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THE EFFECT OF COMMERCIAL ORGANIC AND INORGANIC FERTILIZERS AND RHIZOBIUM INOCULATION ON YIELD AND YIELD COMPONENTS OF FABA BEAN (*VICIA FABA* L.) AND PEA (*PISUM SATIVUM* L.)

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ABSTRACT. This research was conducted to determine the effect of organic and inorganic fertilizers and bacteria inoculation on yield and its components on pea and faba bean in Dicle University Agricultural Faculty, Diyarbakir, Turkey, during 2018 and 2019 growing seasons. The experiment was laid out following a split-plot in completely randomized block design, with three replications. Fertilization treatments and cultivars were designed as main and sub factors, respectively. Data on plant height, plant biomass, pod weight, seed yield per plant, number of pods and number of seeds per plant, biological yield, seed yield and 100-seed weight were recorded at harvest. Number of nodules and nodule dry weight were record in flowering time. The effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on grain yield, seed yield per plant, biological yield was significant at both pea and faba bean. Inorganic fertilizer (urea) was increased the grain yield (2147 kg/ha) and biological yield (4956 kg/ha) in faba bean, but close to control (2080 kg/ha and 4690 kg/ha). Organic-1, Organic-2 and bacteria treatments were decrease the grain yield and biological yield on pea and faba bean, and this decrease on pea was almost half over control. The effect of treatments on number of nodules per plant on pea and faba bean was significant. The highest number of nodules per plant on pea was in bacteria inoculation (125.9) and control (121.5), and differences among nitrogen (109.1), Organic-1 (97.3) and Organic-2 (109.3) treatments was no significant.

Keywords: pea; faba bean; fertilization; nodule; yield.

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INTRODUCTION

Legumes are an important source of protein for humans and livestock. They provide nutritionally rich crop residues for animal feed and also humans and play a key role in maintaining the productivity of soil (Elsheikh, 2011).

Field pea and faba bean are marketed as a dry, shelled product for food. They are commonly used throughout the world in human diets and have high levels of amino acids, lysine and tryptophan, which are relatively low in cereal grains and contains approximately 21-25% protein. Being legume crops and have the inherent ability to obtain much of its nitrogen requirement from the atmosphere by forming a symbiotic relationship with *Rhizobium* bacteria in the soil (Mishra *et al.,* 2010)

Poor soil fertility is one of the biggest problems limiting economically successful agricultural production worldwide. The lack of nutrients in the soil is a specific problem for small farmers which have small landowners in developing countries where monoculture farming is high.

Fertilizer is very important for crop growth and productivity. One example of fertilizer is cow dung, which is obtained from cow, which is environmental friendly, is easily used and compared with chemical fertilizer which increases the environmental problems. Organic fertilizers are used easily from locality products and livestock wastes and cost effective than chemical fertilizer (Solomon *et al.,* 2012).

One of the immediate reasoning to improve agricultural productivity and development is the use of more chemical fertilizers. However, with the resultant effects of heavy fertilizer use in many regions of the world, it is compelling to look for alternatives. Integration of microbial inoculants with less fertilizer, should be considered in many situations as it promises high crop productivity and agricultural sustainability (Adesemoye *et al.,* 2009).

The reduction of chemical fertilizers by using biological fertilizers based on bacteria involved in nitrogen fixation is one of the effective steps in sustainable agriculture. Owing to population growth and increasing food demand, intensive and environment-friendly agricultural bio-fertilizers have become the ideal model for this agriculture system (Adesemoye and Egamberdieva, 2013).

Recently, organic fertilizers, as alternatives to chemical fertilizers and especially the growing of legumes that have an important place in the nitrogen cycle, are examined (Silsbury, 1990). The choices of suitable forms of fertilizer of the crop growth of the plant are governed by local, natural condition and variation in soil and climate with regard to their suitability for crops cultivation.

Biofertilizers are organic products, containing living cells of different types of microorganisms, which have the ability to convert

nutritionally important elements from unavailable to available form, through biological processes (Vessey, 2003). The *Rhizobium*, as fertilizer in pulses, could fix 50-200 kg of N/ha/season and is able to meet 80-90% of the crop requirement for nitrogen. Inoculation in these crops was found to increase the crop yield by about 10-15%, under on farm conditions (Khurana and Dudeja, 1997).

The humic substances are formed through the chemical and biological transformation of plant and animal matter by the biological activities of microorganisms. These substances influence plant growth directly and indirectly. Humic acid is an important component of humic substances that contains many functional groups situated at the carbon chain. They could be acidic, alkaline or neutral groups, which improve plant growth (Patil *et al.*, 2011).

The present study was conducted to determine the effects of organic and inorganic fertilizers and rhizobium inoculation on grain yield and its components of faba bean and pea crops.

MATERIALS AND METHODS

This research was conducted to determine the effect of organic and inorganic fertilizers and bacteria inoculation on yield and its components on pea and faba bean crops in Dicle University, Agricultural Faculty, Diyarbakir, Turkey, during 2018 and 2019 growing seasons.

Experimental area

Diyarbakir is located on grid 37.91°N and 40.2°E, at an altitude of 640 m above sea level. The general climatic conditions of experimental area were characterized as hot and drought, during crop growing season. Average long term precipitation is a little bit lower than 500 mm, and it differently fluctuates among the years. The seasonal rainfall distribution is mainly between November and June. Although unusual, irregular precipitation in June is recorded in recent years. Mean temperature is about 16-20ºC, between January and June. Month of May has an irregular precipitation distribution, but June is usually dry and hot. The relative humidity varies between 60% and 75%, from January to April, but decreases to about 20-30%, after May. In the first experiment year (2018), total precipitation from February to April was 146.8 mm, and weather was dry, but in May, rainfall was 157.8 mm. Mean temperature (February to May) was 11.9ºC. Precipitation from February to April was 365.2 mm, in the second year (2019), but May was considerably dry, with 45.8 mm, and mean temperature (February to May) was 11.35ºC. Growing season in 2019 was quite cool, compared to the preceding growing season (*Table 1*).

The soil analysis indicated that soils were neutral chemical reaction (pH: 7.24), insufficient in organic matter (0.79%) and phosphorus content (13.2 kg ha^{-1}), with clay texture.

Experimental design and agricultural practices

The experiment was laid out following a split-plot in completely randomized block design, with three replications. Fertilization treatments and cultivars were designed as main and sub factors, respectively. Fertilization treatments included of control, inorganic nitrogen as urea, Organic-1, Organic-2 fertilizers and bacteria application. Local varieties of pea and faba bean, collected

from villages of Mediterranean region of Turkey, were used. The seeds were sown with inter and intra row space of 40 × 10 cm, respectively, on 7 February 2018 and 11 February 2019 (Albayrak *et al.,* 2015).

Before sowing, seeds were inoculated with specific strains of *Rhizobium* (*R. leguminosarum* and *R. pisi*) at a rate of 10 g/kg seed as bacteria treatment both pea and faba bean. Inorganic nitrogen were applied at a rate of 40 kg ha^{-1} as urea (46%). Organic-1 fertilizer was consisted of organic materials (45%), organic carbon (20%), organic nitrogen (6%), free amino acids (3.5%) and pH (6-8). Organic-2 fertilizer was contained 45-50% organic material and %50 fulvic acid. Weed, disease and pests were controlled first manually and then using chemical spray. Data on plant height, plant biomass, pod weight, seed yield per plant, number of pods and number of seeds per plant, biological yield, seed yield and 100-seed weight were recorded at harvest.

Data of two years were analyzed separately and pooled by analysis of variance, and means were separated using the Duncan's Multiple Range Test (0.05).

Table 1 - Meteorological data of Diyarbakir for experiment years

Month	Mean temperature (°C)		Total precipitation (mm)		Moisture (%)	
	2018	2019	2018	2019	2018	2019
January	5.2	3.8	86.6	67.6	77.3	81.7
February	7.6	5.4	86.4	77.4	74.5	77.0
March	12.3	8.2	11.6	135.2	63.2	74.9
April	15.9	11.8	48.8	152.6	53.0	78.4
May	19.4	20.1	157.8	45.8	67.5	58.5
June	26.5	28.3	14.4	1.0	37.9	32.5
July	31.2	30.3	0.0	0.07	24.2	24.8

RESULTS AND DISCUSSION

The effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on grain yield, seed yield per plant, biological yield was significant at both pea and faba bean. The effect of treatments on plant biomass was significant on faba bean.

Inorganic fertilizer (urea) was increased the grain yield (2147 kg/ha) and biological yield (4956 kg/ha) in faba bean, but close to control (2080 kg/ha and 4690 kg/ha). Organic-1, Organic-2 and bacteria treatments were decrease the grain yield and biological yield on pea and faba bean, and this decrease on pea was almost half over control.

The lowest grain yield on pea and faba bean was in Organic-2 treatment (882 kg/ha and 1819 kg/ha) and bacteria inoculation (896 kg/ha and 1771 kg/ha). The lowest biological yield on pea and faba bean was in bacteria inoculation (2664 kg/ha and 3867 kg/ha) (*Fig. 1*).

Lal *et al.* (2004) and Servani *et al.* (2014) reported that grain yield increased by nitrogen applications. Ngeno *et al.* (2012) reported that bacteria application was no increased the seed yield. Brkić *et al.* (2004) reported that the effect of nitrogen fertilization depended on the soil type, seed inoculation and molybdenum application increased pea yield.

Organic-1 and Organic-2 fertilizers, which involved humic acid, showed low performance the yield and its components in our study, this may be due to the application dose and the time of application of the fertilizer. Whereas, Patil *et al.,* Wadje (2011) revealed humic acid is an important component of humic substances that contains many functional groups situated at the carbon chain, and they could be acidic, alkaline or neutral groups, which improve plant growth. Differences among years and treatment × year interaction were significant for grain yield, biological yield, plant biomass and seed yield per plant both faba bean and pea (*Table 2*).

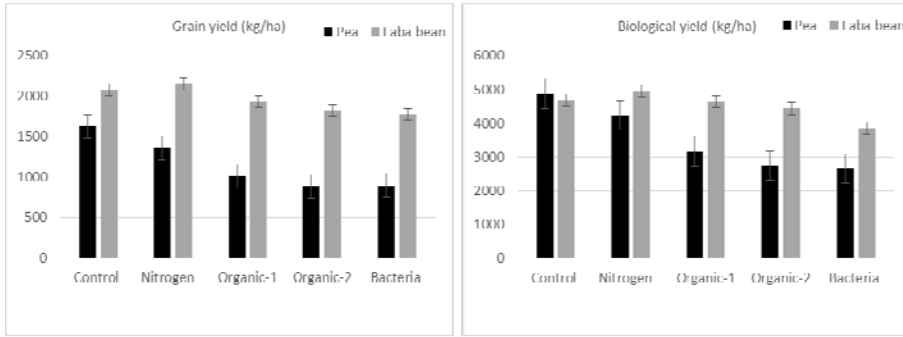

Figure 1 - Effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on grain yield (kg/ha) and biological yield (kg/ha) on pea and faba bean plants

The highest plant biomass (27.3 g) and seed yield per plant (14.1 g) on faba bean was observed from bacteria inoculation, and differ from control (23.8 g for plant biomass and 12.6 g for seed yield per plant). The differences among other treatments for plant biomass on faba bean were no significant. The lowest seed yield per plant (8.9 g) on faba bean was in Organic-2 treatment. The maximum seed yield per plant (7.0 g) on pea was in control, compared to other treatments (*Fig. 2*). In our study, organic treatments showed poor performance for plant traits, however, Dawood *et al.* (2019) noted that humic acid caused the highest significant increases of all vegetative growth parameters relative to control. The effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on number of seeds per plant on pea and plant pod weight on faba bean was significant. The highest number of seeds per plant (26.1 seeds/plant) on pea was obtained from control, and treatments (Organic-1, Organic-2, nitrogen and bacteria inoculation) had decreased the number of seeds per plant. Plant pod weight ranged from 11.7 g to 17.4 g on faba bean. The maximum pod weight was in bacteria inoculation, and the lowest value was in Organic-2 treatment (*Fig. 3*). Otherwise, Sunday and Asaba (2018) reported that low pod yield recorded under control plots.

Table 2 - Effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on plant traits on pea and faba bean over two years

	Biological yield (kg ha^{-1})		Grain yield (kg ha^{-1})		Plant seed yield (g)		Plant biomass (g)		Number of seeds plant^{-1}	
	Pea	Faba bean	Pea	Faba bean	Pea	Faba bean	Pea	Faba bean	Pea	Faba bean
					2018					
Control	4807 a	5611 a	1486 b	2854 a	9.93 a	20.1ab	25.1 a	34.6 b	35.9 a	17.0 a
Nitrogen	5133 a	4660 bc	1562 b	2339 b	6.74 b	15.0 c	21.8 ab	28.0 c	24.9 cd	16.0 a
Organic-1	3850 b	4642 bc	1097 c	2345 b	7.53 ab	19.4 b	18.4 b	31.2 b	28.0 bc	18.3 a
Organic-2	2700 cd	4432 cd	845.7 d	2262 b	5.91 b	11.9 d	18.5 b	26.9 c	22.3 de	12.2 b
Bacteria	3267 bc	4671 bc	1078 c	2421 b	8.7 a	21.9 a	21.6 ab	40.5 a	29.8 b	16.7 a
					2019					
Control	4962 a	3768 d	1768 a	1307 de	4.1	5.2	11.3	12.9	16.4 f	6.8 c
Nitrogen	3328 bc	5251 ab	1156 c	1954 c	3.8	5.6	11.2	13.2	16.3 f	6.5 c
Organic-1	2493 d	4642 bc	929 d	1523 d	4.4	5.6	12.7	14.7	18.5 ef	7.6 c
Organic-2	2774 cd	4459 c	918 d	1377 d	4.5	6.0	12.6	13.9	22.1 de	8.3 c
Bacteria	2061 d	3062 e	714 e	1121 e	3.5	6.3	9.3	14.1	17.1 f	8.1 c
LSD (0.05) int.	721*	678*	125**	253**	1.85*	2.25*	3.39*	4.84*	4.52*	3.37*
					Years					
2018	3951 a	4803 a	1214 a	2444 a	7.7 a	17.7 a	21.1 a	32.2 a	28.2 a	16.0 a
2019	3124 b	4236 b	1097 b	1456 b	4.1 b	5.7 b	11.4 b	13.8 b	18.1 b	7.5 b

**, * and ns: significant at 1 and 5% level, and not significant, respectively

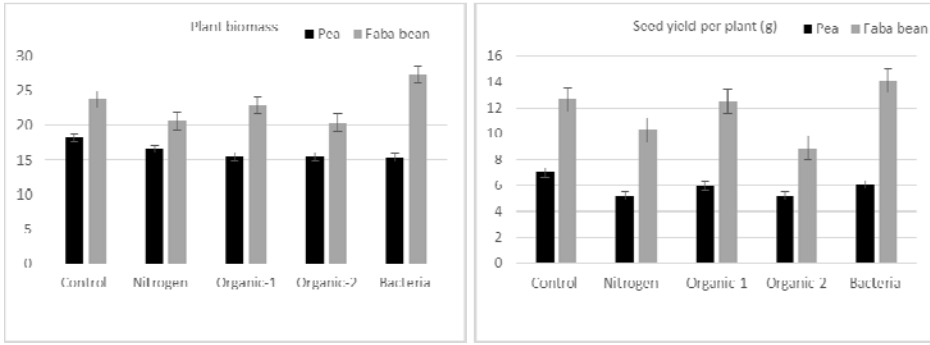

Figure 2 - Effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on plant biomass per plant (g) and seed yield per plant (g) on pea and faba bean plants

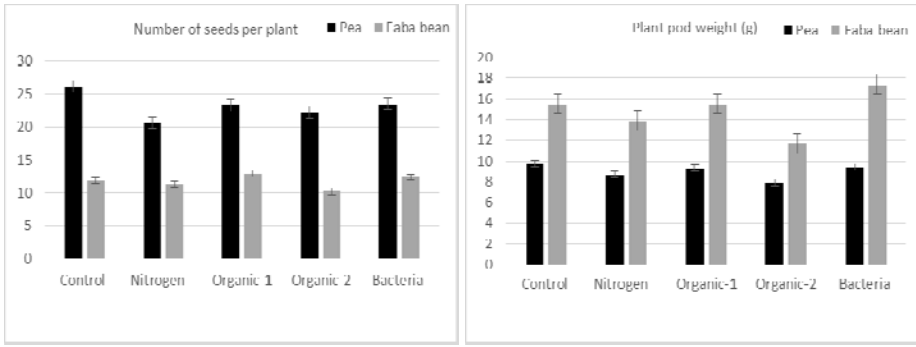

Figure 3 - Effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on number of seeds per plant and plant pod weight per plant (g) on pea and faba bean plants

Differences among years and treatment × year interaction were significant for number of seeds per plant and pod weight, both faba bean and pea (*Table 2*).

Some authors noted that high of nitrogen fertilization with rhizobium inoculation reduced nodulation which brought about a reduction in yield parameters (Brkić *et al.,* 2004).

Organic-1 and Organic-2, despite of humic compounds, were exhibited low performance, but Moraditochaee (2012) noted that humic acid significantly increased seed yield, straw yield and biological yield of peanut. Kumar *et al.* (2005) stated that biological fertilizers with low rates of chemical fertilizers on sesame significantly increased the number of capsules per plant and seed yield. Taylor and Smith (1992) reported that increasing nitrogen up to 200 kg N ha significantly increased the number of pods per plant. If the amount of nitrogen is much less favorable for plant growth and nitrogen removed from mature leaves and young parts transmitted, in this case nitrogen deficiency symptoms, such as

accelerated aging can be seen in older leaves (Pashaki *et al.*, 2016).

The effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on fresh nodule weight was significant on pea. The highest fresh nodule weight on pea was in bacteria inoculation (0.8 g), but Organic-1 (0.5 g), Organic-2 (0.4 g) and nitrogen (0.45 g) treatments were no differ from control (0.5 g). Surprisingly, any fertilizer addition did not enhance the dry nodule weight of peas and faba bean *(Fig. 4)*.

Year and treatment × year interaction for fresh nodule weight on pea and faba bean was significant *(Table 3)*. Giller and Cadisch (1995) reported that small amounts of available soil or fertilizer N have often been shown to have a stimulatory effect on legume nodulation and N_2 fixation. However, Namvar *et al.* (2011) revealed that the presence of high rates of N can inhibit the nodulation and symbiotic N fixation in legumes. Similarly, David and Khan (2001) reported that addition of nitrogen to the soil severely depressed the nodulation on chickpea (*Cicer arietinum*).

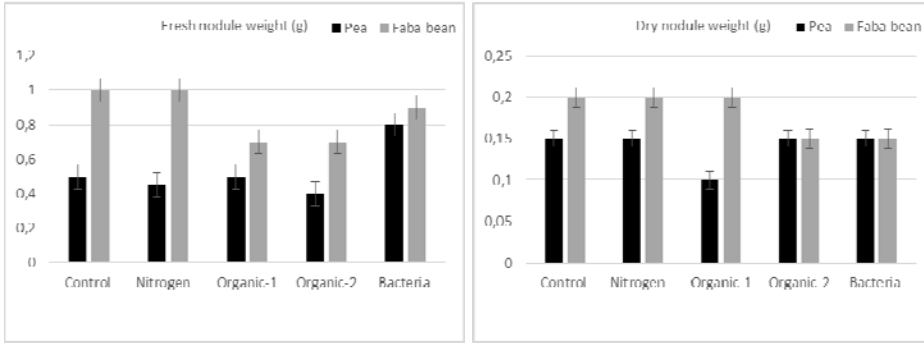

Figure 4 - Effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on fresh and dry nodule weight per plant (g) on pea and faba bean

The effect of treatments on number of nodules per plant on pea and faba bean was significant. The highest number of nodules per plant on pea was in bacteria inoculation (125.9) and control (121.5), and differences among nitrogen (109.1), Organic-1 (97.3) and Organic-2 (109.3) treatments was no significant. In faba bean, the highest number of nodules per plant was in nitrogen treatment, but Organic-1 (111.6), Organic-2 (113.2) and bacteria (130.0) treatments were no differ from control (128.0) (*Fig. 5*). Year and treatment × year interaction for number of nodules per plant at both pea and faba bean was significant (*Table 3*). Olivera *et al.* (2002) reported that rhizobium inoculation increased positive effect on number of nodes and nitrogen fixation in faba bean. Organic fertilizer addition significantly reduced nodules of pea in the field.

Table 3 - Effect of inorganic nitrogen, organic fertilizers and bacteria Inoculation on plant traits on pea and faba bean over two years

Treatments	Plant pod weight (g)		Number of nodules per plant		Fresh nodules weight (g)		Dry nodules weight (g)		100 seed weight (g)	
	Pea	Faba bean	Pea	Faba bean	Pea	Faba bean	Pea	Faba bean	Pea	Faba bean
2018										
Control	13.6 a	24.7 ab	190.7 a	96.0 d	0.8 a	0.5 d	0.2	0.1	25.36	108.4 b
Nitrogen	11.0 b	20.7 c	149.0 b	145.7 bc	0.6 a	0.8 b	0.2	0.1	25.23	101.3 b
Organic-1	11.1 b	23.7 bc	86.3 d	102.0 cd	0.4 b	0.4 d	0.1	0.1	25.86	107.4 b
Organic-2	8.4 c	15.7 d	139.3 b	166.7 bc	0.4 b	0.5 d	0.2	0.1	25.13	103.2 b
Bacteria	13.2 a	27.4 a	177.7 a	174.0 b	0.7 a	0.7 b	0.2	0.1	25.40	134.5 a
2019										
Control	5.7 d	6.4 e	52.3 e	160.0 b	0.2 c	1.5 a	0.1	0.3	22.58	74.6 c
Nitrogen	6.4 cd	7.1 e	69.3 d	221.3 a	0.3 c	1.2 a	0.1	0.3	22.91	77.5 c
Organic-1	7.4 cd	7.2 e	108.3 c	121.3 c	0.6 a	1.0 c	0.1	0.3	22.47	76.2 c
Organic-2	7.4 cd	7.7 e	79.3 d	59.7 e	0.4 b	0.8 b	0.1	0.2	22.97	73.0 c
Bacteria	5.7 d	7.3 e	74.0 d	86.0 d	0.9 a	1.1 a	0.1	0.2	22.48	73.7 c
LSD (0.05) int.	2.4*	3.6**	23.1*	25.7*	2.9*	0.4*	ns	ns	ns	7.87*
Years										
2018	11.5 a	22.4 a	148.6 a	136.9 a	0.58	0.58 b	0.18	0.10 b	25.40 a	110.9 a
2019	6.5 b	7.1 b	76.6 b	129.7 b	0.48	1.12 a	0.10	0.26 a	22.68 b	75.01 b

**, * and ns: significant at 1 and 5% level, and not significant, respectively.

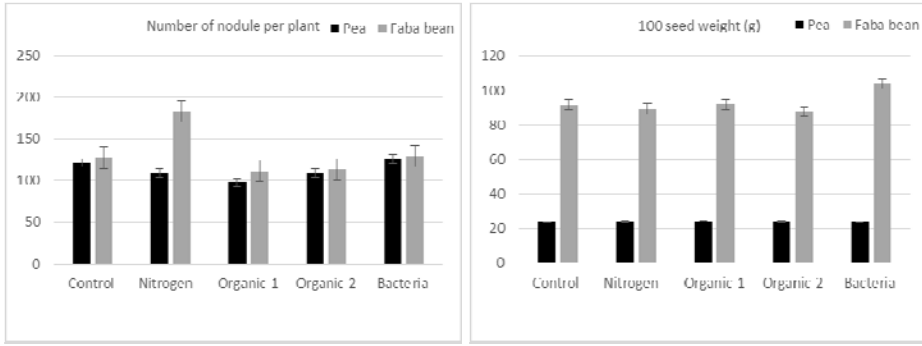

Figure 5 - Effect of inorganic nitrogen, organic fertilizers and bacteria inoculation on number of nodules per plant and 100 seed weight on pea and faba bean

One explanation for the present results would be an increased microbial competition in the rhizosphere. Another possible explanation would be that the addition of available nutrients, especially humic acid in Organic-2 fertilizer, decreases the dependency of plants on nodule (Marschner *et al.,* 2004). The maximum 100-seed weight (104.1 g) on faba bean was in bacteria inoculation, but nitrogen (89.4 g), Organic-1 (91.8 g) and Organic-2 (88.1 g) treatments were no differ from control (91.5 g). The effect of treatments for 100 seed weight on pea was no significant (*Fig. 5*). Treatment × year interaction for 100-seed weight faba bean was significant.

CONCLUSION

It is recommended to apply plant nutrients in soils with low organic matter content. In organic fertilizer applications, especially application dose should be adjustment well. There is no need for bacterial inoculation in soils with special bacterial race.

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