fossil energy creates. The increased use of inputs with adverse environmental impacts caused problems in sustainable agriculture (Sullivan, 2003). The modern growing systems imply the simplification of the structure of the environment over large areas of land, replacing natural plant diversity with only a limited number of cultivated plants in monocultures (Vandermeer *et al*., 1998; Sachs *et al*., 2009; Amini *et al*., 2009).

Intercropping has been traditionally practiced in many parts of world (Anil *et al*., 2000; Karadag, 2004) and has some advantages over monocultures (Anil and Phipps, 1998; Karadag, 2004). Intercropping supplies efficient resource utilization, reduces risk to the environment and production costs, and provides greater financial stability, making the system more suitable particularly for labor-intensive, small farmers (Anil and Phipps, 1998).The plant components of intercropping system do not necessarily have to be sown at the same time, but they should be grown simultaneously for a substantial part of their growth periods (Altieri and Letourneau, 1999).

Currently, bio-fertilizers as an alternative to chemical fertilizers could enhance soil fertility in sustainable agriculture (Wu *et al.,* 2005). The crops with nitrogen-fixing bacteria have an important role in increasing the soil fertility and are used in rotation with other crops or as green manure (Nezami and Bageri, 2005). Biofertilizers of bacteria and fungi are produced for fixing atmospheric nitrogen and releasing phosphate ions, potassium and insoluble iron. These bacteria increase the absorption of certain element, reduce disease and improve soil structure and thus stimulate plant growth and increase the quantity and quality of crop yield (Vessey, 2003).

Plant growth-promoting rhizobacteria (PGPR) have been successful in promoting the growth of crops such as canola, soybean, lentil, pea, wheat and radish have been isolated (Timmusk *et al*., 1999).

Faba bean (*Vicia faba* L.) in one of the pulse crops that is cultivated in East Azarbayjan of Iran for grain production (Parsa and Bagheri, 2009). Cumin (*Cuminum cyminum* L.) also is an important medicinal crop that cultivated at the most area of Iran (Omidbaigi, 2010). Intercropping of faba bean and cumin would increase the productivity of these crops in this region also the effect of different fertilizer treatments could be evaluated. So the aims of this study were investigating the effect of different intercropping patterns of faba bean and cumin on some growth parameters and biomass of faba bean.

Materials and methods

Site description and experimental design

The field experiment was conducted in 2014 at the Research Farm of the University of Tabriz, Iran (latitude 38°05_N, longitude 46°17_E, altitude 1360 m above sea level). The climate of research area is characterized by mean annual precipitation of 285 mm, mean annual temperature of 10°C, mean annual maximum temperature of 16.6°C and mean annual minimum temperature of 4.2°C. The experiment was arranged as factorial based on randomized complete block design with 12 treatments and three replications. The first factor was four cropping systems including monocropping of faba bean; row intercropping of faba bean with cumin at three patterns (1 row faba bean-1 row cumin; 2 rows faba bean-2 row cumin; 4 rows faba bean-4 row cumin and the second factor was three levels of fertilizers as 100% chemical fertilizer, 50% chemical fertilizer + biofertilizer (Azoto barvar + Barvar 2) and vermicompost. The 100% chemical fertilizer was urea at a rate of 50 kg/h and 150 kg/h triple super phosphate. The biofertilizer was Azoto barvar + Barvar 2 as inoculation with the seed at planting time and the vermicompost was used in rate of 10 ton /h. Faba bean seed was obtained from Tabriz, East Azarbayjan.

The faba bean was planted at density of 40 plants/m^2. The plot size (rows number) was different for treatments with 5 m long and 25 cm row distance. At intercropping patterns the cumin was planted at the same rows with replacement patterns. The fertilizer bio-fertilizers of Azotobarvar and Barvar 2 were inoculated with faba bean and cumin seeds at planting time. The vermicompost was used before planting and mixed with the soil. The urea fertilizer was used at three stages including planting time, three-leaf stage and early flowering. The triple super phosphate was used at planting time. The first irrigation was done after planting and the next irrigations were performed once a week by furrow irrigation method. Before crop maturity the irrigation was cut to reduce excess moisture, plants will be ready for harvest.

Data collection

During growth season in order to specify plant height and leaf number per plant, five plants were selected from the three middle rows of each plot and these traits were measured. At flowering stage, three plants were randomly selected and chlorophyll content index (CCI) of upper, middle and lower leaves was measured by a chlorophyll meter (CCM-200, Opti-Science, USA). Also, to determine the faba bean biomass, an area equal to 4 m^2 was harvested from the middle part of each plot (considering marginal effect) and biomass was measured.

Statistical analysis

Analysis of variance (ANOVA) of the data was performed with SPSS (Ver.21) and MSTATC software. The data that were used in ANOVA met the assumptions such as normality and homogeneity of variance and did not require transformation. Duncan multiple range test was applied to compare means of each trait at 5% probability.

Results and discussion

Results showed that the fertilizer had significant effect on plant height of faba bean (Table 1). Effect of cropping pattern was not significant on this trait. Also the interaction effect of cropping pattern × fertilizer was not significant on plant height (Table 1). The greatest faba bean height was observed in 100% chemical fertilizer that was not significantly different with 50% chemical fertilizer +bio-fertilizer (Fig. 1). The plant height of vermicompost fertilizer was lower than two other fertilizer levels; the difference was significant (Fig.1). The high availability of nutrients, especially nitrogen, stimulates growth and increase the length of internodes through increased plant height. The plant height as a result of the use of bio-fertilizers also increased due to better root development and uptake of water and nutrients and the production of growth hormones known as gibberellic acid and auxin (Nazeri *et al.,* 2011). Biological and mineral fertilizers increase decomposition of toxic substances by increasing the biological activity of the soil (Chen *et al.,* 2006).

Table 1. Analysis of variance of faba bean traits affected by fertilizer and intercropping patterns.

S.O.V	df	Plant height	Leaf number	Green cover	Chlorophyll content index	Biomass
Block	2	4.08	14.19 **	90.78	95.01 **	129830.5
Fertilizer(F)	2	60.25 **	2.03	114.53	6.36 **	609522.1 *
Cropping pattern (C)	3	6.22	3.14	51.81	39.11 **	11101302.9 **
F × C	6	17.92	11.14**	93.53	62.78	90252.2
Error	22	55.08	1.77	42.23	9.46	115568.5

* and ** , Significant at 5% and 1% probability level, respectively.

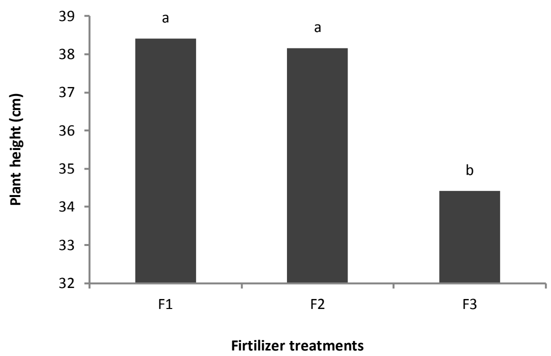

Fig. 1. Effect of different fertilizer treatments (F_1, F_2 and F_3 chemical 100%, 50% chemical + biofertilizerl and vermicompost) on plant height of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

The interaction effect of fertilizer and cropping pattern was significant on leaf number of faba bean, but fertilizer and cropping pattern was not significantly affected this trait (Table 1). In monoculture and 4-4 intercropping, the 100% chemical fertilizer treatments had the highest leaf number and the vermicompost had the lowest leaf number, but was not significantly different with 50% chemical fertilizer treatment was 50% bio-fertilizer (Fig. 2). The leaf number at 1-1 and 2-2 intercropping patterns were not significantly different for chemical fertilizer, 50% chemical and 50% bio-fertilizer and vermicompost (Fig. 2). In other words, at 1-1 and 2-2 intercropping patterns the vermicompost and bio-fertilizer could be a good alternative to chemical fertilizers. The effect of nitrogen fertilizer on the number of leaves per plant nitrogen metabolism of plants is concerned, because it increases the photosynthetic products and increase vegetative organs such as the number of leaves. Increased use of bio-fertilizer increase the nitrogen uptake and effectiveness of this nutrient in the photosynthesis and the production of green surface (Cakmakc *et al.,* 2007). Inoculation with Azotobacter biofertilizers increased plant growth, number of leaves and leaf area (El-zieny *et al.,* 2007).

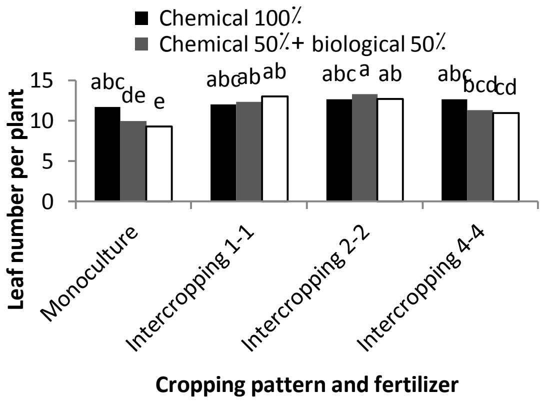

Fig. 2. The interaction effect of cropping pattern and fertilizer on leaf number per plant of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

Cropping patterns and fertilizer had no significant effect on green cover faba bean (Table1). Faba bean leaf chlorophyll content significantly affected by cropping patterns and fertilizer (Table1). The highest CCI was observed in 100% chemical fertilizer that was significantly different with 50% chemical + 50% biological and vermicompost (Fig. 3). The highest CCI (29/22) was observed in the treatment of faba bean monoculture and 1-1 intercropping pattern (Fig. 4). The lowest chlorophyll content index was observed in 4-4 intercropping pattern which showed significant difference with other cropping patterns (Fig. 4).

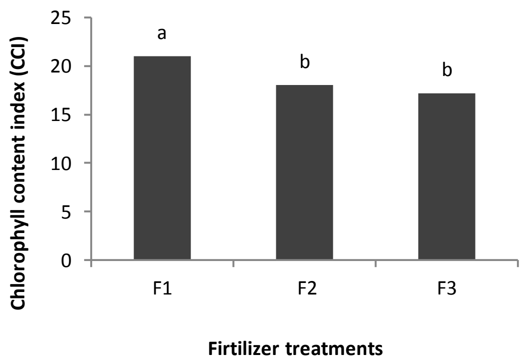

Fig. 3. Effect of different fertilizer treatments (F_1, F_2 and F_3 chemical 100%, 50% chemical + 50% biological and vermicompost) on chlorophyll content index of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

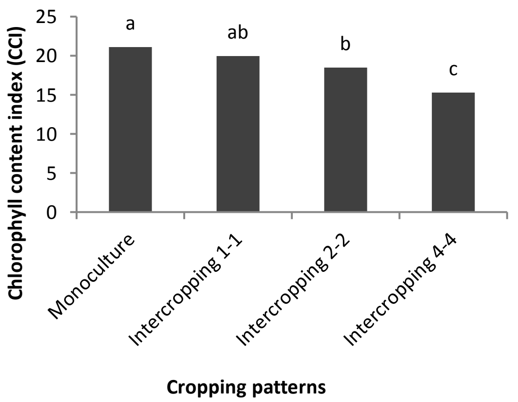

Fig. 4. Effect of different cropping pattern on chlorophyll content index (CCI) of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

Results indicated that, biomass of faba bean was significantly affected by fertilizer treatments (Table 1). The highest biomass (3887.5 kg/h) was observed in 100% chemical fertilizer and the lowest was observed at vermicompost treatment (Fig. 5). There was no significant difference between treatments 50% chemical + 50% bio-fertilizer and vermicompost (Fig. 5). The monoculture cropping patterns had the highest faba bean biomass (5246.9 kg/ha) and the lowest biomass was observed in 2-2 intercropping pattern (Fig. 6). Also there was no significant difference between 1-1 and 4-4 intercropping patterns in term of biomass. Dabbagh Mohammadi Nassab *et al.* (2015) found that application of bio-fertilizers had no significant effect on grain yield of corn at intercropping with red kidney bean (*Phaseolus vulgaris* L.). Allahdadi *et al.*, (2013) also observed that at intercropping of soybean (*Glycine max* (L.) Merrill.) and Calendula (*Calendula officinalis* L.) the cropping patterns of 1-1 and 6-4 had the highest grain yield and highest land equivalent ratio (LER) that indicates these cropping patterns could be recommended to growers. Evaluating the intercropping of corn (*Zea mays* L.), sunflower (*Helianthus annuus* L.) and soybean indicated that the most grain yield of corn was shown at intercropping patterns of corn-soybean and corn-soybean-sunflower-soybean (Amini *et al.,* 2013).

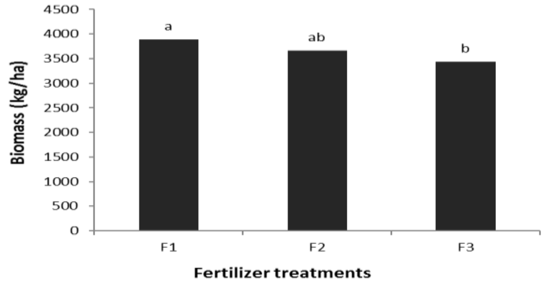

Fig. 5. Effect of different fertilizer treatments (F_1, F_2 and F_3 chemical 100%, 50% chemical + 50% biological and vermicompost) on faba bean biomass (Different letters indicate significant differences at $p \leq 0.05$).

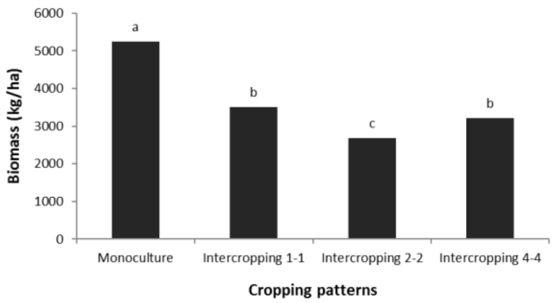

Fig. 6. Effect of different cropping pattern treatments on faba bean biomass (Different letters indicate significant differences at $p \leq 0.05$).

Conclusion

In the present study, the highest biomass was obtained in 100% chemical fertilizer and application of biofertilizer or vermicompost reduced the faba bean biomass but results indicated that chemical fertilizers could be replaced with vermicompost and other bio-fertilizers in order to produce healthy product and reduce environmental pollution. In comparison of intercropping pattern the 1-1 and 4-4 faba bean-cumin patterns could be recommended to growers for higher faba bean growth and production.

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