FIMEK

Journal of Agronomy, Technology and Engineering Management

Article

The effect of fertilizer treatment on plant traits of faba bean in pre-blooming and full blooming periods under greenhouse conditions

Fatma Basdemir [1], Zubeyir Turk [2], Seval Elis [3], Murat Tunç [3], Sibel Ipekesen [3] and Behiye Tuba Bicer [3,*]

[1] Ceylanpinar Agriculture Vocational School, Harran University, 63300 Şanlıurfa, Turkey
[2] Agriculture Vocational High School, Dicle University, 21280 Diyarbakir, Turkey
[3] Department of Field Crops, Faculty of Agriculture, Dicle University, 21280 Diyarbakir, Turkey; tbicer@dicle.edu.tr
* Correspondence: tbicer@dicle.edu.tr

Received: 15 November 2019; Accepted: 3 March 2020

Abstract: This experiment was conducted out at Dicle University Agriculture Faculty, Diyarbakir, Turkey during February-May, 2019 in the greenhouse. This research was aimed to determine the effect of fertilizer treatments (organic and inorganic) at different periods (pre-blooming, full-blooming and post blooming periods) on plant traits of faba bean varieties (Salkım, Filiz 99 and Eresen 87). All traits for fertilizer treatments were evaluated separately in pre-blooming, full blooming, and post-blooming. The effect of treatment on the number of nodules plant^{-1} and the fresh nodule weight was significant. P fertilizer treatment was generally higher than other treatments. The effect of treatments on fresh and dry leaf weight was significant in the pre-flowering period. Fresh leaf weight ranged from 5.9 g in bacteria inoculation to 8.3 g in N fertilizer. Dry leaf weight in N (0.81 g), control (0.79 g) and P (0.73 g) were high, but in organic fertilizer (0.69 g) and bacteria inoculation (0.62 g) treatments were low.

Keywords: *Vicia faba;* fertilizer; phosphourus; nitrogen; bacteria; nodule

---

1. Introduction

Faba beans (*Vicia faba* L.), one of the Leguminosae crops cultivated in the world and it can be used as human food in developing countries as a green vegetable or dried, fresh. Faba bean seeds are high in protein, vitamins, and minerals. Faba bean responds to and changes its environment by altering on-site soil fertility, microclimate, and co-habitats of wild flora and fauna. Besides its worldwide use for food and feed, extensive knowledge exists about its ability to symbiotically fix and add nitrogen to the soil, making additional soil nitrogen available and thereby enhancing and sustaining soil productivity [1].

Nitrogen fixation is a process of changing atmospheric nitrogen to ammonia or other molecules needed by living organisms. Nitrogen fixation is an important process for agriculture and the manufacturing of fertilizers. In legumes, atmospheric nitrogen (N_2) fixation happens in the nodules. Nodules grow in the roots that are produced by N_2-fixing rhizobial bacteria. Most of these bacteria belong to the genera of *Bradyrhizobium, Mesorhizobium, Rhizobium* and *Sinorhizobium* [2–5].

Fertilizer-N not only inhibits the initiation and growth of legume nodules but also inhibits nitrogen fixation activity of nodules, even after their development. Most of the emphasis has been on the effect of NO_3, which is the most common form of nitrogen available to the plant roots growing in cultivated soil. The effect of mineral nitrogen in soil on the *Rhizobium*-legume symbiosis has been reviewed. Initial nodulation and onset of nitrogen fixation by most of the legumes were stimulated by a small amount of nitrogen. In *Phaseolus vulgaris*, if this small amount of nitrogen is not added, nodule formation, nitrogen fixation, individually or both are delayed considerably [6].

While it is established that high levels of combined N inhibit the development and function of legume root nodules, the application of low-level "starter" doses of fertilizer-N is sometimes recommended to improve nodulation and N_2 fixation in the long term. The amounts of combined N which are required to optimize legume symbiosis are poorly defined [7].

Researches proved that nodulated legumes need more phosphorus than non-symbiotic plants. The direct relationship between nitrogen fixation and phosphorus content on nodules simply proves how important phosphorus is to legumes. N_2-fixing legumes that are grown with inadequate phosphorus did not grow well because nitrogen fixation on bacteroids, ammonium absorption of amino acids and ureides in the plant cell of nodules are not enough to support plant growth. These processes require more phosphorus in the transfer of energy which occurs in nodule functioning [5]. Microorganisms that increase soil fertility and have a positive effect on plant growth are called microbial fertilizers. Bacteria among the microorganisms that live free in soil [8], promote plant growth and are used as biological fertilizers are called as rhizobacteria that promote plant growth. The use of these bacteria is becoming increasingly common [9]. Although legumes do not require fertilization, many farmers and research studies have focused on this subject. This research was carried out to determine the effect of fertilizer treatments at different periods in controlled conditions.

2. Materials and Methods

This study was a greenhouse experiment conducted at Dicle University Agriculture Faculty, Diyarbakir, Turkey during February-May, 2019. Faba bean varieties (Salkım, Filiz 99 and Eresen 87) were conducted. Treatments consisted of organic, inorganic and bio-fertilizers. Inorganic fertilizers were applied at a rate of 40 kg ha^{-1} nitrogen (DAP 18-46%) and 80 kg ha^{-1} phosphor (TSP 46%). Organic fertilizer consisted of organic materials (45%), organic carbon (20%), organic nitrogen (6%), free amino acids (3.5%) and pH (6-8). *Rhizobium leguminoserum* as bio-fertilizer was inoculated at 10 g each/kg seed.

Forty-five pots (30 cm diameter) were used to triplicate five treatments with split-plot in a completely randomized block design. Each pot was filled with 10 kg soil after grinding and screening through a 2 mm sieve. The soil was clay loam with pH 7.65, organic matter 0.7%, NO_3 - N 6.23 mg kg^{-1}, and available P 13 mg kg^{-1}.

Rhizobium culture in peat was obtained from the Soil and Fertilizer Research Institute, Ankara. The seeds were sown on 11 February in 2019. All fertilizers were applied at the sowing. Plants were harvested at three periods which the pre-blooming, full-blooming and post blooming periods. Plants were washed off the soil, and were dried gently with a soft paper towel to remove any free surface moisture. In dry weight measurements, plants were dried in an oven set to heat (70 °C) overnight. Data were statistically analyzed using M-STAT C software and Duncan test was applied for treatment means at $p<0.05$.

3. Results and Discussion

Fertilizer treatments were significant for fresh plant biomass at all periods. Variety x treatment interaction was significant at pre-blooming and post-blooming period. The highest plant biomass was in the control group (36.8 g) with phosphorus (36.0 g), nitrogen (36.3 g) and organic (33.3 g) treatments at the pre-blooming period. Nitrogen (45.8 - 55.6 g) was high at full-blooming and post-blooming periods, respectively. Bacteria treatment was decreased the fresh plant biomass (Table 1).

Fertilizer treatments for plant height were significant in pre-blooming and full-blooming periods. N fertilizer treatment (46.6 - 67.8 cm) was higher than control (42.7 - 51.7 cm) in the pre and full-blooming, respectively. Nitrogen and organic fertilizer treatments were increased plant height, but bacteria treatment was decreased in pre-blooming (Table 1). Bolland et al. [10], reported that faba bean for grain yield was mostly highly responses to phosphorus (P) fertilizer treatment than wheat. Daoui et al. [11], found that plant dry weight was significantly increased when nitrogen doses even increase only from 0.0 kg to 20.0 kg per hectare.

Table 1. Effect of fertilizer treatments on plant biomass and plant height.

	Fresh plant biomass plant^{-1} (g)				Plant height (cm)			
Pre-blooming	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**
Control	33.3	35.0^{a}	42.0^{a}	36.8^{a}	41.0^{b}	38.7^{b}	48.3^{a}	42.7^{b}
Phosphorus	34.0	40.7^{a}	33.3^{b}	36.0^{a}	39.0^{b}	44.7^{a}	42.7^{a}	42.1^{b}
Nitrogen	33.7	38.3^{a}	37.0^{a}	36.3^{a}	47.7^{a}	47.0^{a}	45.0^{a}	46.6^{a}
Organic	28.7	31.0^{b}	40.3^{a}	33.3^{a}	39.3^{b}	45.3^{a}	46.3^{a}	43.7^{ab}
Rhizobium	30.0	29.7^{b}	25.0^{f}	28.2^{b}	27.3^{c}	40.0^{ab}	40.0^{b}	35.8^{c}
Mean	31.9	34.9	35.5	34.1	38.9^{b}	43.1^{a}	44.5^{a}	42.2
Full blooming								
Control	41.1	35.7	33.4	36.7^{b}	52.0^{c}	43.0^{b}	60.0^{b}	51.7^{c}
Phosphorus	36.7	39.9	34.5	37.0^{b}	60.3^{b}	66.0^{a}	67.3^{a}	64.6^{b}
Nitrogen	43.7	45.0	48.8	45.8^{a}	67.3^{a}	65.7^{a}	70.3^{a}	67.8^{a}
Organic	44.6	30.8	34.9	36.7^{b}	60.0^{b}	63.7^{a}	62.7^{b}	62.1^{b}
Rhizobium	38.4	41.4	38.7	39.5^{b}	54.0^{c}	65.0^{a}	66.0^{a}	61.7^{b}
Mean	40.9	38.6	38.0	39.2	58.73	60.67	65.27	61.5
Post blooming								
Control	38.2^{b}	51.0^{a}	45.3^{b}	44.8^{b}	79.3	78.0	76.3	77.9
Phosphorus	36.4^{b}	49.3^{a}	52.1^{a}	45.9^{b}	75.7	88.7	71.3	78.6
Nitrogen	53.6^{a}	54.3^{a}	58.9^{a}	55.6^{a}	92.0	81.0	72.0	81.7
Organic	51.3^{a}	41.4^{b}	40.6^{b}	44.4^{b}	85.3	88.3	66.3	80.0
Rhizobium	45.1^{ab}	54.2^{a}	44.6^{b}	47.9^{b}	75.7	88.0	72.7	78.8
Mean	44.9	50.1	48.3	47.7	81.6^{a}	84.8^{a}	71.7^{b}	78.8

The treatments were effected fresh and dry root weight, and P fertilizer treatment has high effects in all three periods (Table 2). The highest fresh root weight in phosphor fertilizer was 20.0 g in the pre-blooming period, and the treatment was not different from the control group and nitrogen fertilizer treatment. The lowest weight was 12.9 g in *R. leguminoserum* inoculation. In full and post-blooming periods, fresh root weight was also high in P fertilizer treatment 23.9 g and 24.6 g, respectively (Table 2).

The highest dry root weight was 1.4 g (P fertilizer) in the pre-blooming period, but not different from the control group. P and N fertilizer treatment showed high values with 1.6 g and 1.5 g in full blooming periods, respectively (Table 2). Some researchers reported that bacteria affect by the root weight and a number of roots [12].

Table 2. Effect of fertilizer treatments on fresh and dry root weight.

	Fresh root weight plant^{-1} (g)				Dry root weight plant^{-1} (g)			
Pre-blooming	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**
Control	15.3	19.0^{a}	19.0^{a}	17.8^{ab}	1.2	1.3	1.4	1.3^{ab}
Phosphorus	16.3	20.3^{a}	23.3^{a}	20.0^{a}	1.3	1.5	1.4	1.4^{a}
Nitrogen	17.3	21.0^{a}	16.3^{b}	18.2^{ab}	1.1	1.5	1.2	1.3^{ab}
Organic	15.3	15.7^{ab}	20.3^{a}	17.1^{b}	1.3	1.1	0.9	1.1^{b}
Rhizobium	16.7	9.0^{b}	13.0^{c}	12.9^{c}	1.2	1.2	0.8	1.0^{b}
Mean	16.2^{b}	17.0^{b}	18.4^{a}	17.2	1.2	1.3	1.2	1.2
Full blooming								
Control	20.0	17.1	18.8	18.6^{b}	1.4	1.1	1.2	1.2^{b}
Phosphorus	20.7	25.2	25.9	23.9^{a}	1.3	1.8	1.8	1.6^{a}
Nitrogen	20.3	20.3	16.8	19.2^{b}	1.6	1.5	1.2	1.4^{ab}
Organic	19.7	18.6	17.9	18.8^{b}	1.2	1.3	1.4	1.3^{b}
Rhizobium	19.1	21.7	18.9	19.9^{b}	1.2	1.3	1.2	1.2^{b}
Mean	20.0	20.6	19.7	20.1	1.4	1.4	1.4	1.4
Post-blooming								
Control	13.3^{b}	19.4^{ab}	19.1^{b}	17.3^{bc}	1.6^{b}	1.8^{b}	1.4^{b}	1.6^{b}
Phosphorus	22.8^{a}	23.3^{a}	27.8^{a}	24.6^{a}	2.4^{a}	2.4^{a}	2.9^{a}	2.6^{a}
Nitrogen	11.3^{b}	17.9^{b}	19.1^{b}	16.1^{c}	1.2^{c}	1.9^{b}	1.5^{b}	1.5^{b}
Organic	22.9^{a}	16.2^{b}	16.9^{b}	18.7^{bc}	2.2^{a}	1.7^{b}	1.6^{b}	1.8^{b}
Rhizobium	17.2^{b}	21.2^{a}	18.7^{b}	19.0^{b}	1.8^{b}	1.3^{c}	1.4^{b}	1.5^{b}
Mean	17.5	19.6	20.3	19.1	1.8	1.8	1.8	1.8

The effect of treatment on the number of nodules plant^{-1} and the fresh nodule weight was significant (Table 3). P fertilizer treatment was generally higher than other treatments. In the pre-blooming period, the number of nodules plant^{-1} was high in the control (91.7), but P (77.2) and N (76.2) fertilizer treatments were significantly higher than organic and bacteria treatments. P fertilizer treatment increased the number of nodules in the full and post-blooming periods. In all periods, the lowest value was in organic fertilizer treatment.

Fresh nodule weight plant^{-1} was higher in control (0.42 g) and P (0.43 g) in pre-blooming, but low in N (0.27 g), organic (0.28 g) and bacteria (0.32 g) fertilizer treatments. In the full blooming period, all treatments were significant and higher than the control group. Organic fertilizer treatment for fresh weight was low in post-blooming (Table 3).

Table 3. Effect of fertilizer treatments on root nodule traits.

	Number of nodules plant^{-1}				Fresh nodule weight (g)			
Pre-blooming	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**
Control	83.7^{b}	74.3^{a}	117.0^{a}	91.7^{a}	0.48	0.46	0.31	0.42^{a}
Phosphorus	84.3^{b}	41.0^{d}	106.3^{a}	77.2^{ab}	0.50	0.38	0.43	0.43^{a}
Nitrogen	94.3^{a}	62.3^{b}	72.0^{c}	76.2^{ab}	0.23	0.28	0.30	0.27^{b}
Organic	41.7^{d}	47.0^{d}	89.0^{b}	59.2^{b}	0.25	0.30	0.29	0.28^{b}
Rhizobium	70.3^{c}	54.0^{c}	74.3^{c}	66.3^{b}	0.35	0.34	0.25	0.32^{b}
Mean	74.9^{a}	55.7^{b}	91.7^{a}	74.1	0.36	0.35	0.32	0.34
Full blooming								
Control	73.7^{ef}	78.0^{ef}	143.3^{c}	98.3^{c}	0.30^{b}	0.43^{b}	0.19	0.31^{b}
Phosphorus	223.7^{a}	59.3^{fg}	144.0^{c}	142.3^{a}	0.45^{a}	0.61^{a}	0.44	0.50^{a}
Nitrogen	101.7^{d}	40.7^{g}	101.7^{d}	81.3^{d}	0.33^{b}	0.31^{b}	0.68^{a}	0.44^{a}
Organic	100.7^{d}	43.7^{g}	86.7^{de}	77.0^{d}	0.42^{a}	0.49^{a}	0.36	0.42^{a}
Rhizobium	171.0^{b}	75.7^{ef}	106.7^{d}	117.8^{b}	0.40^{a}	0.55^{a}	0.45	0.47^{a}
Mean	134.1^{a}	59.47^{c}	116.5^{b}	103.4	0.38^{c}	0.48^{a}	0.42^{b}	0.43
Post blooming								
Control	159.0	182.0^{b}	99.33	146.8^{ab}	0.48^{b}	0.70^{a}	0.48^{b}	0.55^{ab}
Phosphorus	158.3	230.7^{a}	174.3	187.8^{a}	0.66^{a}	0.85^{a}	0.49^{b}	0.67^{a}
Nitrogen	119.7	127.7^{b}	186.7	144.7^{ab}	0.51^{b}	0.65^{c}	0.79^{a}	0.65^{a}
Organic	55.67	51.00^{d}	144.3	83.67^{b}	0.50^{b}	0.41^{d}	0.52^{b}	0.48^{b}
Rhizobium	31.67	151.7^{c}	229.0	137.4^{ab}	0.22^{c}	0.79^{a}	0.79^{a}	0.60^{a}
Mean	104.9	148.6	166.7	140.06	0.48	0.68	0.61	0.59

	Dry nodule weight plant^{-1} (g)			
Pre-blooming	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**
Control	0.073^{a}	0.083^{a}	0.070^{a}	0.076^{a}
Phosphorus	0.073^{a}	0.070^{a}	0.043^{b}	0.062^{ab}
Nitrogen	0.043^{b}	0.050^{b}	0.047^{b}	0.046^{b}
Organic	0.037^{c}	0.053^{b}	0.087^{a}	0.059^{b}
Rhizobium	0.053^{b}	0.087^{a}	0.033^{c}	0.057^{b}
Mean	0.056	0.069	0.055	
Full blooming				
Control	0.050	0.057	0.057	0.055
Phosphorus	0.068	0.071	0.057	0.065
Nitrogen	0.049	0.045	0.087	0.061
Organic	0.051	0.065	0.051	0.055
Rhizobium	0.056	0.054	0.059	0.056
Mean	0.055	0.058	0.062	
Post blooming				
Control	0.099^{b}	0.14^{a}	0.084^{b}	0.109
Phosphorus	0.105^{a}	0.115^{a}	0.138^{a}	0.119
Nitrogen	0.020^{c}	0.158^{a}	0.138^{a}	0.105
Organic	0.087^{b}	0.071^{b}	0.089^{b}	0.082
Rhizobium	0.118^{a}	0.112^{a}	0.086^{b}	0.105
Mean	0.086^{b}	0.120^{a}	0.107^{ab}	

Table 4. Effect of fertilizer treatments on leaf traits.

	Number of leaf plant^{-1}				Fresh leaf weight plant^{-1} (g)			
Pre-blooming	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**
Control	26.7	18.0	24.7	23.1^{ab}	7.7	7.3	9.3	8.1^{a}
Phosphorus	23.0	17.7	20.3	20.3^{bc}	7.7	8.7	8.3	8.2^{a}
Nitrogen	25.3	23.0	23.3	23.9^{a}	8.3	8.7	8.0	8.3^{a}
Organic	22.3	17.7	23.3	21.1^{ab}	6.7	6.7	8.7	7.4^{ab}
Rhizobium	19.0	17.7	16.3	17.7^{c}	6.7	5.7	5.3	5.9^{b}
Mean	23.3	18.8	21.6	20.7	7.4	7.4	7.9	7.6
Full blooming								
Control	36.3	33.7^{b}	40.7^{a}	36.9	9.5	10.0	8.4	9.3
Phosphorus	41.7	33.3^{b}	38.3^{ab}	37.8	10.0	10.1	9.7	9.9
Nitrogen	42.7	39.0^{a}	44.3^{a}	42.0	11.1	11.5	11.1	11.2
Organic	40.3	37.3^{a}	39.7^{ab}	39.1	10.9	10.7	10.1	10.6
Rhizobium	36.0	31.7^{b}	36.7^{b}	34.8	9.1	14.3	9.2	10.9
Mean	39.4	35.0	39.9	38.1	10.1	11.3	9.7	10.4
Post blooming								
Control	84.3^{b}	59.7^{c}	66.7^{a}	70.2^{ab}	7.9	12.3	9.1	9.7
Phosphorus	53.7^{c}	93.3^{a}	59.7^{b}	68.9^{b}	5.9	14.6	12.2	10.9
Nitrogen	117.0^{a}	72.7^{b}	72.7^{a}	87.4^{a}	11.9	13.6	13.5	13.0
Organic	71.7^{b}	65.7^{c}	72.3^{a}	69.9^{b}	11.0	11.1	10.6	10.9
Rhizobium	63.3^{c}	76.0^{b}	54.7^{b}	64.7^{b}	11.1	14.8	10.1	12.0
Mean	78.0	73.5	65.2	72.2	9.5	13.3	11.1	11.3
	Dry leaf weight plant^{-1} (g)				**Leaf area**			
Pre-blooming	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**	**Eresen-87**	**Salkım**	**Filiz-99**	**Mean**
Control	0.82	0.74	0.80	0.79^{a}	288.9	316.8	310.0	305.2^{ab}
Phosphorus	0.72	0.69	0.77	0.73^{ab}	298.1	309.5	370.8	326.1^{a}
Nitrogen	0.78	0.74	0.92	0.81^{a}	328.2	356.5	314.4	333.1^{a}
Organic	0.62	0.66	0.79	0.69^{b}	259.6	288.0	325.6	291.0^{b}
Rhizobium	0.62	0.64	0.59	0.62^{b}	230.9	262.4	223.4	238.9^{c}
Mean	0.71	0.69	0.78	0.73	281.2^{b}	306.7^{a}	308.8^{a}	298.9
Full blooming								
Control	1.19	1.01	1.00	1.07	376.2	367.4	334.3	359.3^{d}
Phosphorus	1.08	1.23	0.76	1.02	431.4	421.4	397.4	416.7^{b}
Nitrogen	1.12	1.43	1.28	1.28	447.8	469.9	421.9	446.5^{a}
Organic	1.29	1.15	1.17	1.20	420.5	398.6	364.5	394.5^{bc}
Rhizobium	1.25	1.35	1.00	1.20	372.1	386.0	352.6	370.2^{cd}
Mean	1.18	1.23	1.04	1.15	409.6	408.7	374.1	397.5
Post blooming								
Control	1.73^{b}	2.28^{ab}	0.99^{c}	1.67	340.2	555.9	342.2	412.8
Phosphorus	1.50^{b}	2.40^{a}	2.41^{a}	2.10	469.6	608.5	415.5	497.9
Nitrogen	2.26^{a}	2.51^{a}	1.90^{b}	2.22	491.7	514.5	577.6	527.9
Organic	2.31^{a}	1.89^{b}	1.40^{bc}	1.87	486.7	552.0	449.3	496.0
Rhizobium	2.30^{a}	1.92^{b}	1.32^{c}	1.85	320.5	617.0	471.0	469.5
Mean	2.02	2.20	1.60	1.94	421.7^{b}	569.6^{a}	451.1^{b}	480.8

The effect of treatments on dry nodule weight was significant in the pre-blooming period, but not significant in other periods. The control group (0.076 g) and P (0.062 g) treatment were higher than other treatments in the pre-blooming period. In the control group, nodule formation also showed high values in some periods and varieties (Table 3).

Fageria [13] reported that phosphorus plays an important role in the fixation of symbiotic nitrogen in legumes and stresses that occurs in plants due to P deficiency in seed and fruit formation, similarly, due to P deficiency plant not only yield but also poor quality seeds and pods produce.

Clayton et al. [14], reported that the number of nodules increased during the flowering period. Wolyn et al. [15], reported that the number of nodules and nodule weight reached the highest value during pod formation due to the high nitrogenase activity. The root nodules of faba bean pods are large heart-shaped and completely attached to the main root. In a short time after the plant harvest, root and root nodules became black, and they become uncountable, therefore, when the nodule counted, should be fastly counting or plants should be harvested at different times due to accurately count.

Fertilizer treatments for the number of leaves plant^{-1} were significant in pre and post blooming periods (Table 4). N (23.9), control (23.1) and organic (21.1) treatments were high, but bacteria inoculation (17.7) were low in the pre-flowering period. Similarly, N fertilizer (87.4) increased the number of leaves in the post-blooming. Variety x treatment interaction was significant in full and post-blooming. In the full blooming period, N and organic fertilizer treatments in Salkım variety were high compared with the control group, but the control group and other treatments in Filiz 99 variety were high for a number of leaves. In post-blooming, bacteria inoculation showed low values, but other treatments and varieties showed a different response.

The effect of treatments on fresh and dry leaf weight was significant in the pre-flowering period. All treatments and control group, except for bacteria, was significant and high for fresh weight. Fresh leaf weight ranged from 5.9 g in bacteria inoculation to 8.3 g in N fertilizer. Dry leaf weight in N (0.81 g), control (0.79 g) and P (0.73 g) were high, but in organic fertilizer (0.69 g) and bacteria inoculation (0.62 g) treatments were low.

The effect of fertilizer treatments on the leaf area was significant. P (326.1) and N (331.1) treatments were high in the pre-blooming period. N (446.5) fertilizer treatment was higher than other treatments in the full blooming period.

4. Conclusions

Nodules develop when a root hair (growing out from active roots) is infected by *Rhizobium* bacteria. Plant tissue develops around the infected area, forming the nodule and site of bacterial growth and the fixation of elemental N from the soil. Although legumes are capable of fixing N_2 in the atmosphere, they are often insufficient in fixation in deficient soils, therefore, fertilization is necessary. We aimed to determine the effect of nitrogen, phosphorus and bacteria fertilizer treatments in faba bean on plant traits under the greenhouse. Plants were harvested in three different periods, stem, root, root nodule and leaf traits were evaluated. We determined that variety x treatment interaction all traits were almost significant in all periods, and each treatment including the control group had different effects on plant traits.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Köpke, U.; Nemecek, T. Ecological services of faba bean. *Field Crops Res* **2010**, *115*, 217–233.
2. Jim, D. *The nitrogen cycle and nitrogen fixation*; Institute of Cell and Molecular Biology, The University of Edinburgh: Edinburgh, UK, 2015
3. Schulze, J. How are nitrogen fixation rates regulated in legumes? *J Plant Nutr Soil Sci* **2004**, *167*, 125–137.

4. Badri, D.V.; Weir, T.L.; van der Lelie, D.; Vivanco, J.M. Rhizosphere chemical dialogues: plant-microbe interactions. *Curr Opin Biotechnol* **2009**, *20*, 642–650.
5. Reem, M.H. The effect of phosphorus in nitrogen fixation in legumes. *Agri Res Tech* **2017**, *5*, 555–652.
6. Dogra, R.C.; Dudeja, S.S. Fertilizer N and nitrogen fixation in legume-Rhizobium symbiosis. *Ann Biol Res* **1993**, *9*, 149–164.
7. Eaglesham, A.R.J.; Hassouna, S.; Seegers, R. Fertilizer-N effects on N_2 fixation by cowpea and soybean. *Agron J* **1983**, *75*, 61–66.
8. Tomičić, Z.; Čabarkapa, I.; Čolović, R.; Đuragić, O.; Tomičić, R. Salmonella in the feed industry: Problems and potential solutions. *J Agron Technol Eng Manag* **2019**, *2*, 130–137.
9. Cebel, N. Microbial fertilizers. In Proceedings of the Agri-Industry Environmental; Tokat, Turkey, 2004; Vol. 3, pp. 845–852.
10. Bolland, M.D.A.; Siddique, K.H.M.; Loss, S.P.; Baker, M.J. Comparing responses of grain legumes, wheat and canola to applications of superphosphate. *Nutr Cycling Agroecosyst* **1999**, *53*, 157–175.
11. Daoui, K.; Karrou, M.; Mrabet, R.; Fatemi, Z.; Draye, X.; Ledent, J.F. Genotypic variation of phosphorus use efficiency among moroccan faba bean varieties (*Vicia faba* Major) under rainfed conditions. *J Plant Nutr* **2012**, *35*, 34–48.
12. Cakmakcı, M.L. Use of plant growth promoting rhizobacteria in agriculture. *Ataturk Uni J Agr Fac* **2004**, *36*, 97–107.
13. Fageria, N.K. *The use of nutrients in crop plants*; Taylor and Francis Group: London, 2009; ISBN 978-0-367-38688-7.
14. Clayton, G.W.; Rice, W.A.; Lupwayi, N.Z.; Johnston, A.M.; Lafond, G.P.; Grant, C.A.; Walley, F. Inoculant formulation and fertilizer nitrogen effects on field pea: Crop yield and seed quality. *Can J Plant Sci* **2004**, *84*, 89–96.
15. Wolyn, D.J.; Attewell, J.; Ludden, P.W.; Bliss, F.A. Indirect measures of N2 fixation in common bean (Phaseolus vulgaris L.) under field conditions: The role of lateral root nodules. *Plant Soil* **1989**, *113*, 181–187.