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Effect of Different Levels of Nitrogen on the Yield, Efficiency and Nitrogen Harvest Index of Marigold and *Vicia faba* in Different Mixed Cropping Patterns

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Abstract: In order to evaluate the effect of different levels of nitrogen fertilizer on yield, nitrogen use efficiency and nitrogen harvest index of perennial and bean plants in different patterns of mixed cropping, an experiment in the form of a split plot in the form of a randomized complete block design with four replications in two crop years (2020-2021) was implemented in the research farm of Khuzestan University of Agricultural Sciences and Natural Resources. The main factor includes different amounts of nitrogen fertilizer (0, 75 and 150 kg per hectare of pure nitrogen from the source of urea fertilizer) and the secondary factor includes the patterns of mixed cultivation of broad *Vicia faba* L and spring flowers in 5 levels: 1- pure cultivation of spring flowers (8 rows in per plot), 2- planting 75% Calendula officinalis L + 25% broad *Vicia faba* L. (6 rows of Calendula officinalis L and 2 rows of broad *Vicia faba* L.), 3- planting 50% Calendula officinalis L + 50% broad *Vicia faba* L. (4 rows of Calendula officinalis L and 4 rows of broad *Vicia faba* L.)), 4- the cultivation of 25% of marigolds + 75% of broad *Vicia faba* L. (2 rows of marigolds and 6 rows of broad *Vicia faba* L.) and 5- pure cultivation of broad *Vicia faba* L. (8 rows per plot) were considered. The results showed that the effect of using different amounts of nitrogen fertilizer on yield, nitrogen use efficiency and nitrogen harvesting index of perennial and bean plants was significant. In most of the analyzed traits, the treatment of 50% of broad *Vicia faba* L. and 50% of marigold at 75 kg/ha of nitrogen was superior to the other treatments.

Keywords: Cropping, Nitrogenous Fertilizer, Spring Flowers

1. Introduction

Sustainable agriculture studies, especially self-sustainable, low-input and high-efficiency agricultural systems in terms of energy consumption, have always been of interest to many farmers, researchers, and policymakers around the world [9]. Since diversity in agricultural systems is necessary for the stability of production and the use of several vessels is one of the main components in this agriculture [1, 24]. Among the disadvantages of monoculture, we can mention the high use of chemical fertilizers, intensive irrigation and high water consumption, chemical control of pests and diseases, and the right place for the destructive attack of certain pests [16]. Mixed cropping, as one of the types of multi-cropping, is preferable to single-cropping for better use of resources such as water, light and food [24]. Mixed cropping refers to the cultivation of two or more crops that are cultivated together in one plot of land and in one cropping year in such a way that they interact with each other from an agricultural point of view and lead to synergistic production during a certain time [18]. This cultivation system has the maximum compatibility with the principles of ecology and as one of the agricultural solutions to increase the absorption and consumption of light, it can lead to the improvement of crop production and increase in economic performance [12, 15].

As one of the components of sustainable agriculture, while increasing ecological and economic diversity, intercropping increases yield, reduces soil erosion, increases the amount of organic matter, improves soil fertility through the fixation of atmospheric nitrogen by legumes, and reduces the population of weeds. Pests and plant diseases and better use of environmental factors such as light and humidity are caused by placing the organs of plants participating in mixed cultivation in different layers [19].

Excessive use of chemical fertilizers causes environmental problems and increase in production costs, soil degradation, reduction of organic matter, lack of low-use elements, increase in plants' sensitivity to pests and diseases, and decrease in soil organisms [2]. Considering the environmental problems of existing agricultural systems, especially the environmental pollution caused by the use of pesticides in pest control and the use of chemical fertilizers, as well as the reduction of agricultural land, the use of new methods in order to minimize It is necessary to remove the negative effects and replace the current agricultural systems with suitable agricultural systems such as mixed farming [7].

Bean (Vicia faba L.) is one of the leguminous plants, which is an annual plant with a straight and hollow stem. Legumes are among the most important crops cultivated by humans and not only have a high nutritional value for humans, but also have a positive effect on the fertility of agricultural soils [22].

Marigold plant (Calendula officinalis L.) from the chicory family (Asteracea) is one of the most famous and widely used medicinal plants, and as a bush plant, the flowers of this plant, in addition to edible uses, have effective substances and compounds that are used in the industry. Pharmacy is used [11].

Mixed cultivation of plants of other genera with leguminous plants is one of the most common types of mixed cultivation [8], which is necessary for the development of sustainable food production systems, especially in planting systems based on reducing the consumption of foreign inputs. It is recommended [3]. The importance of these systems relies on nitrogen fixation by leguminous species [20].

Since human health is very important in the production of medicinal plants, therefore, in order to prevent the adverse effects of the residues of agricultural inputs on the health of the consumers of these plants and also to prevent the reduction of the quality of these products, it is necessary to use the principles of ecology. Like mixed cultivation, it seems necessary in the production of these plants. In addition, mixed cultivation of medicinal plants with other plants can be very useful by reducing the consumption of agricultural inputs and controlling weeds. According to the limited information and published results about mixed cultivation of marigold and broad Vicia faba L., the purpose of this research is to investigate the role of nitrogen in improving the quantitative and qualitative yield of marigold and broad Vicia faba L. in mixed cultivation. Also, considering the importance of using chemical fertilizers, especially nitrogen, in production and the environmental effects of its excessive use, the necessity of using integrated programs to minimize its use and increase the efficiency of productivity in the last two years. has done so much Therefore, the use of planting a mixture of different plants, especially nitrogen-fixing plants and medicinal plants, can be considered as a positive step in the direction of sustainable agriculture in addition to various environmental advantages.

2. Materials and Methods

In order to evaluate the effect of different levels of nitrogen fertilizer on the yield, nitrogen consumption efficiency and nitrogen harvest index of perennial and broad bean plants in different mixed cropping patterns, a two-year experiment was carried out in the cropping years of 2019-2020 and 2020-2021 in the research farm of Khuzestan University of Agricultural Sciences and Natural Resources. It was carried out 30 km northeast of Ahvaz. The area in question has a latitude of 31 degrees and 35 minutes and a longitude of 48 degrees and 53 minutes and an altitude of 25 meters from the sea level. The experiment was carried out as a split plot in the form of a randomized complete block design with four replications. The main factor includes different amounts of nitrogen fertilizer (0, 75 and 150 kg per hectare of pure nitrogen from the source of urea fertilizer) and the secondary factor includes the patterns of mixed cultivation of broad Vicia faba L. and spring flowers in 5 levels: 1- pure cultivation of spring flowers (8 rows in per plot), 2- planting 75% Calendula officinalis L + 25% Vicia faba L. (6 rows of Calendula officinalis L and 2 rows of Vicia faba L.), 3- planting 50% Calendula officinalis L + 50% Vicia faba L. (4 rows of Calendula officinalis L and 4 rows of Vicia faba L.)), 4- the cultivation of 25% of marigolds + 75% of broad Vicia faba L. (2 rows of marigolds and 6 rows of broad Vicia faba L.) and 5- the pure cultivation of broad Vicia faba L. (8 rows per plot) were considered.

First, in order to stimulate the germination of weeds and better control them and to provide adequate moisture for the preparation of the land, two weeks before the preparation, the experimental plot was irrigated. Plowing was done after the soil moisture level reached the desired level (agricultural capacity limit). In order to completely crush the clods and level the ground, two disc steps were performed in the direction perpendicular to each other. Before the stage of discusting the amount of phosphorus and potassium based on the soil test from the tertyl superphosphate source, potassium sulfate was uniformly distributed on the field. Based on the test plan, it was created by using the atmospheric furrower and the ridges, and then the water transfer streams on the ground were determined and the streams were created using the streamers. After the implementation of agricultural operations, stacking and creation of irrigation streams, cultivation was carried out according to the plan. Perennial and broad bean cultivation was prepared based on the patterns of planting in rows and stacks at a distance of 20*50 cm for broad Vicia faba L. and 12*50 for perennial. The area of each plot is 12 square meters including 8 crop lines. The required seed was calculated and planted in the middle of November 2020 and 2021 for all experimental units according to the capacity and weight of 1000 seeds. Irrigation of the field was done according to the growing season and water needs of the plants in the form of leakage, as well as weeding and spraying in case of seeing pests and diseases. In this period, nitrogen fertilizer from the source of urea fertilizer was given in two stages after thinning the plants and the 8-leaf stage, and the thinning operation was also done in the 3-4-leaf stage. Harvesting was done at the time of ripening and when the color of the bean pods and the flowers of the ever-spring flowers were yellow. To determine the final yield in each plot, two side rows and half a meter from the beginning and end of the plot were removed as a marginal effect, and after harvesting the plants from the remaining surface, the biological yield and grain yield were determined for each plant separately. To determine the harvest index, after measuring the seed and biological yields of both plants, the harvest index was calculated from the following relationship.

(100×total dry weight / grain dry weight) = harvest index (percentage)

To measure the carotenoids of the ever-spring flower, one gram of fully developed fresh sample was separated and ground in a Chinese mortar with 3 ml of 99% methanol to extract carotenoids, then the sample was centrifuged for 5 minutes at a speed of 3000 rpm. After that, the extracted extract was passed through a filter paper and poured into a cuvette. After reading the final solution by a spectrophotometer at 455 nm, we calculate the percentage of the total amount of carotenoid compounds from the following relationship [17]:

$$TC(\%) = \frac{D\times10^4\times L}{241.25\times M}$$

TC: total amount of carotenoid compounds (%), D: spectrophotometer reading number, L: dilution ratio (5), M: weight of plant material (one gram).

In order to measure the percentage of nitrogen, after drying and grinding the samples (Vicia faba L. and marigolds) in the laboratory, one gram of each sample was separated and placed in a test tube, then a digestion tablet containing potassium sulfate and copper sulfate was added to it. became. Then, 10 ml of concentrated sulfuric acid was added to each of the samples, and then the test tubes containing the samples were placed in a special rack and placed in an electric furnace under the hood. By gradually increasing the temperature to 400°C, the digestion of the samples continued for 2-3 hours until a colorless solution of the samples was reached. After turning off the furnace and cooling the samples and reaching the ambient temperature, the nitrogen percentage of the samples was measured by Kjeldahl device. The reading of the Kjeldahl device was reported as nitrogen percentage. Seed protein percentage was calculated by measuring the nitrogen percentage of the whole seed using the Kjeldahl method and multiplying it by 6.25 [23]. To measure the efficiency index of nitrogen use and the index of nitrogen removal, according to the relation proposed by Fan [4], it was calculated from the following relations.

$$\text{NUEt} = \frac{\text{Wg}}{\text{Nf}}$$

NUEt = Nitrogen utilization efficiency (gram of seed per gram of nitrogen absorbed in the plant), Wg = seed weight in grams per square meter and Nf = nitrogen absorbed in the plant in grams per square

$$\text{NHI}= \frac{Ng}{Np} * 100$$

Ng and Np = total seed and plant nitrogen in grams per square meter.

The composite variance analysis of the data was done after performing Bartlett's test and ensuring the uniformity of the errors for two years of project implementation. Composite variance analysis of data and comparison of averages were done using SAS statistical analysis software. The average data was compared with the LSD test and at the 5% error level, and the graphs were drawn using Excel software.

3. Results and Discussion

3.1. Calendula Officinalis L. Yield

The effect of planting pattern on marigold yield was significant at 1% level (Table 1), the effect of nitrogen on marigold yield was significant at 1% level, and the interaction effect of planting pattern and nitrogen was significant at 1% level. The treatment of 50% of broad Vicia faba L. and 50% of marigolds at 75 kg/ha of nitrogen had the highest yield with a yield of 2165.5 grams (Table 2). The lowest yield of marigolds was assigned to the treatment of 75% of Vicia faba L. and 25% of marigolds at 150 kg/ha of nitrogen with a weight of 1010.4 grams. The obtained results show that increasing the consumption of nitrogen fertilizer has decreased the final yield. In this experiment, the presence of high amounts of nitrogen caused a decrease in grain yield, so that in both years, the highest yield components were obtained from the consumption of 75 kilograms per hectare, and the consumption of 150 kilograms caused a decrease in the yield components. Slowing down the speed of grain ripening in high amounts of nitrogen and increasing the share of osmolytes in favor of protein can be the cause of yield loss in amounts that are more than optimal [10].

The graph of changes in the final performance of marigold plant due to different cultivation patterns and nitrogen fertilizer is shown in Figure 1. Ghobadi [6] during a research showed that by increasing nitrogen fertilizer up to the recommended amount, yield and yield components increased, but with further increase of nitrogen fertilizer, yield and yield components decreased. With the optimal use of nitrogen, the growth rate of the leaves is increased and the leaves complete their growth in a shorter period of time compared to the lack of nitrogen use, and the excess photosynthetic materials are stored and transferred to the seeds after pollination. In relation to the reduction of yield and yield components due to the application of excessive amounts of nitrogen fertilizer compared to the recommended amount, it can be said that in such a case, excessive increase of nitrogen fertilizer by extending the vegetative growth, delays the reproductive phase of the plant as a result of This delay during the seed filling period is reduced and the seeds will have less time to accumulate photosynthetic assimilates. Zidan et al. [25] stated in relation to the effect of high amounts of nitrogen that the consumption of nitrogen fertilizers more than the plant needs reduces the length of the seed filling period by 3 to 4 days and as a result the seed capacity and yield decreases.

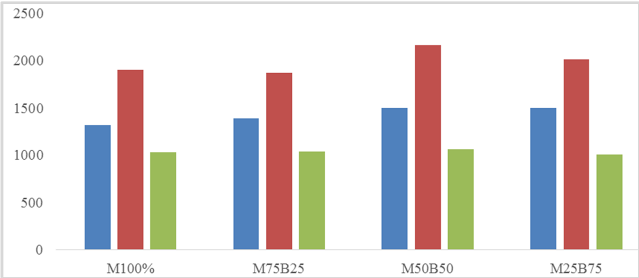

Figure 1. *Final performance of marigold plant due to different cultivation patterns and nitrogen fertilizer.*

3.2. The Final Yield of Vicia faba L.

The effect of planting pattern on the final yield of Vicia faba L. was significant at the level of 1% (Table 1). The effect of nitrogen on the final yield of Vicia faba L. was also significant at the level of 1%. Also, the interaction of planting pattern and nitrogen was significant at the level of 1%. The treatment of 75% of Vicia faba L. and 25% of marigolds at 75 kg/ha of nitrogen had the highest yield of Vicia faba L. with 2526.9 kg/ha (Table 1). The lowest yield of broad Vicia faba L. was assigned to the treatment of 75% of broad Vicia faba L. and 25% of marigold in 150 kg of nitrogen at the rate of 1006.9 kg/ha, which was not significantly different from all the treatments of 150 kg of nitrogen. The results show that with the increase of nitrogen fertilizer, the reproductive growth of Vicia faba L. has decreased and the vegetative growth has increased. Ghobadi [6] during a research showed that by increasing nitrogen fertilizer up to the recommended amount, yield and yield components increased, but with further increase of nitrogen fertilizer, yield and yield components decreased. With the optimal use of nitrogen, the growth rate of the leaves is increased, and the leaves complete their growth in a shorter period of time compared to the absence of nitrogen use, and they store the photosynthetic materials in excess of their needs and transfer them to the seeds after pollination. In relation to the reduction of yield and yield components due to the application of excessive amounts of nitrogen fertilizer compared to the recommended amount, it can be said that in such a case, excessive increase of nitrogen fertilizer by extending the vegetative growth, delays the reproductive phase of the plant. As a result of this delay, the length of the seed filling period is reduced and the seeds will have less time to accumulate photosynthetic assimilates. Regarding the effect of high amounts of nitrogen, Zidan et al. [25] stated that the consumption of nitrogen fertilizers more than the plant needs reduces the length of the seed filling period by 3 to 4 days, and as a result, the seed capacity and yield decrease.

The graph of changes in the final yield of the bean plant due to different cultivation patterns and nitrogen fertilizer is shown in Figure 2.

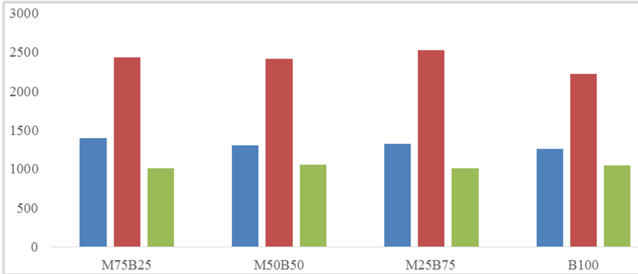

Figure 2. *The final performance of the bean plant due to different cultivation patterns and nitrogen fertilizer.*

3.3. Calendula Carotenoids

The effect of planting pattern on marigold carotenoids was significant at the 1% level (Table 1). The treatment of 50% Vicia faba L. and 50% marigolds at 75 kg/ha of nitrogen had the highest marigold carotenoids with 3.2 µg/mg (Table 2). Nitrogen per hectare was allocated with 1.3 µg/mg, which was not significantly different with the treatment of 50% of Vicia faba L. and 50% of marigolds at 150 kg/ha of nitrogen. Optimum consumption of nitrogen fertilizer increases metabolic activities effective on reproductive growth and has been able to influence its amount with a positive effect on the production of carotenoid precursors [13].

3.4. Biological Performance of Marigold and Vicia faba L.

The effect of planting pattern on the biological performance of marigold was significant at the level of 1% (Table 1). The effect of nitrogen on the biological performance of marigold was also significant at the level of 1%. Also, the interaction between planting pattern and nitrogen was significant at the level of 1%. The treatment of 75% of broad Vicia faba L. and 25% of marigolds at 75 kg/ha of nitrogen had the highest biological yield of marigolds with 9587.5 kg/ha (Table 2). Nitrogen per hectare was allocated with 6662.5 kg per hectare. The obtained results show that with the increase in the use of nitrogen fertilizer, the biological performance has decreased, which can be attributed to leaf burning and a decrease in photosynthesis in the nitrogen consumption of more than 120 kg per hectare, and a decrease in the production of photosynthetic substances and a decrease in the weight of the whole plant [5].

The effect of planting pattern on the biological performance of broad Vicia faba L. was significant at the level of 1% (Table 3). The effect of nitrogen on the biological performance of broad Vicia faba L. was also significant at the level of 1%. Also, the interaction between the pattern of planting and nitrogen was significant at the level of 1%. The treatment of 75% of broad Vicia faba L. and 25% of marigolds at 75 kg/ha of nitrogen had the highest biological yield of Vicia faba L. with 6937.5 kg/ha, which was not significantly different from the treatment of 50% of broad Vicia faba L. and 50% of marigolds at 75 kg/ha of nitrogen. (Table 4) The lowest biological yield of broad Vicia faba L. was allocated to the treatment of 100% of broad Vicia faba L. in the absence of nitrogen consumption, 3656.3 kg/ha, which was not significantly different from the treatment of 50% of broad Vicia faba L. and 50% of marigolds in the absence of nitrogen consumption. The obtained results show that with the increase in the use of nitrogen fertilizer, the biological performance has decreased, which can be attributed to leaf burning and a decrease in photosynthesis in the nitrogen consumption of more than 120 kg per hectare, and a decrease in the production of photosynthetic substances and a decrease in the weight of the whole plant [5, 14].

3.5. Marigold and Bean Harvest Index

The effect of planting pattern on marigold harvest index was significant at the 1% level (Table 1). The effect of nitrogen on the marigold harvest index was also significant at the 1% level. Also, the interaction effect of planting pattern and nitrogen was significant at the 1% level. The treatment of 50% of broad Vicia faba L. and 50% of marigolds at 75 kg/ha of nitrogen had the highest marigold harvest index with 23.5% (Table 2). had no significant difference with the treatment of 25% of broad Vicia faba L. and 75% of marigold at 150 kg/ha of nitrogen. The obtained results show that by increasing the consumption of nitrogen fertilizer from the optimal level, the harvest index has decreased, which can be attributed to the increase in vegetative growth compared to the reproductive growth of the plant, which means that the seed yield has decreased to a greater extent than the biological yield. As a result, the harvest index has decreased.

The effect of planting pattern on bean harvest index was significant at 1% level (Table 3). The effect of nitrogen on bean harvest index was also significant at 1% level. Also, the interaction effect of planting pattern and nitrogen was significant at 1% level. The 100% bean treatment with 75 kg/ha of nitrogen had the highest bean harvest index with 36.7%/ha. (Table 4) The lowest indicator of bean harvest was assigned to the treatment of 100% of Vicia faba L. at 150 kg/ha of nitrogen with 15.9%. The obtained results show that by increasing the consumption of nitrogen fertilizer from the optimal level, the harvest index has decreased, which can be attributed to the increase in vegetative growth compared to the reproductive growth of the plant, which means that the seed yield has decreased to a greater extent than the biological yield. As a result, the harvest index has decreased.

Table 1. *Variance analysis of investigated traits in mixed cultivation of marigolds and beans.*

HI Marigold	Biological yield Marigold	Marigold carotenoids	yield Beans	yield Marigold	DF	Source
8.02455^{**}	550808^{*}	$0.0421875^{n.s}$	$14307.64^{n.s}$	120460.03^{**}	1	Year
$0.569765^{n.s}$	$52617^{n.s}$	$0.01283861^{n.s}$	$2755.37^{n.s}$	$2515.03^{n.s}$	6	Rep (year)
322.543312^{**}	32161263^{**}	14.9962225^{**}	13330496.4^{**}	5887117.81^{**}	2	Nitrogen
25.479309^{**}	955030^{**}	$0.0085275^{n.s}$	$21590.2^{n.s}$	54550.26^{**}	2	year*nitrogen
$0.485787^{n.s}$	$49583^{n.s}$	$0.02274611^{n.s}$	$13493.82^{n.s}$	$3010.6^{n.s}$	12	nitrogen*rep (year)
1586.30447^{**}	314570415^{**}	24.96793417^{**}	12071408.89^{**}	10672382.35^{**}	4	Intercrop
22.498689^{**}	3100969^{**}	1.51042667^{**}	870165.47^{**}	398131.75^{**}	8	nitrogen*intercropp
9.360026^{**}	387201^{**}	0.2260875^{**}	$3002.94^{n.s}$	35605.1^{**}	4	year*intercrop
3.587249^{**}	217614^{*}	0.13204^{**}	21956.02^{**}	12834.76^{**}	8	year*nitrogen*intercropp
0.904556	90115	0.0126353	7892.5	1947.34	72	Error
6.54907	4.648784	6.199187	7.016437	3.715527		c.v

Table 2. *Comparison of the average effect of cultivation pattern and nitrogen fertilizer on the investigated traits of marigold.*

HI Marigold (%)	Biological yield Marigold (kg/h)	Marigold carotenoids (μg /ml)	yield Beans (kg/h)	yield Marigold (kg/h)	Intercrop	nitrogen
17.13^{cd}	7737.5^{e}	1.94^{e}	1393.1^{d}	1318.4^{f}	$M_{100\%}$	0
17.86^{c}	7800^{e}	2.01^{e}	1306.2^{de}	1390.1^{e}	$M_{75}B_{25}$	0
16.9^{cd}	8882.5^{c}	2.38^{d}	1325.8^{de}	1502^{d}	$M_{50}B_{50}$	0
16.84^{de}	8911.3^{c}	2.53^{c}	1257.3^{e}	1500.6^{d}	$M_{25}B_{75}$	0
21.52^{b}	8868.8^{c}	2.6^{c}	2433.8^{b}	1907.7^{c}	$M_{100\%}$	75
22.12^{b}	8487.5^{d}	3.12^{b}	2413.6^{b}	1875.2^{c}	$M_{75}B_{25}$	75
23.53^{a}	9212.5^{b}	3.26^{a}	2526.9^{a}	2165.5^{a}	$M_{50}B_{50}$	75
21.2^{b}	9587.5^{a}	3.23^{a}	2220.7^{c}	2011.6^{b}	$M_{25}B_{75}$	75
14.87^{g}	6975^{f}	1.67^{g}	1009.3^{f}	1033.9^{hg}	$M_{100\%}$	150
14.94^{g}	6961.3^{gf}	1.8^{f}	1053.7^{f}	1039.6^{hg}	$M_{75}B_{25}$	150
15.94^{fe}	6662.5^{g}	1.33^{h}	1006.9^{f}	1060.1^{g}	$M_{50}B_{50}$	150
15^{gf}	6775^{gf}	1.29^{h}	1045.2^{f}	1010.4^{h}	$M_{25}B_{75}$	150

M'100% pure marigold cultivation M'75B'25 cultivation 75% marigold+25% beans
M'50B'50 Cultivation of 50% marigolds + 50% beans M'25B'75 Cultivation of 25% marigolds + 75% beans

Table 3. *Variance analysis of investigated characteristics of beans in intercropping with beans.*

Bean protein yield	Bean protein yield	HI Beans	Biological yield Bean	DF	Source
290.4326$^{n.s}$	290.4326$^{n.s}$	0.69353$^{n.s}$	7.5$^{n.s}$	1	Year
71.2665$^{n.s}$	71.2665$^{n.s}$	1.17293$^{n.s}$	48244.2$^{n.s}$	6	Rep (year)
284826.0904**	284826.0904**	2768.94264**	51032800.8**	2	Nitrogen
1437.1421**	1437.1421**	0.27879$^{n.s}$	25292.5$^{n.s}$	2	year*nitrogen
236.8072$^{n.s}$	236.8072$^{n.s}$	1.65565$^{n.s}$	63553.3$^{n.s}$	12	nitrogen*rep (year)
123094.4246**	123094.4246**	4011.79854**	150777897.1**	4	Intercrop
18667.888**	18667.888**	177.10497**	5102769.6**	8	nitrogen*intercrop
147.599$^{n.s}$	147.599$^{n.s}$	1.36445$^{n.s}$	2122.1$^{n.s}$	4	year*intercrop
418.4814*	418.4814*	5.64155**	14844.6$^{n.s}$	8	year*nitrogen*intercropp
169.965	169.965	1.3119	61474.6	72	Error
10.21487	10.21487	4.95294	5.532024		c. v

Table 4. *Comparison of the average effect of cropping pattern and nitrogen fertilizer on the studied characteristics of beans.*

Bean protein yield (kg/h)	% Bean protei	HI Beans (%)	Biological yield Bean (kg/h)	intercropp	nitrogen
100.77^{d}	7.23^{f}	33.26^{d}	4581.3^{e}	$M_{100\%}$	0
102.77^{d}	7.89^{f}	34.85^{b}	3742.5^{g}	$M_{75}B_{25}$	0
94.57^{d}	7.14^{f}	33.67^{cd}	4012.5^{f}	$M_{50}B_{50}$	0
90.4^{d}	7.18^{f}	34.54^{bc}	3656.3^{g}	$M_{25}B_{75}$	0
276.7^{b}	11.37^{b}	35.64^{ab}	6762.5^{a}	$M_{100\%}$	75
290.45^{a}	12^{a}	35.12^{b}	6873.8^{a}	$M_{75}B_{25}$	75
302.08^{a}	11.95^{ab}	35.37^{b}	6937.5^{a}	$M_{50}B_{50}$	75
256.04^{c}	11.56^{ab}	36.7^{a}	6050^{c}	$M_{25}B_{75}$	75
102.43^{d}	10.15^{c}	17.48^{e}	5437.5^{d}	$M_{100\%}$	150
103.07^{d}	9.77^{cd}	17.4^{e}	6375^{b}	$M_{75}B_{25}$	150
93.62^{d}	9.3^{d}	16.87^{ef}	6037.5^{c}	$M_{50}B_{50}$	150
101.5^{d}	9.7^{cd}	15.98^{f}	6762.5^{a}	$M_{25}B_{75}$	150

3.6. Protein Percentage of Bean Seeds

The effect of planting pattern on protein percentage of bean seed was significant at 1% level (Table 3). The effect of nitrogen on protein percentage of bean seed was also significant at 1% level. Also, the interaction effect of planting pattern and nitrogen was significant at 1% level. The treatment of 50% of broad Vicia faba L. and 50% of marigolds at 75 kg/ha of nitrogen with 12% had the highest percentage of bean seed protein (Table 4). It accounted for 7.1 percent. Considering that the protein percentage is obtained from the product of seed nitrogen percentage in 6.25, from the obtained results, we can conclude that the seed nitrogen percentage was the highest in the consumption of 75 kg/ha of nitrogen.

3.7. Bean Seed Protein Yield

Pattern Effect Planting on protein yield of bean seed was significant at 1% level (Table 3), the effect of nitrogen on protein yield of bean seed was significant at 1% level, also the interaction effect of planting pattern and nitrogen was significant at 1% level. The treatment of 75% of broad Vicia faba L. and 25% of marigolds at 75 kg/ha of nitrogen had the highest bean seed protein yield with 302 kg/ha, which was not significantly different from the treatment of 50% of broad Vicia faba L. and 50% of marigolds at 75 kg/ha of nitrogen. (Table 4) The lowest bean seed protein yield was assigned to the 100% bean treatment with no nitrogen use with 90.4 kg per hectare, which was not significantly different from the no nitrogen use and 150 kg nitrogen treatments. Since the protein yield is the product of protein percentage and bean seed yield, and according to the results obtained in the treatments with 75 kg/ha of nitrogen, the protein percentage and seed yield were the highest, and as a result of these treatments, the protein yield is the highest.

3.8. Marigold and Bean Seed Nitrogen Percentage

The effect of planting pattern on the percentage of marigold seed nitrogen was significant at the level of 1% (Table 5). The effect of nitrogen on the percentage of marigold seed nitrogen was significant at the level of 1%. Also, the interaction effect of planting pattern and nitrogen was significant at the level of 1%, which with all treatments 75 kg of nitrogen had no significant difference. The treatment of 50% of broad Vicia faba L. and 50% of marigolds at 75 kg/ha of nitrogen had the highest nitrogen percentage of marigold seeds with 0.11%/ha, which was not significantly different from all treatments of 75 kg of nitrogen. (Table 6) The lowest percentage of marigold seed nitrogen was allocated to the treatment of 25% of Vicia faba L. and 75% of marigolds in the absence of nitrogen consumption with 0.08%. The results showed that by increasing the use of nitrogen fertilizer from the optimal level, the percentage of seed nitrogen has decreased, which can be attributed to the loss of parts of the plant's roots and also to the reduction of nitrogen fixation by the bean roots.

The effect of planting pattern on nitrogen percentage of bean seeds was significant at 1% level (Table 5). Nitrogen had no significant difference. The treatment of 50% of broad Vicia faba L. and 50% of broad Vicia faba L. at 75 kg/ha of nitrogen with 1.9%/ha had the highest percentage of nitrogen in bean seeds. (Table 6) The lowest percentage of nitrogen in bean seeds was assigned to the treatment of 75% of Vicia faba L. and 25% of Vicia faba L. in the absence of nitrogen consumption with 1.14%, which is with all treatments.

3.9. Nitrogen Use Efficiency of Marigold

The effect of planting pattern on the efficiency of marigold nitrogen use was significant at the 1% level (Table 5). 75 kg of nitrogen had no significant difference. The treatment of 25% of broad Vicia faba L. and 75% of marigolds in the absence of nitrogen consumption with 22.85 grams of seeds per gram of nitrogen consumption had the highest nitrogen utilization efficiency of marigolds, which was not significantly different from all treatments of nitrogen deficiency. (Table 6) The lowest efficiency of marigold nitrogen use was assigned to the treatment of 75% of Vicia faba L. and 25% of marigold in 150 kg of nitrogen at the rate of 13.9 grams of seeds per gram of nitrogen used, which was not significantly different from all treatments of 150 kg of nitrogen.

Nitrogen utilization efficiency (physiological efficiency) is the performance of the production product per the amount of nitrogen in the biomass. The increase in the use of nitrogen fertilizer caused a decrease in the efficiency of nitrogen consumption. In the conditions where nitrogen fertilizer was not used (control treatment), the highest efficiency of nitrogen use was 22-21 grams of sunflower seeds per gram of nitrogen, but when 75 kilograms of nitrogen fertilizer was used per hectare, the efficiency of nitrogen consumption was between 17-20 grams of sunflower seeds per gram. It was nitrogen, with the use of 150 kg/ha of nitrogen fertilizer, the efficiency of using this element was 13-14 grams per gram of nitrogen. According to the law of diminishing returns regarding the consumption of nutrients, because the primary units of fertilizer have a greater effect on performance, the more nitrogen consumption increases, the efficiency of its use decreases. In their research, Sinbo and colleagues [21] found that increasing the use of nitrogen fertilizer decreases the efficiency of nitrogen use.

3.10. Marigold Seed Nitrogen Uptake Index

The effect of planting pattern on the nitrogen harvest index of marigold seeds was significant at the 1% level (Table 5). The treatment of 100% marigold in 75 kg of nitrogen had the highest nitrogen harvest index of marigold seeds with 23.68%, which was not significantly different from the treatment of 50% of Vicia faba L. and 50% of marigold in 75 kg/ha of nitrogen. (Table 6) The lowest marigold seed nitrogen harvesting index was assigned to the treatment of 100% marigold in 150 kg of nitrogen at the rate of 12.86%, which was not significantly different from all treatments of 150 kg of nitrogen. The obtained results show that with the increase in nitrogen fertilizer consumption, the nitrogen harvesting index of marigold seeds has decreased, which can be attributed to the loss of roots due to the high consumption of nitrogen fertilizer and the decrease in the transfer of nitrogenous photosynthetic materials to the marigold seeds.

Table 5. *Variance analysis of investigated traits of marigolds in intercropping with beans and marigolds.*

NHI Beans	NUEt Beans	% Nitrogen of bean seeds	NHI Marigold	NUEt Marigold	% Nitrogen of Marigold seeds	DF	Source
10.56047$^{n.s}$	0.052865$^{n.s}$	0.02408333$^{n.s}$	1.471415**	2.196525$^{n.s}$	0.00029297**	1	Year
10.69373$^{n.s}$	1.934425$^{n.s}$	0.00269667$^{n.s}$	4.069985$^{n.s}$	2.955614$^{n.s}$	0.00000589$^{n.s}$	6	Rep (year)
480.69791**	237.605378**	3.1320175**	450.625251**	382.763454**	0.00581547**	2	nitrogen
21.40905$^{n.s}$	0.798541$^{n.s}$	0.03102083*	5.802728$^{n.s}$	18.259638*	0.00091547**	2	year*nitrogen
7.7228$^{n.s}$	3.094022$^{n.s}$	0.0036925$^{n.s}$	0.926041$^{n.s}$	0.766905$^{n.s}$	0.00001547$^{n.s}$	12	nitrogen*rep (year)
5343.80351**	2352.598572**	11.35618208**	1628.755863**	1693.572947**	0.04717005**	4	intercropp
59.49553**	22.652441**	0.21331646**	34.580249**	27.940961**	0.00046911**	8	nitrogen*intercropp
10.28957$^{n.s}$	4.383678$^{n.s}$	0.00807292$^{n.s}$	6.629107$^{n.s}$	5.320671$^{n.s}$	0.00005443$^{n.s}$	4	year*intercropp
14.57328$^{n.s}$	3.239983$^{n.s}$	0.00843229$^{n.s}$	10.985114**	8.845579**	0.00043943**	8	year*nitrogen*intercropp
9.49031	3.90406	0.00987931	3.558559	2.854756	0.00002304	72	Error
11.55693	11.16746	8.084156	12.83263	11.27108	6.070908		c.v

Table 6. *Comparison of the average effect of cropping pattern and nitrogen fertilizer on the examined characteristics of broad bean and marigold.*

% NHI Beans seed	NUEt been	% Nitrogen of bean seeds	% NHI Marigold seed	NUEt Marigold	% Nitrogen of Marigold seeds	intercropp	nitrogen
0	0	0	19.13^{b}	22.56^{a}	0.085^{cd}	$M_{100\%}$	0
30^{c}	25.94^{ab}	1.16^{f}	19.11^{b}	22.86^{a}	0.083^{d}	$M_{75}B_{25}$	0
30.4^{c}	24.19^{bc}	1.26^{f}	20^{b}	22.6^{a}	0.089^{c}	$M_{50}B_{50}$	0
29.1^{c}	25.4^{ab}	1.14^{f}	19.4^{b}	21.8^{ab}	0.089^{c}	$M_{25}B_{75}$	0
31^{c}	27^{a}	1.15^{f}	0	0	0	$B_{100\%}$	0
0	0	0	23.7^{a}	20.62^{c}	0.12^{a}	$M_{100\%}$	75
36.7^{a}	20.18^{e}	1.82^{b}	20.7^{b}	17.95^{d}	0.12^{a}	$M_{75}B_{25}$	75
39.44^{a}	20.48^{de}	1.9^{a}	23^{a}	19.87^{c}	0.116^{a}	$M_{50}B_{50}$	75
38.5^{a}	20.13^{e}	1.9^{ab}	20.4^{b}	17.66^{d}	0.116^{a}	$M_{25}B_{75}$	75
38.34^{a}	20.8^{de}	1.85^{ab}	0	0	0	$B_{100\%}$	75
0	0	0	12.87^{c}	14.94^{e}	0.086^{cd}	$M_{100\%}$	150
36.1^{b}	22.25^{cd}	1.63^{cd}	13.5^{c}	15.47^{e}	0.088^{cd}	$M_{75}B_{25}$	150
31.7^{c}	20.3^{de}	1.56^{cd}	14.7^{c}	14.6^{e}	0.10^{b}	$M_{50}B_{50}$	150
29.3^{c}	19.8^{e}	1.5^{d}	14^{c}	13.93^{e}	0.10^{b}	$M_{25}B_{75}$	150
29.3^{c}	18.95^{e}	1.55^{cd}	0	0	0	$B_{100\%}$	150

4. Conclusion

The results showed that the effect of using different amounts of nitrogen fertilizer on yield, nitrogen use efficiency and nitrogen harvesting index of perennial and bean plants was significant. In most of the analyzed traits, the treatment of 50% of broad Vicia faba L. and 50% of marigold at 75 kg/ha of nitrogen was superior to the other treatments.

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