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Effect Of Fertilizer Treatments On Plant Characteristics In Chickpea Varieties In Pre-Flowering And Full-Flowering Periods

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Abstract

The experiment was conducted at Dicle University Field Crops Department, Southeast Anatolia, Diyarbakir, Turkey in early spring growth period in 2018 -2019. The study were evaluated the effect of fertilizer treatments (control, diammonium phosphate, urea, phosphorus, and Rhizobium) on plant traits of chickpea varieties (Gokce, Diyar 95, Aziziye 94 and Taek-Sagel). The fertilizer treatments were applied with sown in both years, and plants were harvest in pre-flowering and full flowering periods. Measurements were taken on root, root nodule and leaf traits. In the pre-flowering period, dap and phosphorus treatments for the number of nodules plant^{-1}were higher than control group. Plant height, fresh root weight, fresh leaf weight, and dry nodule weight were no affected by fertilizer treatments in both periods.

Keywords: Chickpea, *Cicer arietinum* L., fertilizer, root nodule

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the most important staple legume crops widely grown across many semi-arid regions of the world and has the capacity to fix large quantities of atmospheric nitrogen by forming a symbiotic interaction with *Mesorhizobium ciceri* (Kant et al., 2016). Symbiotic nitrogen fixation is an important biological event that allows legumes to grow efficiently under nitrogen limiting conditions and also has important agronomical and environmental benefits. Due to their unique ability to form symbiotic relationship with a group of nitrogen fixing bacteria called 'Rhizobia', legumes represent an important and diverse group of plants since 50–70% of biological nitrogen fixation, leading to a terrestrial input of 40–50 million tons of nitrogen per year (Vitousek et al., 1997), is carried out by symbiotic nitrogen fixation. Response of chickpea plants to the nutrients applied to the soils vary based on available nutrient quantities in soils, climate conditions, cultivar or genotypes and some other cultural practices (Singh and Diwakar, 1995). In soils with nitrogen deficiency, there is a need to apply small dose of N fertilizer to legumes to overcome the deficiency and harness their growth and this low dose of N applied externally is called starter dose (Giller and Cadisch, 1995). Similarly, chickpea requires low rates of N which is about 15-20 kg ha^{-1} in N deficient soils (Thaku et al., 1989). Lemma et al. (2013) reported that nitrogen treatments in chickpea produced significantly higher number of nodule, nodule weight, but P treatments were no significant differences on these parameters. A greenhouse experiment showed that nitrogen application increased plant height, dry root and shoot weights of chickpea (David and Khan, 2001). Fertilizer applications in chickpeas among legumes have been increasing in parallel with the feed value in recent years. However, it is not clear whether fertilizer application is necessary. This research was carried out in order to determine the effect of the most widely used fertilizer forms on yield and yield components of different chickpea cultivars under field conditions and to determine whether fertilization application is necessary in this plant.

MATERIALS and METHODS

Experiment was conducted at Dicle University Field Crops Department, Southeast Anatolia, Diyarbakir Turkey in early spring growth period in 2018-2019. The Diyarbakir is located on grid 37.91 °N, 40.2 °E, at an altitude of 640 m above sea level (masl). The experimental has a hot and dry climate most of the year. The area receives rainfall with an annual mean below about 500 mm, with a wide variation between the years. Precipitation is mainly received from November to June, and generally in June is not, and in last decade, precipitation is increasingly irregular in the same periods. Mean temperature is about 16-20 ºC in January to June, growing season for long-day plants such as wheat, lentil and chickpea. May has an irregular climate for rainy, but June is dry and hot. The relative humidity varies between 60-75% in January to April, but get lower about 20-30% after May. In 2018 in first experiment year, precipitation from Feb to April was dry with total 146.8 mm rainy, but in May was considerably received it with 157.8 mm, and mean temperature (Feb to May) has been 11.9 ºC. In 2019 growing season, precipitation from February to April was wet with total 365.2 mm rainy, but May was considerably dried with 45.8 mm, and mean temperature (Feb to May) was been 11.35 ºC, and highly cool compared with 2018 growing season (Table 1). The soil analysis indicate that soils are neutral to slightly alkaline (pH: 7.24), un-sufficient in organic matter (0.79%), and phosphorus content (13.2 kg ha $^{-1}$). The soil texture was 44% clay.

Table 1. Meteorological data in Diyarbakir

Month	Mean temperature (ºC)		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

Experimental design and layout

An experiment testing the effects of different fertilizer treatments (control, diammonium phosphate, urea, phosphorus as TSP, and Rhizobium) on plant traits of chickpea varieties (Gokce, Diyar 95, Aziziye 94 and Taek-Sagel) was conducted. Rhizobium culture in peat was obtained from Soil and Fertilizer Research Institute, Ankara. The experimental design was a split plot arranged in a randomized complete block design with three replications. The seeds were sown on 7 February 2018 and 11 February in 2019, at 40 cm x 10 cm spacing. Before sowing, seeds were inoculated with specific strain of Rhizobium at 10 g each/kg seed. Inorganic fertilizers were applied in the form of diammonium phosphate (18-46%) and triple superphosphate (46% P_2O_5), and inorganic fertilizers were applied at a rate of nitrogen 40 kg ha^{-1} and phosphorus and 80 kg ha^{-1}. All fertilizers were applied at the sowing. Crop was irrigated after sown in 2018 due to drought. Weed, disease and pests were controlled by hand and chemical spray, respectively. Plants were harvested two different periods which pre-blooming and full-blooming, and plant traits were measured. In 2018 season, due to drought, before the plant samples were removed from the plots, plots were irrigated with sprinkler so that plants could be easily removed from the soil with their roots, and soil was kept until the field capacity. However, in 2019 season any irrigation water was applied, due to rainy conditions. After plants were removed from the plots, were wash off soil, and were dried gently with soft paper towel to remove any free surface moisture. In dry weight measurements, plants were dried in an oven set to heat (70 ºC) overnight (Wood and Roper, 2000). Data of two years were separately and pooled, were subjected to analysis of variance, and means were separated using the Duncan's Multiple Range Test.

RESULTS and DISCUSSION

Fertilizer treatments for fresh plant weight in both pre-flowering and full flowering periods were significant over two years the combined analysis. All fertilizer treatments and control group, except for P treatment were higher than in both periods. In pre-flowering period, variety x treatment x year interaction was significant, and control group was higher than other treatments for Gokce in 2018 and Taek-Sagel varieties in both years. Gokce variety was highly affected by urea and phosphorus fertilizer treatments in second year (Table 2). In full flowering period, control group was higher than other treatments for Gokce and Aziziye 94 in 2018 and Taek-Sagel varieties in both years. In 2019 year, bacteria fertilizer treatment had high effect on all cultivars except Gokce, and the effect of bacteria treatment is similar to or higher than the control group (Table 2). Demirbas et al. (2018) reported that the greatest dry matter production was obtained from bacteria and supply N treatment. Some researchers have reported that nitrogen fertilizer treatments significantly were increase stem weight (Bicer, 2014). Differences between the two trial years for fresh plant weight may be due to climatic conditions. In 2018 growth period; February, March and April were quite dry and hot, and the experiment was regularly irrigated by sprinkler irrigation. Irrigation supply water, sunny days and warm weather during vegetation period and high rainfall in May had a positive effect on plant development. In 2019 growth period; since February, March and April were quite rainy and the cloudy weather, the low temperature was downgrade the plant growth at the beginning of the growth season. Seed germination and emergence was delayed due to low soil temperature, emergence rate and seedling vigor was low and weak. Most of seeds that could not emergence due to low soil temperature could not survive under the soil. As a result, the number of plants per parcels decreased. May 2019 was extremely dry, and caused negative effects on plants during the generative period. In 2019, the vegetative period started late and progressed heavily. Finally, the drought in the generative period delayed the development of the plant (Table 2). The effect of fertilizer treatments for dry plant biomass was significant in pre-flowering period, but not significant during the full flowering period. However, in both periods the year, variety and year x variety interaction was significant. Phosphorus fertilizer treatment was the lowest in dry weight and other applications showed the same effect with control group in the pre-flowering period. Variety x treatment interaction revealed that variety performances were change from treatment to treatment. Above all, varieties were similar to control or different from control in trial years. In 2018 at both periods, fertilizer treatments in Gokce, Aziziye 94 and Taek-Sagel varieties dry plant biomass were low compared to the control group (Table 2). Differences among fertilizer treatment for plant height were not significant, but cultivar, year and cultivar x treatment interaction were significant in both periods. The year x treatment x cultivar interaction showed that the differences among treatments was significant only in Gokce and Diyar 95 varieties. Compared to the control group, urea fertilizer in Gokce cultivar and phosphorus fertilizer in Diyar 95 cultivar were high in pre-flowering period. However, in full blooming period, all treatments were almost similar to each other and control group (Table 3). The differences among the fertilizer treatments and varieties for fresh root weight were not significant, but year and their interaction is important in both periods. Interaction revealed that the response of the varieties to the treatments was different (Table 4). The low fresh plant weight and high fresh root weight in 2019 were caused by high rainfall and soil moisture content. When the root dry weight was evaluated, it was found that the amount of water contained in the root was higher compared to 2018. However, because the test soil was high clay, the root could not be completely removed. It was concluded that reliable root weight could not be reached because all capillary roots could not be reached due to clay soil texture. The differences fertilizer treatments for dry root weight were significant in pre-flowering period, but non-significant in full flowering period. Year x variety x treatment interaction were significant in both periods. The dry root weight obtained from the treatments was higher than control group in pre-flowering period. Although the treatments were similar each other, phosphorus and urea fertilizer treatments were increase the dry root weight.

Table 2. Effect of fertilizer treatments on fresh and dry plant biomass in Chickpea

Fresh plant biomass (g)									
	Gokce		Diyar 95		Aziziye 94		Taek-Sagel		
Pre-blooming	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**Mean**
Control	50.4 a	9.63c	35.2 c	14.8	25.0 c	19.7	39.3 a	32.5 a	28.3 ab
DAP	35.1 b	10.7 bc	67.3 a	18.3	44.9 a	20.7	29.9 b	26.4 bc	31.6 a
Urea	39.7 b	21.0 a	53.0 b	17.7	34.2 bc	23.2	32.8 ab	25.2 cd	30.8 a
Phosphor	33.5 b	19.7 a	29.7 c	17.1	29.3 c	23.2	16.8 c	21.8 d	23.9 b
Bacteria	37.1 b	12.8 b	34.6 c	15.6	42.4 ab	17.6	18.3 c	29.7 ab	26.0 ab
Mean	39.2 a	14.7 b	44.0 a	16.7 b	35.2 a	20.9 b	27.4	27.1	
Variety	27.0		30.3		28.05		27.2		
Year	27.4 a	20.9 b							
Full-blooming									
Control	78.9 a	33.4 b	57.4 d	37.7 b	55.9 a	20.5 c	66.0 a	47.7 a	49.7 a
DAP	62.6 b	55.7 a	129.1 b	39.1 b	49.3 a	25.9 bc	49.2 b	28.4 b	54.9 a
Urea	44.2 c	35.8 b	183.7 a	27.1 c	37.1 b	26.3 bc	55.5 ab	19.8 c	53.7 a
Phosphor	72.4 ab	38.4 b	44.1 d	41.0 ab	38.0 b	31.0 b	44.1 b	49.1 a	44.8 b
Bacteria	35.2 c	21.3 c	103.6 c	47.1 a	36.3 b	40.7 a	52.9 b	49.3 a	48.3 a
Mean	58.7	36.9	103.6	38.4	43.3	28.9	53.6	38.9	
Variety	47.8		71.0		36.1		46.2		
Year	53.6 a	38.9 b							
Dry plant biomass (g)									
	Gokce		Diyar 95		Aziziye 94		Taek-Sagel		
Pre-blooming	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**Mean**
Control	8.2 a	3.0 b	6.8 c	3.3 b	5.9 a	1.7 b	9.9 a	4.1 ab	5.4 a
DAP	7.8 a	5.2 a	13.3 b	4.6 a	5.2 ab	2.9 ab	5.7 b	2.8 b	5.9 a
Urea	5.4 b	3.2 b	20.9 a	2.9 b	4.7 ab	2.9 b	6.1 b	2.7 b	6.1 a
Phosphor	9.4 a	3.5 b	4.4 d	3.9 ab	4.0 bc	3.0 ab	5.1 b	5.4 a	4.9 b
Bacteria	4.1 b	1.8 c	12.1 b	4.7 a	3.3 c	4.4 a	7.0 b	4.9 a	5.3 a
Mean	7.0 b	3.4 c	11.5 a	3.9 c	4.6 c	2.9 c	6.8 b	4.0 c	
Variety	5.2 b		7.7 a		3.8 c		5.4 b		
Year	6.8 a	4.0 b							
Full-blooming									
Control	20.0 a	8.3 b	13.8 d	9.8 a	14.7 a	4.2 c	19.7 a	10.6 a	12.6
DAP	16.5 b	12.9 a	31.1 b	10.8 a	13.8 a	6.2 bc	14.1 b	6.3 b	14.0
Urea	11.1 c	7.8 b	47.5 a	6.7 b	10.2 b	5.7 bc	13.7 b	6.4 b	13.6
Phosphor	19.4 a	8.6 b	11.2 d	9.8 a	10.3 b	7.0 b	11.4 b	11.7 a	11.2
Bacteria	9.5 c	4.5 c	27.0 c	11.6 a	9.6 b	9.38 a	14.3 b	10.9 a	12.1
Mean	15.3 b	8.4 c	26.1 a	9.8 c	11.7 bc	6.5 c	14.6 b	9.20 c	
Variety	11.9 b		17.9 a		9.1 b		11.9 b		
Year	16.9 a	8.5 b							

Table 3. Effect of fertilizer treatments on plant height in Chickpea

Plant height (cm)									
Pre-blooming	**Gokce**		**Diyar 95**		**Aziziye 94**		**Taek-Sagel**		
	2018	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**Mean**
Control	48.0 d	36.17	50.33	36.0 c	52.3	55.3	54.7	47.0	47.5
DAP	53.3 b	34.33	50.33	32.7 d	53.0	54.3	49.3	49.7	47.1
Urea	54.7 a	37.00	49.67	39.2 b	47.0	48.3	47.0	50.7	46.7
Phosphor	51.0 c	29.33	53.33	43.0 a	54.0	53.3	51.7	46.0	47.7
Bacteria	51.3 c	33.67	50.67	30.3 d	54.0	56.7	47.7	46.7	46.4
Mean	51.7 a	34.10 b	50.9 a	36.2 b	52.0 a	53.6 a	50.1 a	48.0 ab	
Variety	42.9 b		43.6 b		52.8 a		49.0 a		
Year	50.1	48.0							
Full-blooming									
Control	65.3 bc	55.0 a	73.3 a	48.3	63.7	48.0	74.3	54.7	60.3
DAP	60.3 c	52.3 a	70.0 a	59.0	66.7	54.0	70.3	50.0	60.3
Urea	66.7 b	54.7 a	74.0 a	47.6	63.3	48.3	70.7	49.3	59.3
Phosphor	77.7 a	54.0 a	71.0 a	53.0	62.7	57.0	74.3	58.0	63.5
Bacteria	64.0 bc	42.3 b	62.7 b	55.3	55.3	57.3	68.7	57.3	57.9
Mean	66.8	51.7	70.2	52.6	62.3	52.9	71.7	53.9	
Variety	59.2		61.4		57.6		62.8		
Year	71.67	53.87							

Table 4. Effect of fertilizer treatments on fresh and dry root weight in Chickpea

Fresh root weight (g)									
	Gokce		**Diyar 95**		**Aziziye 94**		**Taek-Sagel**		
Pre-blooming	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**Mean**
Control	4.9	3.3 b	3.6 b	5.8 b	3.0 b	5.2 b	4.7 a	4.7	4.4
DAP	4.8	5.7 a	3.6 b	5.3 b	6.2 a	6.8 a	3.2 b	6.0	5.2
Urea	4.6	6.3 a	10.0 a	3.9 b	3.6 b	7.0 a	5.1 a	6.5	5.9
Phosphor	6.1	5.0 a	3.6 b	5.1 b	4.4 ab	6.2 a	2.4 b	6.9	5.0
Bacteria	4.8	4.5 a	4.2 b	7.4 a	4.7 ab	6.6 a	2.7 b	5.4	5.0
Mean	5.1	4.9	5.0	5.5	4.4	6.4	3.6	5.9	
Variety	5.0		5.2		5.4		4.8		
Year	3.6	5.9							
Full-blooming									
Control	6.6	5.4 a	6.1 c	5.5 b	8.9 a	9.2 a	5.8	5.2	6.6
DAP	8.2	7.0 a	12.2 a	5.0 b	7.1 ab	8.5 a	4.9	4.5	7.2
Urea	5.1	6.3 a	13.0 a	3.9 c	7.7 ab	5.1 b	6.6	5.6	6.7
Phosphor	8.3	5.7 a	5.6 c	5.1 b	6.6 bc	4.9 b	4.9	4.9	5.8
Bacteria	5.8	3.3 b	9.6 b	7.2 a	4.6 c	7.3 b	5.8	6.5	6.3
Mean	6.8	5.6	9.3	5.3	7.0	7.0	5.6	5.4	
Variety	6.2		7.3		7.0		5.5		
Year	5.6	7.0							

Dry root weight (g)									
	Gokce		**Diyar 95**		**Aziziye 94**		**Taek-Sagel**		
Pre-blooming	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**Mean**
Control	0.84 c	0.37	0.64 d	0.47	0.77 c	0.47	1.17	0.43	0.64 b
DAP	1.10 bc	0.36	1.00 c	0.39	0.87 bc	0.57	0.73	0.45	0.69 ab
Urea	1.33 ab	0.43	1.36 b	0.49	1.01 bc	0.62	1.14	0.59	0.87 a
Phosphor	1.56 a	0.27	1.67 a	0.46	1.77 a	0.59	0.88	0.51	0.96 a
Bacteria	1.10 bc	0.34	0.85 cd	0.39	1.16 b	0.62	0.83	0.45	0.72 ab
Mean	1.18	0.35	1.11	0.44	1.11	0.58	0.95	0.49	
Variety	0.77		0.77		0.85		0.72		
Year	0.95	0.49							
Full-blooming									
Control	1.09 c	0.61abc	1.10 d	0.76 ab	0.98	0.45 c	1.28 b	0.93 a	0.90
DAP	1.70 a	0.84 a	2.14 b	0.88 a	1.26	0.44 c	1.02 b	0.57 b	1.11
Urea	1.11 c	0.74 ab	2.64 a	0.59 b	1.10	1.20 b	1.69 a	0.70 ab	1.22
Phosphor	1.44 b	0.54 bc	1.05 d	0.81 ab	0.89	3.16 a	0.89 b	0.88 a	1.21
Bacteria	0.88 c	0.36 c	1.55 c	0.98 a	0.78	0.64 bc	0.90 b	0.90 a	0.87
Mean	1.24	0.62	1.70	0.80	1.00	1.19	1.16	0.80	
Variety	0.93		1.25		1.09		0.98		
Year	1.16	0.80							

The differences among the fertilizer treatments, varieties and years for number of nodules in the plant in both periods were significant. The number of nodules plant^{-1} ranged from 85.48 to 104.46 in pre-flowering, and ranged from 102.76 to 121.67 in full flowering period. In the pre-flowering period, dap (101.0) and phosphorus (104.5) treatments were higher than control group (85.5). In full flowering period, control (121.7) and dap (120.1) treatment were higher than other treatments (Table 5). Although it has been reported that nitrogen application decreases the number of nodules plant, it has been found that the varieties response positively to nitrogen application in different years. Although most of small nodules were detected in some plots, chickpea root nodules were usually large pieces formed by the combination of small nodules. Legume-Rhizobia relationship to fixed the N is very important, small amount of nitrogen needs to be available in the soil in which will be used by the plant. It will be help growth chickpea until the onset of N-fixation. Similarly Giller and Cadisch (1995) reported that in order to promote nodulation in soils with low organic matter, it was found that it is important to give starting nitrogen with sowing. Differences among fertilizer treatments for fresh nodule weight plant $^{-1}$ in pre-flowering period were significant, but were not significant in full flowering period. Year, variety and treatment x variety x year interaction is important in both periods. In the pre-flowering period, nodule weight ranged from 1.44 g to 1.61 g. Dap, urea and phosphorus fertilizer treatments were higher than control group. In blooming period, fresh nodule weight were remarkable response to bacteria treatment in Diyar 95, Aziziye 94 and Taek-Sagel varieties (Table 6).

Table 5. Effect of fertilizer treatments on number of nodules plant^{-1}in Chickpea

	Number of nodules plant^{-1}								
	Gokce		**Diyar 95**		**Aziziye 94**		**Taek-Sagel**		
Pre-blooming	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**Mean**
Control	75.7 cd	99.3 ab	112.7 a	75.7 bc	93.7 b	58.7 d	75.3 c	92.7 b	85.5 b
DAP	109.0 a	128.7 a	52.3 c	61.0 d	111.7 ab	141.7 a	151.7 a	51.7 c	101.0 a
Urea	89.3 b	61.7 c	70.0 c	81.0 b	125.0 a	94.0 c	119.0 b	113.0 a	94.1 b
Phosphor	68.7 d	103.0 ab	89.0 b	165.3 a	117.0 a	84.7 c	119.0 b	89.0 b	104.5 a
Bacteria	82.0 bc	88.0 bc	69.7 c	66.0 cd	106.0 ab	112.7 b	157.3 a	43.0 c	90.6 b
Mean	84.9	96.1	78.7	89.8	110.7	98.4	124.5	77.9	
Variety	90.5		84.3		104.5		101.2		
Year	124.5	77.9							
Full-blooming									
Control	80.7 c	111.3 b	102.7 b	137.7 b	137.0 a	94.0 c	96.7 b	213.3 a	121.7 a
DAP	137.0 b	139.0 a	148.7 a	132.0 bc	95.3 b	96.7 c	73.7 c	138.3 b	120.1 a
Urea	83.3 c	157.0 a	93.3 bc	94.67 d	72.3 c	116.0 b	105.0 ab	135.7 b	107.2 b
Phosphor	177.7 a	117.0 b	68.3 d	117.7 c	110.0 b	90.0 c	78.7 c	62.7 c	102.8 b
Bacteria	75.3 c	67.0 c	83.7 c	155.0 a	63.0 c	164.7 a	118.3 a	117.3 bc	105.5 b
Mean	110.8	118.3	99.4	127.4	95.5	112.3	94.5	133.5	
Variety	114.5		113.4		103.9		114.0		
Year	94.5	133.5							

Khan et al. (1992) reported that rhizobium inoculation produced higher nodule weight than N and P fertilizer treatments. On other hand, Otieno et al. (2009) reported that nitrogen + bacteria inoculation were decreased the nodulation. The differences among treatments for dry nodule weight were insignificant in both periods, but year, variety and their interaction were significant. In pre-blooming period, treatments for dry nodule weight were significant in Diyar 95 and Aziziye 94 varieties in 2018 season, and in Taek-Sagel variety in 2019 growth period. It has been observed that the number and size of the root nodules differ surprisingly from plant to plant, also, large nodules were occasionally observed on the capillary roots as well as the main roots. It was concluded that the exact fresh nodule weight could not be measured, because the length of the counting time sometimes was affect the fresh nodule weight. In the second year of the experiment, although the shoot and leaf weight was low compared to the first year, nodule traits such as number, fresh and dry nodule weight were high especially in full flowering period. In 2018, the vegetative period was dry, but the generative period in which flowers and pods were formed was rainy. Eventually, number of nodules, fresh and dry nodule weight in full-blooming were decline due to drought. In 2019 growth season, the vegetative period was rainy, but the generative period was hot and dry. However, the soil moisture level remained suitable for nodule formation. Since experiment area soil due to excessive clay was not allow to the root to develop much, we think that a nodule formation occurs below the expected level. It has been found that the bacteria inoculation was reduce nodule weight, which might be caused by the bacteria used in this experiment. Many investigators report that suitable strains were important in bacteria inoculation (Albayrak et al., 2015). Differences among fertilizer treatments for number of leaves and dry leaf weight and leaf area in full-flowering period were significant, but were no significant in pre-flowering period (Table 7). Variety and treatment x variety interaction were significant in both periods. The number of leaves plant^{-1} ranged from 39.0 to 46.9 in pre-flowering period, and 59.8 to 81.8 in full flowering period. The highest number of leaves was obtained from bacteria and urea treatments, control group and dap treatment showed similar effect. The lowest value was observed in phosphorus treatment. Dry leaf weight ranged from 2.8 g to 4.3 g, and only phosphorus treatment was lower than other treatments in full flowering period. Leaf area ranged from 256.4 to 303.3 in pre-flowering, and 461.7 to 676.9 in full flowering period. The highest leaf area obtained from control group as well as urea and dap treatment. Differences among fertilizer treatments for fresh leaf weight period were no significant, but variety and treatment x variety interaction was significant were in both periods (Table 7).

Table 6. Effect of fertilizer treatments on fresh and dry nodule weight in Chickpea

				Fresh nodule weight (g)					
	Gokce		**Diyar 95**		**Aziziye 94**		**Taek-Sagel**		
Pre-blooming	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**Mean**
Control	1.08 b	1.02 b	1.53 ab	0.90 bc	2.29 ab	0.84 b	1.57 c	1.11 b	1.29 b
DAP	1.76 a	1.41 a	1.32 b	0.64 c	1.96 b	1.99 a	3.24 a	0.58 d	1.61 a
Urea	1.88 a	0.62 c	1.31 b	1.01 b	2.78 a	0.92 b	2.34 b	1.96 a	1.60 a
Phosphor	1.05 b	1.15 ab	1.94 a	1.89 a	2.37 ab	1.10 b	2.36 b	0.85 c	1.59 a
Bacteria	1.44 a	1.25 ab	1.43 b	0.75 bc	2.58 a	1.39 b	1.95 bc	0.70 cd	1.44 b
Mean	1.44 b	1.09 b	1.51 b	1.04 b	2.40 a	1.25 b	2.29 a	1.04 b	
Variety	1.27		1.27		1.82		1.67		
Year	2.29 a	1.04 b							
Full-blooming									
Control	1.39 b	2.37 a	2.33 b	2.83 b	2.75 a	1.61 b	2.07 b	4.19 a	2.44
DAP	2.66 a	3.00 a	3.42 a	2.29 bc	1.91 bc	2.07 b	1.38 c	2.41 bc	2.39
Urea	1.40 b	3.04 a	2.13 bc	1.65 c	1.59 c	2.06 b	2.47 b	2.19 bc	2.07
Phosphor	3.36 a	2.56 a	1.48 c	2.17 bc	2.62 ab	2.12 b	2.18 b	1.20 c	2.21
Bacteria	1.48 b	1.25 b	1.97 bc	3.60 a	1.32 c	3.14 a	3.22 a	3.17 ab	2.39
Mean	2.06	2.44	2.27	2.51	2.04	2.20	2.26	2.63	
Variety	2.25		2.39		2.12		2.45		
Year	2.26 b	2.63 a							
				Dry nodule weight (g)					
Pre-blooming	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**Mean**
Control	0.129	0.14	0.20 b	0.11	0.32	0.13 b	0.22	0.18b	0.18
DAP	0.241	0.24	0.19 b	0.13	0.30	0.25 a	0.36	0.11 b	0.23
Urea	0.260	0.14	0.14 b	0.23	0.39	0.10 b	0.39	0.36 a	0.25
Phosphor	0.119	0.17	0.29 a	0.14	0.35	0.16 b	0.40	0.16 b	0.22
Bacteria	0.176	0.14	0.21 b	0.13	0.40	0.19 b	0.30	0.40 a	0.24
Mean	0.19 bc	0.17 c	0.21 b	0.15 c	0.35 a	0.17 c	0.33 a	0.24 b	
Variety	0.18 b		0.18 b		0.26 a		0.29 a		
Year	0.33 a	0.24 b							
Full-blooming									
Control	0.23 c	0.50 a	0.19 b	0.65 ab	0.36	0.32	0.21 c	0.65 a	0.39
DAP	0.33 b	0.52 a	0.41 a	0.51 bc	0.31	0.33	0.21 c	0.40 ab	0.38
Urea	0.26 bc	0.59 a	0.26 ab	0.42 c	0.36	0.31	0.44 b	0.48 a	0.39
Phosphor	0.71 a	0.46 a	0.29 ab	0.46 c	0.36	0.33	0.40 bc	0.20 b	0.40
Bacteria	0.09 d	0.24 b	0.34 a	0.72 a	0.21	0.53	0.83 a	0.60 a	0.45
Mean	0.32 c	0.46 b	0.30 c	0.55 a	0.32 c	0.36 c	0.42 b	0.47 b	
Variety	0.39 b		0.43 a		0.34 b		0.44 a		
Year	0.34 b	0.47 a							

Table 7. Effect of fertilizer treatments on leaf traits in Chickpea

	Pre-blooming					Full-blooming				
	Gokce	**Diyar 95**	**Aziziye 94**	**Taek-Sagel**	**Mean**	**Gokce**	**Diyar 95**	**Aziziye 94**	**Taek-Sagel**	**Mean**
Number of leaves plant^{-1}										
Control	19.7 c	29.7 c	64.7 a	42.0	39.0	67.0 b	76.3 b	53.7 b	91.3 ab	72.1 ab
DAP	63.7 a	37.0 b	38.0 d	45.7	46.1	94.7 a	80.0 ab	57.3 b	57.7 c	72.4 ab
Urea	24.7 c	45.0 a	47.7 cd	52.0	42.3	72.0 b	89.0 ab	59.3 b	107.0 a	81.8 a
Phosphor	47.7 b	34.3 bc	54.0 bc	51.7	46.9	67.7 b	43.0 c	54.0 b	74.7 bc	59.8 b
Bacteria	37.3 b	36.0 bc	62.0 ab	40.7	44.0	65.7 b	92.7 a	77.0 a	87.7 ab	80.8 a
Mean	38.6 b	36.4 b	53.3 a	46.4 ab		73.4 ab	76.2 a	60.3 b	83.7 a	
Fresh leaf weight (g)										
Control	1.7 b	3.8 c	13.8 a	5.9	6.3	15.2 b	14.5 b	8.6 c	17.8 ab	14.1
DAP	4.9 a	7.1 a	7.1 d	8.0	6.8	23.5 a	16.1 ab	9.8 bc	11.0 c	15.1
Urea	5.3 a	5.7 ab	9.7 c	8.2	7.3	15.1 b	17.1 ab	12.6 ab	19.8 a	16.2
Phosphor	3.9 a	5.4 abc	8.9 c	7.4	6.4	14.2 b	10.6 c	9.1 c	13.7 bc	11.9
Bacteria	4.1 a	5.4 bc	11.6 b	6.0	6.8	9.8 c	18.8 a	15.8 a	18.3 ab	15.7
Mean	4.0	5.5	10.2 a	7.1		15.5	15.4	11.2	16.1	
Dry leaf weight plant^{-1}										
Control	0.51 d	0.9 b	2.9 a	1.7 bc	1.53	4.3 b	4.1 ab	2.0 c	5.5 a	4.0 a
DAP	1.5 a	1.4 a	1.8 b	1.8 abc	1.63	6.1 a	4.6 a	2.8 bc	2.9 b	4.1 a
Urea	0.7 cd	1.5 a	2.2 b	2.3 a	1.65	4.2 b	4.4 ab	3.4 ab	5.4 a	4.3 a
Phosphor	1.1 b	1.5 a	2.2 b	2.1 ab	1.72	3.9 b	2.9 b	1.6 c	3.0 b	2.8 b
Bacteria	0.9 bc	1.2 ab	2.9 a	1.5 c	1.63	2.3 c	5.4 a	4.3 a	5.0 a	4.3 a
Mean	0.9	1.3	2.4	1.9		4.2	4.3	2.8	4.4	
Leaf area										
Control	69.3 e	142.5 c	657.4 a	264.3 c	283.4	947.8 a	598.1 c	321.7 cd	840.0 a	676.9 a
DAP	277.4 a	254.4 a	321.7 d	306.4 bc	290.0	573.5 b	649.0 bc	398.2 c	477.9 c	524.7 b
Urea	124.2 d	238.3 a	378.1 cd	285.1 bc	256.4	389.9 c	847.4 a	513.1 b	889.7 a	660.0 a
Phosphor	177.9 b	188.9 b	436.3 c	410.1 a	303.3	600.0 b	442.3 d	249.9 d	554.6 bc	461.7 c
Bacteria	163.1 c	195.7 b	523.5 b	327.1 b	302.3	569.6 b	787.3 ab	613.0 a	712.9 ab	670.7 a
Mean	162.38	203.96	463.40	318.60		616.2	664.8	419.2	695.0	

CONCLUSION

In our study, fertilizer treatments important in many features examined, and nitrogen fertilizers, dap and urea were generally effective for vegetative parts. However, phosphorus fertilizer treatment affected the nodule formation. The treatment x variety interaction was significant in almost all traits, that is, cultivars were affected differently in each treatment. The effect of bacteria inoculation on seed was small and ignorable.

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