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Research Article

EFFECT OF POPULATION DENSITY AND DOSE OF NITROGEN AND POTASSIUM FERTILIZERS ON PERFORMANCE OF GREEN BEAN (*PHASEOLUS VULGARIS*)

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ABSTRACT

This experiment was executed in a split randomized complete block design with three replications. Two plant densities (D), (D_1; D_2) equal to one plant and two plants per pot and seven fertilizers doses (F), (N_0 K_0; N_1 K0; N_1 K_1; N_2 K_0; N_2 K_2; N_0 K_1; N_0 K_2) were investigated. N_0, N_1 and N_2 equal to 0, 0.46, and 0.92 g urea while, K_0, K_1 and K_2 equal to 0, 0.42 and 0.84 g potassium sulfate, respectively. The results showed that the treatments had no effect on the number of branches per plant and vice versa the interaction. Lower plant density (D_1) and higher dose of both elements (N_2 K_2) significantly increased shoots dry weight, number of pods and pod yield per plant while, in second season the higher value of those yield parameters was obtained at lower dose of nitrogen (N_1 K_0), the interaction of those treatments increased significantly plant dry weight. The interaction between lower plant density (D_1) and nitrogen irrespective of their quantity and potassium, (N_1 K_0; N_1 K_1; N_2 K_0 and N_2 K_2) increased the number of pods and pods yield per plant, while the greatest yield per hectare was obtained at density planting (D_2) receiving higher doses of both fertilizer and lower dose of nitrogen (N_2 K_2: N_1 K_0) at the first and second season respectively.

Keywords: Cultivar Djadida; Nutrient Competition; Vegetative Productivity.

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1. INTRODUCTION

Green beans are dicotyledonous plants forming part of the species (*Phaseolus vulgaris* L.). According to Monfreda et al., (2008) estimate for the year 2006, the world beans production was 1235 kg ha^{-1} while, that of Africa was 799 kg ha^{-1}. These low yields are pronounced in grain legumes and are often associated with declining soil fertility due to biological and environmental factors (Mfilinge et al., 2014). Nitrogen is one of the most limiting nutrients to plant growth (Hirel et al., 2007). Potassium improved fruit quality (Beg and Sohrab, 2012) while, nitrogen consumption increased dry weight resulting in increased plant yield (Hatami et al., 2009). Vorob (2000) recorded positive effect of potassium application at all proportions on growth and yield of peas. Lower density had the heaviest shoot dry weights (Elhag and Hussein, 2014) and the highest number of pods per plant (Mtaita and Mutetwa, 2014). Low crop productivity and quality are a general phenomenon facing most producers. The objective of this study was to investigate the effect of plant density and dose of nitrogen and potassium on Green bean Cv. Djadida.

2. MATERIALS AND METHODS

2. 1. Site of Experiment

This study was carried out during winter seasons of the years 2015 and 2016 in glasshouse of laboratory of vegetables production, faculty of Nature and Life Sciences, University of Blida-1, Algeria. The geographical coordinates are 36º 28˙7˙˙ North, 2º 49˙44˙˙ East, 260 m above sea level.

2.2. Experimental Design

The experiment was executed in split trial in randomized complete block design with three replications. Four plastic pots 33 × 30 cm in dimensions contain 8.5 Kg soil were used as an experimental units.

2. 3. Treatments

The treatment consisted of two plant densities (D), (D_1) one plant per pot (107145 plants per hectare) and two plants per pot D_2 (214290 plants per hectare) used as main plot, and seven fertilizers doses (F), (N_0 K_0; N_1 K_0; N_1 K_1; N_2 K_0; N_2 K_2; N_0 K_1; and N_0 K_2) used as sub plot. N_0, N_1 and N_2 equal to 0, 0.46, and 0.92 g urea (46% nitrogen) per pot respectively, while K_0, K_1 and K_2 equal to 0, 0.42 and 0.84 g potassium sulfate (50% potassium) per pot respectively.

2. 4. Soil characteristics

The soil is heavy clay with pH 7.75, and electric conductivity of 0.49 ds m^{-1}, contained 0.002

Meg g^{-1} potassium sulfate, 0.8 g Kg^{-1} azotes and 1.80% organic matter.

2.5. Sowing

The seeds were soaked in water for one day and pre-sown in a moist piece for four days, and then transplanted. The fertilizers treatment applied as one dose, four weeks from sowing.

2.6. Data Collection

The data of both seasons was recorded (40 days from sowing) to evaluate the effect of treatments on the number of branches per plant, shoot dry weight, number of pods per plant, pod fresh weight, pod yield per plant and pod yield per hectare.

2.7. Statistical Analyses

The data was statistically analyzed using computer software programme (MSTAT-C). Randomized Complete Block Design (R. C. B. D) was applied for data analysis and Duncan multiple range test D. M. R. T, was used for mean separation.

3. RESULTS

3.1. Number of branches per plant

No significant effect was noticed in both seasons on the number of branches per plant due to the plant density or due to nitrogen and potassium fertilizer (Table 1). Number of branches per plant was significantly affected by plant density and nitrogen and potassium interaction. A single plant per pot (D_1) treated with lower doses of nitrogen without potassium (N_1 K_0) in the first season screened a superior number of branches per plant which was positively different from all other treatments and significantly for higher plant density (D_2) receiving a high dose of potassium without nitrogen (N_0 K_2) contrary, this treatment decreased the number of branches per plant in the second season. Single plant per pot (D_1) receiving nitrogen at higher dose (N_2 K_0) and two plants per pot (D_2) received no fertilizer or receiving potassium at higher dose (N_0 K_0; N_0 K_2) was statistically similar and had the highest number of branches per plant.

Table 1. Effect of plant density and dose of nitrogen and potassium on number of branches per plant

Fertilizer doses		First season			Second season		
		1 plant/pot	2 plants/pot	Mean	1 plant/pot	2 plants/pot	Mean
N_0	K_0	6.00^{ab}	6.42^{ab}	6.21^{a}	5.75^{ab}	6.17^{a}	6.69^{a}
N_1	K_0	6.72^{a}	6.33^{ab}	6.53^{a}	4.83^{b}	6.00^{ab}	5.42^{a}
N_1	K_1	6.17^{ab}	6.33^{ab}	6.25^{a}	5.53^{ab}	5.50^{ab}	5.51^{a}
N_2	K_0	6.67^{ab}	6.33^{ab}	6.50^{a}	6.19^{a}	5.61^{ab}	5.90^{a}
N_2	K_2	6.56^{ab}	6.50^{ab}	6.53^{a}	5.78^{ab}	5.53^{ab}	5.65^{a}
N_0	K_1	6.17^{ab}	6.42^{ab}	6.29^{a}	5.83^{ab}	5.67^{ab}	5.75^{a}
N_0	K_2	6.25^{ab}	5.67^{b}	5.96^{a}	6.00^{ab}	6.25^{a}	6.13^{a}
Mean		6.36^{a}	6.29^{a}		5.70^{a}	5.82^{a}	
LSD at 0.05		D 0.94	F 0.75	DF 0.89	D 1.44	F 0.912	DF 1.9
C V%				8.39			11.22

Differences between means as indicated by the same letters for the different treatments are not statistically significant at probability⩽0.05.

3.2. Shoot dry weight (g)

As in Table 2 Plant density, fertilizer doses and their interaction had a significant effect on plant dry weight. Increasing plant density up to two plants per pot (D_2) decreased significantly plant dry weight, compared with lower plant density (D_1). The higher dose of nitrogen and potassium (N_2 K_2) in both seasons and lower dose of nitrogen without potassium in the second season (N_1 K_0) gave the greatest dry weights of the plant. Lower and higher dose of potassium without nitrogen (N_0 K_1 and N_0 K_2) and plant receiving no fertilizer (N_0 K_0) decreased plant dry weight. In both seasons, lower plant density (D_1) treated with higher doses of nitrogen and potassium (N_2 K_2) and lower dose of nitrogen (N_1 K_0) were significantly higher in dry weight. Higher plant density (D_2) receiving potassium without

nitrogen of higher or lower dose (N_0 K_1; N_0 K_2) was mild in weight.

Table 2. Effect of plant density and dose of nitrogen and potassium on shoot dry weight (g)

Fertilizer doses		First season		Mean	Second season		Mean
		1 plant/pot	2 plants/pot		1 plant/pot	2 plants/pot	
N_0	K_0	22.04^{abc}	16.60^{def}	19.32^{abc}	26.26^{b}	14.59^{def}	20.42^{bc}
N_1	K_0	25.97^{a}	16.14^{ef}	21.06^{ab}	29.82^{a}	16.78^{de}	23.30^{a}
N_1	K_1	20.48^{bcd}	14.65^{fg}	17.57^{cd}	21.46^{c}	17.85^{d}	19.66^{bc}
N_2	K_0	23.71^{ab}	14.73^{fg}	19.22^{abcd}	26.60^{b}	16.94^{de}	21.77^{ab}
N_2	K_2	25.59^{a}	19.17^{cde}	22.38^{a}	30.35^{a}	17.85^{d}	24.12^{a}
N_0	K_1	21.01^{bc}	10.91^{g}	15.96^{d}	23.59^{bc}	14.13^{ef}	18.86^{c}
N_0	K_2	23.16^{abc}	12.78^{fg}	17.97^{bcd}	23.81^{bc}	12.97^{f}	18.39^{c}
Mean		23.14^{a}	15.00^{b}		26.00^{a}	15.86^{b}	
LSD at 0.05		D 4.94	F 3.11	DF 3.71	D 1.13	F 3.12	DF 2.61
C V%				11.54			8.84

Differences between means as indicated by the same letters for the different treatments are not statistically significant at probability⩽0.05.

3.3. Number of pods per plant

There were significant differences on number of pods per plant due to plant density, fertilizer and their interaction (Table 3). Lower plant density (D_1) gave the maximum number of pods per plant compared with the higher plant density (D_2). During the first season, the greatest number of pods per plant was obtained by plant treated with the highest dose of both elements (N_2 K_2) while, the lower dose of nitrogen with potassium or without potassium (N_1 K_1; N_1 K_0) gave the highest number of pods per plant in the second season, the pair doses were statistically similar. A similar results in both seasons were presented when lower plant density (D_1) treated with high doses of fertilizer (N_2 K_2) in the first season and (N_1 K_1; N_1 K_0) in the

second season. Less number of pods per plant was a base phenomenon of higher plant density (D_2) overall fertilizer treatments compared with lower plant density (D_1) which received the same dose of fertilizer or other dose.

Table 3. Effect of plant density and dose nitrogen and potassium on number of pods per plant

Fertilizer doses		First season		Mean	Second season		Mean
		1 plant/pot	2 plants/pot		1 plant/pot	2 plants/pot	
N_0	K_0	31.84^{b}	21.92^{cd}	26.88^{b}	28.61^{bc}	19.14^{e}	23.88^{c}
N_1	K_0	34.72^{ab}	23.78^{cd}	29.25^{ab}	32.38^{a}	23.00^{d}	27.69^{a}
N_1	K_1	35.80^{ab}	24.11^{cd}	29.96^{ab}	32.38^{a}	22.88^{d}	27.62^{a}
N_2	K_0	35.89^{ab}	21.43^{cd}	28.66^{b}	32.25^{a}	20.92^{de}	26.58^{ab}
N_2	K_2	38.96^{a}	26.00^{c}	32.48^{a}	30.75^{ab}	21.75^{de}	26.25^{ab}
N_0	K_1	32.04^{b}	21.50^{cd}	26.77^{b}	30.25^{abc}	19.38^{e}	24.81b^{c}
N_0	K_2	32.92^{b}	21.25^{d}	27.08^{b}	27.74^{c}	19.50^{e}	23.62^{c}
Mean		34.59^{a}	22.86^{b}		162.7^{a}	20.94^{b}	
LSD at0.05		D 3.57	F 3.50	DF 4.18	D 1.52	F 2.12	DF 2.53
C V%				8.63			5.81

Differences between means as indicated by the same letters for the different treatments are not statistically significant at probability⩽0.05.

3.4. Pod fresh weight (g)

Table 4 shows that pod fresh weight was not affected by different plant density nor with different doses of nitrogen and potassium fertilizers. The interaction between plant density and fertilizer doses varied significantly with a variation of plant density and fertilizer doses in the first season. In the first season, the individual plant per pot (D_1) with application of high rate of potassium without nitrogen (N_0 K_2) was superior to the other plants in term of pod

fresh weight, especially with a dense planting (D_2) that received higher doses of nitrogen and potassium (N_2 K_2).

Table 4. Effect of plant density and dose of nitrogen and potassium on pod fresh weight (g)

Fertilizer doses		First season			Second season		
		1 plant/pot	2 plants/pot	Mean	1 plant/pot	2 plants/pot	Mean
N_0	K_0	5.23ab	5.04ab	5.13a	5.18a	5.30a	5.21a
N_1	K_0	5.32^{ab}	5.29^{ab}	5.31^{a}	5.58^{a}	5.37^{a}	5.48^{a}
N_1	K_1	5.41^{ab}	5.12^{ab}	5.26^{a}	5.45^{a}	5.21^{a}	5.33^{a}
N_2	K_0	4.97^{ab}	5.23^{ab}	5.10^{a}	5.10^{a}	5.10^{a}	5.10^{a}
N_2	K_2	5.48^{ab}	4.95^{b}	5.21^{a}	5.18^{a}	5.46^{a}	5.32^{a}
N_0	K_1	5.29^{ab}	5.57^{ab}	5.43^{a}	5.47^{a}	5.02^{a}	5.25^{a}
N_0	K_2	5.74^{a}	5.21^{ab}	5.47^{a}	5.25^{a}	5.04^{a}	5.15^{a}
Mean		5.35^{a}	5.20^{a}		5.30^{a}	5.21^{a}	
LSD at 0.05		D 0.17	F 0.55	DF 0.66	D 0.23	F 0.44	DF 0.53
C V%				7.39			5.98

Differences between means as indicated by the same letters for the different treatments are not statistically significant at probability⩽0.05.

3.5. Pod yield per plant (g)

The data pooled in Table 5 indicated that the plant yield responded significantly to the plant density (D), different doses of nitrogen (N) and potassium (K) fertilizer and their interaction. Lower plant density (D_1) enhances pods yield per plant than the higher plant density (D_2). In the first season higher doses of both fertilizer (N_2 K_2) increased pod yield per plant significantly, while in the second season the half dose of nitrogen without potassium (N_1 K_0) gave a superior yield of pods per plant followed by a plant which received a similar dose of

nitrogen with a half dose of potassium (N_1 K_1) in both seasons. Pod yield declined when received no fertilizer (N_0 K_0) and when receiving potassium without nitrogen at higher dose (N_0 K_2). Interaction between plant density and fertilizer showed that the lower plant density (D_1) improved plant yield under all different fertilizer doses compared with the higher plant density, whereas the lower plant density (D_1) with a complete dose of nitrogen and potassium (N_2 K_2) in the first season and half dose of nitrogen without potassium (N_1 K_0) and half dose of both (N_1 K_1) in the second season increased plant yield. High plant population (D_2) treated with higher potassium dose (N_0 K_2) had a negative effect on pod yield followed by a similar density that received no fertilizer dose (N_0 K_0).

Table 5. Effect of plant density and dose nitrogen and potassium on pod yield per plant (g)

Fertilizer doses		First season			Second season		
		1 plant/pot	2 plants/pot	Mean	1 plant/pot	2 plants/pot	Mean
N_0	K_0	166.6^{b}	110.2^{b}	138.4^{b}	146.7^{c}	101.5^{de}	124.1^{c}
N_1	K_0	187.1^{ab}	125.9^{cd}	156.5^{ab}	180.9^{a}	123.6^{cd}	152.3^{a}
N_1	K_1	194.1^{ab}	122.5^{cd}	158.3a^{b}	176.7^{a}	117.7^{de}	147.2^{ab}
N_2	K_0	178.4^{b}	112.1^{cd}	145.2^{b}	164.6^{ab}	97.62^{e}	131.1^{bc}
N_2	K_2	213.4^{a}	139.8^{c}	176.6^{a}	158.4^{ab}	118.7^{de}	138.8^{abc}
N_0	K_1	169.3^{b}	112.7^{cd}	141.0^{b}	165.4^{ab}	102.9^{de}	134.1^{abc}
N_0	K_2	179.3^{b}	118.3^{cd}	148.8^{b}	145.6^{bc}	98.43^{e}	122.0^{c}
Mean		184.0^{a}	120.2^{b}		162.7^{a}	108.6^{b}	
LSD at 0.05		D 12.04	F 21.59	DF 25.75	D 6.68	F 22.05	DF 18.48
C V%				10.05			9.46

Differences between means as indicated by the same letters for the different treatments are not statistically significant at probability≤0.05.

3.6. Pod yield per hectare (ton ha^{-1})

Pods yield per hectare was calculated from the yield per plant multiplying by a number of plants per hectare; therefore the results followed the same pattern of significance and presented a different picture as green pod yield per plant (Table 6). Higher plant density (D_2) increased yield per unit area compared with lower density (D_1). A full dose of nitrogen and potassium fertilizer in the first season (N_2 K_2) and half dose of nitrogen in the second season (N_1 K_0) had superior means in term of plant yield per hectare, followed by a plant treated with lower doses of nitrogen and potassium (N_1 K_1) in both seasons, and plant receiving nitrogen without potassium (N_1 K_0), in the first season. Plant grown without fertilizer (N_0 K_0) or with potassium only (N_0 K_1; N_0 K_2) gave the lowest yield per hectare except the lower dose of potassium in the second season. Interaction between plant density and fertilizer had the same result due to doubling density. Higher density with all doses of fertilizers over yielded lower density. Dense plant (D_2) received a full dose of nitrogen and potassium (N_2 K_2) in the first season and the plant received a half dose of nitrogen only (N_1 K_0) in the second season, gave the greatest means. The lower density (D_1) receiving no fertilizer (N_0 K_0) in both seasons decreased yield.

Table 6. Effect of plant density and dose nitrogen and potassium on pod yield per hectare (ton ha^{-1})

Fertilizer doses		First season			Second season		
		1 plant/pot	2 plants/pot	Mean	1 plant/pot	2 plants/pot	Mean
N_0	K_0	18.00^{e}	23.62^{bc}	20.81^{b}	15.62^{f}	21.75^{bc}	18.73^{c}
N_1	K_0	20.04^{cde}	26.64^{ab}	23.34^{ab}	19.38^{cdef}	26.50^{a}	22.94^{a}
N_1	K_1	20.80^{cde}	26.04^{ab}	23.42^{ab}	18.93^{cdef}	25.22^{ab}	22.08^{ab}
N_2	K_0	20.78^{cde}	24.01^{bc}	22.40^{b}	17.64^{def}	20.92^{cde}	19.28^{bc}
N_2	K_2	22.86^{bcd}	29.96^{a}	26.41^{a}	17.03^{ef}	25.42^{ab}	21.23^{abc}
N_0	K_1	18.13^{e}	24.15^{bc}	21.14^{b}	17.72^{def}	22.05^{bc}	19.89^{abc}
N_0	K_2	19.20^{de}	25.34^{b}	22.27^{b}	15.60^{f}	21.08^{cd}	18.34^{c}
Mean		19.97^{b}	25.68^{a}		17.43^{b}	23.28^{a}	
				DF			DF
LSD at 0.05		D 2.35	F 3.15	3.76	D 2.05	F 2.97	3.54
C V%				9.78			10.32

Differences between means as indicated by the same letters for the different treatments are not statistically significant at probability⩽0.05.

4. DISCUSSION

The results of this experiment showed that the plant density and fertilizer doses had no effect on the number of branches per plant. This is in agreement with the results of Elhag and Hussein, (2014) who reported that there was no significant effect on the number of branches due to the number of plants per hole. Nutrient availability led to increase in plant dry weight. In both seasons lower plant density and higher dose of nitrogen and potassium in addition to lower nitrogen dose with potassium or without potassium and their interaction increased plant

dry weight, resulting in an increasing in the number of pods and pods yield per plant. Similar result was obtained by Koli and Akashe (1995). They reported that increased dry weight in French beans with increasing in row spacing. Hatami et al., (2009) ~~who~~ found that the nitrogen consumption increased plant dry weight resulting in increased plant yield. There was an inverse relationship between the density of plants and the number of pods per plant and a positive correlation between density and productivity of pods per unit area. Higher plant density produced fewer number of pods per plant, but the highest yield per unit area, due to increase the total number of plants per unit area, while the pod fresh weight was not affected (Figure 1). These results are in accordance with that of Elhag and Hussein, (2014) who found positive effects due to increase plant density. Alghamdi, (2002) reported that the number of plants per unit area seems to be more critical than the number of pods per planting influencing yield per unit area. Additionally, the application of nitrogen fertilizer at a higher or lower dose increased plant yield. This result is in close conformity with the findings of Moniruzzaman et al., (2009) recorded that the maximum number of green pods per plant with the lower plant density at the highest nitrogen level while, Srinivas and Naik, (1990); and Mtaita and Mutetwa, (2014) recorded the maximum pod yield of French bean at two higher doses of nitrogen. The application of potassium fertilizer without nitrogen had no effect on vegetative growth and yield parameters. This finding agrees with Ghallab et al., (2014) found that the highest total green pod yields was obtained by application of both nitrogen and potassium. However, a potassium fertilizer (alone) and untreated plants gave the lowest green pods. Seedy vegetables such as Pea and Bean absorbed less amount of potassium from the soil about 35 Kg fed^{-1} while, leafy vegetables absorbed more quantity of potassium about 160 Kg fed^{-1} (Hassan, 1997).

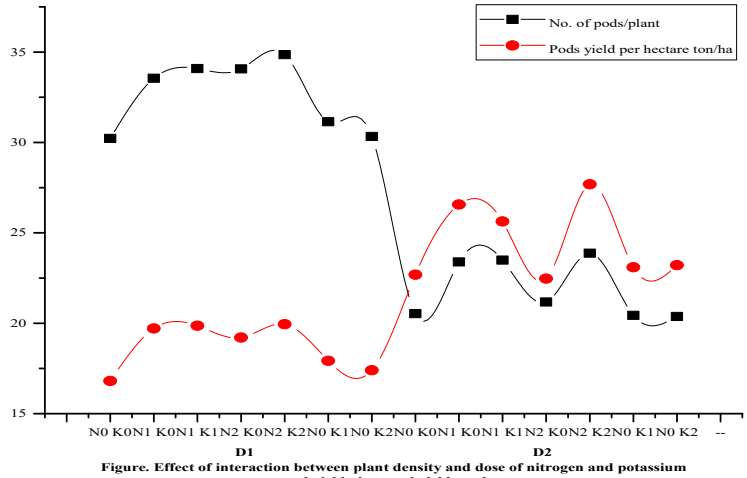

Figure. Effect of interaction between plant density and dose of nitrogen and potassium on pod yield plant and yield per hectar.

5. CONCLUSION

From the above discussion, it could be concluded that the bean plant should be cultivated in the soil of Blida state and the areas of the similar soils at the plant density of two plants per pot (214290 plants per hectare) with application of fertilizer dose spatially nitrogen in lower 0.46 or higher dose 0.92 g/pot (98.57 or 197.14 Kg urea/ha) while, the individual application of potassium fertilizer had a limited effect on pod fresh weight in the first season.

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