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Growth characteristics and grain yield of faba bean (*Vicia faba* L.) as influenced by intercropping with Moldavian balm (*Dracocephalum moldavica*) and fertilizers application

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Key words: Faba bean, Grain yield, Intercropping, Organic fertilizer, Vermicompost

Abstract

In order to evaluate the effect of different fertilizer treatments and intercropping patterns on growth characteristics and grain yield of faba bean (*Vicia faba* L.), a field experiment was conducted as factorial on the bases of randomized complete block design with three replications in 2015. The first factor was four cropping systems including monoculture of faba bean; row intercropping of faba bean with Moldavian balm (*Dracocephalum moldavica*) at three patterns (1 row faba bean-1 row Moldavian balm; 2 rows faba bean-2 row Moldavian balm; 4 rows faba bean-2 row Moldavian balm and the second factor was three levels of fertilizers including 100% chemical fertilizer, 50% chemical fertilizer + biofertilizers (Azoto barvar + Barvar 2) and vermicompost. The results showed that the maximum chlorophyll content index and leaf number per plant was obtained in chemical fertilizer treatment. The highest plant height (62.14cm) was observed in 1:1 intercropping system. The effect of fertilizer treatment was not significant on plant height. The highest amount of number of pods per plant (3.52) was obtained from 2:2 intercropping system and chemical fertilizer application. The maximum grain yield per occupied unit area was observed in sole cropping (279.41g/m^2) and among fertilizer treatments was belonged to 100% chemical fertilizer (222.08g/m^2). In comparison of intercropping patterns the 2-4 faba bean- Moldavian balm pattern could be recommended to farmers for higher faba bean growth and production.

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Introduction

In recent years, a trend in agricultural production systems has changed towards achieving high productivity and promotes sustainability over time. Farmers are developing different crop production systems to increase productivity and sustainability since ancient times. This includes crop rotation, relay cropping and intercropping of major crops with other crops. Intercropping, the agricultural practice of cultivating two or more crops in the same space at the same time is an old and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and labor. The most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height, and nutrient requirements based on the complementary utilization of growth resources by the crops (Silwana and Lucas, 2002).

Grain legumes (pulses) such as faba bean (*Viciafaba* L.) are rich in protein and suited for animal feed as well as for human diet. Other positive effects of faba bean is the symbiotic nitrogen (N2) fixation (SNF) ability supplying N for agriculture, recycling of N-rich crop residues and the break-crop effect in cereal-rich rotations (Jensen, 1997).

The Moldavian balm (*Dracocephalum moldavica* L.) is an annual, herbaceous, essential oil-producing, spicy aromatic medicinal plant of the deadnettle family (Lamiaceae), which reaches 25-75cm in height. *D. moldavica* contains 0.06–0.92% essential oil, with the maximal level during flowering. Its lemon-like scented essential oil consists mainly of oxygenated acyclic monoterpenes, e.g. geraniol, geranyl acetate, geranial, neral and nerylacetate. It has been reported that the plant possesses antibacterial, antioxidant and cardio protective effects (Dastmalchi *et al.,* 2007).

Plant nutrition is one of the most important factors that increase plant production. The use of chemical fertilizers has been increased worldwide for plant production due to availability of inexpensive fertilizers (Abril *et al.,* 2007).

The continued use of chemical fertilizers causes health and environmental hazards such as ground and surface water pollution by nitrate leaching. Intensive use of chemical fertilizers and other chemicals has produced environmental problems and increased production costs. There centesimo crisis and environmental problems has raised interest in environmental friendly sustainable agricultural practices, which can reduce input costs (Salantur *et al.,* 2005).

Biofertilizers are becoming increasingly popular in many countries and for many crops. They are defined as products containing active or latent strains of soil microorganisms, either bacteria alone or in combination with algae or fungi that increase the plant availability and uptake of mineral nutrients (Vessey, 2003). There is a wide range of reports on the effect of biofertilizer application in crops. Razie and Anas (2008) claimed that the inoculation of rice seedlings with *Azotobacter* spp. and *Azospirillum* spp. was able to substitute for the application of inorganic N fertilizer, and that this technology enabled rice yields of 3.9 to 6.4 ton/ha (yield increases in comparison with the control were about 2–3 ton/ha).

Vermiform posting is a low-cost method of treating organic wastes exploiting the ability of some earthworms to fragment the waste residuals in their grinding gizzards (Atiyeh *et al.,* 2002).

The digestion process fragments the waste substrate, accelerates rates of decomposition and increases its plant available nutrient content. Vermicomposts can contain biologically active substances such as plant growth regulators and have frequently been shown to increase plant growth rates in glasshouse and field trials, whether used as a soil additive or as a substitution to soilless growth media. Most studies have reported beneficial effects of vermicompost on germination, plant growth and yield with substitutions of 20-40% of vermicompost into a commercial growth medium (Chaoui *et al.,* 2003; Arancon *et al.,* 2004).

Intercropping of faba bean and Moldavian balm 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 Moldavian balm on some growth parameters and grain yield of faba bean.

Material and methods

Site description and experimental design

The field experiment was conducted in 2015 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 Moldavian balm at three patterns (1 row faba bean-1 row Moldavian balm; 2 rows faba bean-2 row Moldavian balm; 4 rows faba bean-2 row Moldavian balm 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 50kg/ha and 80kg/ha 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 5 ton /ha. The faba bean was planted at density of 40 plants/m2. The plot size (rows number) was different for treatments with 5m long and 25cm row distance. At intercropping patterns the Moldavian balm was planted at the same rows with replacement patterns. The bio-fertilizers were inoculated with faba bean and Moldavian balm 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.

Measurement of traits

To specify plant height and pod number per plant, ten plants were selected from the middle of the plots and then, they were measured. Also at maturity, to determine of grain yield an area equal to 1m² was harvested from middle part of each plot considering border effect. Harvested plants were dried in 25°C and under shadow and air flow, and then grains were separated from the remains by threshing. 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).

Statistical analysis

Statistical analysis of the data was performed with MSTAT-C software. Duncan multiple range test was applied to compare means of each trait at 5% probability.

Results and discussion

Chlorophyll content index, significantly affected by fertilizer treatment, but cropping pattern and their interaction had no effect on this trait (Table 1). Minimum Chlorophyll content index (33.39) was obtained under vermicompost treatment (Fig. 1). Highest Chlorophyll content index (39.22) was achieved at 100% chemical fertilizers treatment (Fig. 1). Chlorophyll content is of particular significance to precision in agriculture as an indicator of photosynthetic activity. A positive correlation between N fertilization and the chlorophyll content is well documented for a number of plant species and has been investigated for rapid Ndetermination for most major crops including corn, rice, wheat (Sabo *et al.,* 2002; Bojovic and Stojanovic, 2005; Houles *et al.,* 2007). The results obtained in this study are confirmed with those obtained by Kate *et al.,* (2005) on potato and Golkz *et al.,* (2006) on Sweet basil.

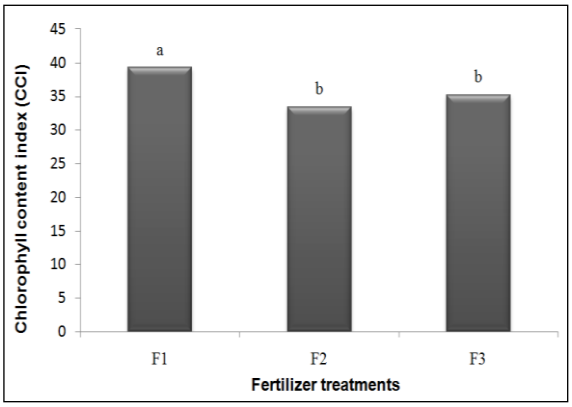

Fig. 1. Effect of different fertilizer treatments (F_1, F_2 and F_3: chemical 100%, vermicompost and 50% chemical + biofertilizer) on chlorophyll content index of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

Plant height of faba bean significantly affected by cropping pattern. Effect of fertilizer treatment and interaction effect of cropping pattern × fertilizer was not significant on plant height (Table 1). The greatest faba bean height was observed in 1-1 intercropping and this was significantly different from the other cropping systems (Fig. 2). The canopy characteristics of crops are not constant, but may change due to the presence of other crops species (Caldwell, 1987). This result is similar with finding of Silwana and Lucas (2002) who reported that intercropping of maize with bean enhanced the plant height of maize. In other results, Thwala and Ossom (2004) did not find any significant difference in plant height between mono cropping and intercropping of maize with sugar bean and ground nuts.

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

S.O.V	df	Mean Square				
		Chlorophyll content index	Plant height	Leaf number	Pod number per plant	yield
Block	2	3.402	1.381	0.91	0.204**	6706.078**
Cropping pattern (C)	3	0.014	35.69*	4.31	0.205**	26186.978**
Fertilizer(F)	2	107.383*	0.003	23.163*	0.739**	4574.774**
F × C	6	0.062	0.015	0.499	0.042**	37.782*
Error	22	19.283	8.914	4.426	0.004	10.532

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

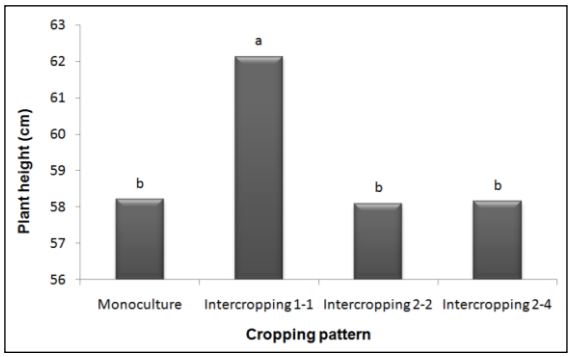

Fig. 2. Effect of different cropping pattern on plant height of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

There was no significant difference in leaf number of faba bean among the cropping systems as shown in Table 1, but this trait significantly affected by fertilizer treatments. The highest leaf number (16.6) of faba bean was obtained in 100% chemical fertilizer treatment.

The lowest leaf number (14.2) was recorded under vermicompost treatment (Fig. 3). Gulser (2005) also reported that increments in the nitrogen rate of the fertilizers increased the number of leaves in spinach. Shahbazi (2005) showed that there was a significant differences in the number of leaves among nitrogen levels (0, 50, 100, 150 and 200kgN/ha), and that the highest leaf number was obtained with 200kgN/ha.

Our results showed that cropping pattern, fertilizer treatment and interaction of cropping pattern and fertilizer treatments had significant effect on pod number per plant (Table 1). The maximum pod number per plant (3.52) was obtained from 2-2 intercropping pattern and 100% chemical fertilizer treatment (Fig.4). The minimum pod number per plant (2.65) obtained from 2-4 intercropping pattern under vermicompost treatment (Fig. 4). Similarly, Amir Mardfar *et al.*, (2013) observed that at

intercropping of wheat and oilseed rape, strip intercropping with 12 rows of wheat and 4 rows of oilseed rape and application of 100% chemical fertilizers had the highest spike per plant, grain yield and highest land equivalent ratio (LER), that indicates these cropping patterns could be recommended to growers.

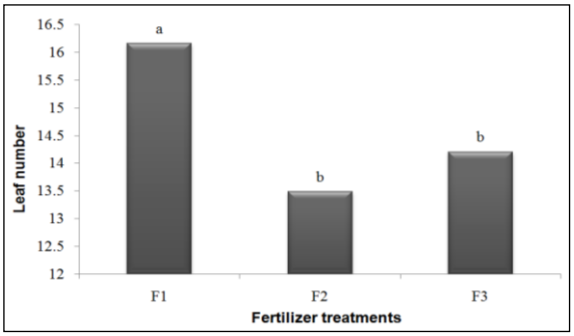

Fig. 3. Effect of different fertilizer treatments (F_1, F_2 and F_3: chemical 100%, vermicompost and 50% chemical + biofertilizer) on leaf number of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

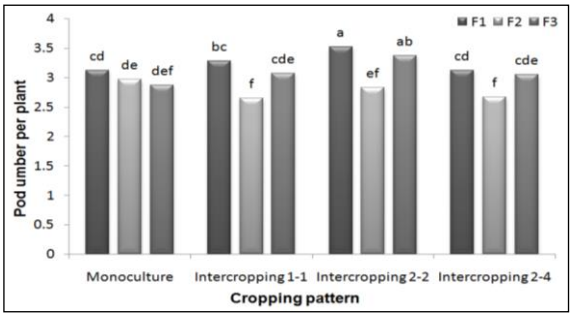

Fig. 4. The interaction effect of cropping pattern and fertilizers (F_1, F_2 and F_3: chemical 100%, vermicompost and 50% chemical + biofertilizer) on pod number per plant of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

Grain yield significantly affected by cropping pattern and fertilizer treatments, whereas interaction of cropping pattern and fertilizer treatments had no significant effect on the grain yield (Table 1). The highest grain yield (222.08g/m²) was observed in 100% chemical fertilizer and the lowest was observed at vermicompost treatment (Fig. 5). The monoculture cropping patterns had the highest faba bean grain yield (279.41g/m²) and the lowest grain yield was observed in 1-1 intercropping pattern (Fig. 6).

In agreement to this research, the general trend in most intercropping experiments is that the grain yield of a given crop in a mixture are less than the yield of the same crop grown alone, but in total productivity per unit of land is usually greater than for sole crop (Natarajan and willy1981). Competition for soil moisture and nutrients could have been high and might have caused the yields of faba bean to drop significantly. N fertilizer in this study had a significant effect on faba bean grain yield. Study on the effect of N fertilization on growth and yield components showed increase in canola grain yield (Ahmadi and Bahrani, 2009). Evaluating the intercropping of corn, sunflower and soybean indicated that the most grain yield of corn was obtained at intercropping patterns of corn-soybean and corn-soybean-sunflower-soybean (Amini *et al.,* 2013). Dabbagh Mohammad 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.).

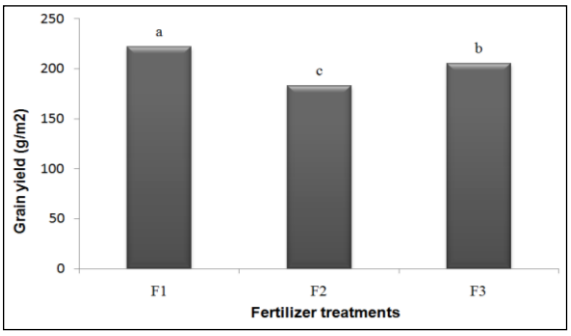

Fig. 5. Effect of different fertilizer treatments (F_1, F_2 and F_3: chemical 100%, vermicompost and 50% chemical + biofertilizer) on grain yield of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

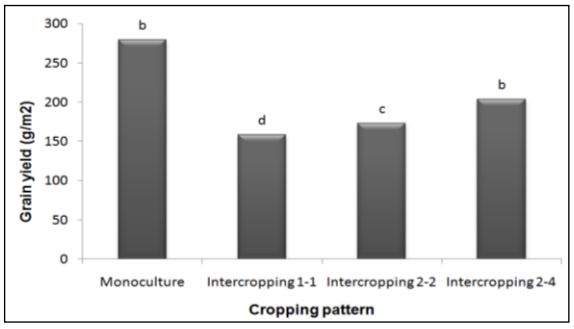

Fig. 6. Effect of different cropping pattern on grain yield of faba bean (Different letters indicate significant differences at $p \leq 0.05$).

Conclusion

In the present investigation, grain yield of faba bean in sole system was generally greater than those of intercropping system. It can be concluded that chemical fertilizers increased grain yield of faba bean in sole and intercropping system. In comparison of intercropping patterns, the 2-4 faba bean-Moldavian balm patterns could be recommended to growers for higher faba bean growth and production.

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