Productivity and Quality of Lima Bean Grown in Sandy Soil as Affected by Plant Densities and NPK Applications

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Abstract

Two field experiment were carried out during 2008 and 2009 summer seasons (5th March), at the experimental farm of Faculty of Agriculture, Sohag University Egypt, to investigate the influence of three plant densities (17.1, 11.4 and 9.1 plant/m^2) and four NPK equations i.e., 119.6-55.3-59.5, 159.5-73.8-119.0, 199.3 -92.2-178.5 and 239.2-110.7-238.0 Kg N-P-K/ha on productivity and quality of lima bean cv. 'Raio de sol' grown in sandy soil. The obtained results showed that, plant population densities significantly affected vegetative growth parameters i.e., (plant height and number of branches/plant); yield and its components expressed as number of pods/plant, pod length, pod width, number of seeds/pod, weight of 100-seeds and total seeds yield as well as quality characteristics i.e., protein, phosphorus and potassium percentages as well as vitamin B1. However, the medium plant densities (11.4 plant/m^2) resulted in the highest values of pod length cm, weight of 100 seeds, and total seeds yield, in both seasons. Increasing NPK rates significantly increased all studied characteristics in the two experimental seasons. Moreover, the plants received the highest rate (239.2-110.7-238.0 Kg N-P-K/ha) gave the highest values for all studied characteristics as compared to other NPK equations.

The interaction between the two studied factors (plant densities and NPK equations) significantly affected vegetative growth criteria, seed yield and its components as well as quality characteristics. Meanwhile, the combinations between medium plant density and NPK application rate (11.4 plant/m^2 and 199.3-92.2-178.5 Kg N-P-K/ha) recorded the highest values for pod length, number of seeds/pod, weight of 100 seeds, and total seeds yield as well as all quality characteristics in both seasons.

INTRODUCTION

Lima beans (*Phaseolus lunatus* L.) rank among the most popular legumes in tropical regions due to its ample adaptation and good protein production. As consequence, the species is a pragmatic option to reduce the dependence on common beans especially with the complicated problems faced the cultivation and production of common beans (Vieira, 1992).

Lima beans are alternative food consumed processed, either as canned or frozen green grains. It considered as very good source of cholesterol-lowering In addition to lowering cholesterol, lima beans' high fiber content prevents blood sugar levels from rising too rapidly after a meal, making these beans an especially good choice for individuals with diabetes, insulin resistance or hypoglycemia (Ensminger and Esminger, 1986). Lima beans grow well in sandy or medium texture soils (Filgueira, 2000).

Efforts are needed to grow this type of crops and to extend the basic knowledge and suitable agricultural practices to involved persons. Now a days, great efforts are being made all over the world for production more and better food to satisfy the needs of the over increasing population of the world, especially, in the developing countries. In this connection, high density sowing offer promising means of reducing the cost of growing by increasing the productivity and making better use of input resources on a per area basis. The literature offers little information relative to the effect of population density on the yield and quality of lima bean. (Matthews, 1933; Aranenda, 1981; Samali and Rweyemau, 1987; Hornzy, 1988; Abubaker, 2008).

Mineral fertilizers play an important role of lima bean plant growth and productivity. Nitrogen is essential for synthesis of chlorophyll, enzymes and proteins. Phosphorus is essential for root growth, phospho-proteins, phospholipids and ATP, ADP formation. Potassium play an important role of promotion of enzymes activity and enhancing the translocation of assimilates and protein synthesis (Delvin and Withman, 1986).

Consequently, adjustment of the crop management by adding NPK fertilizers in suitable amount for rare vegetable crop as lima bean especially, in new reclaimed soil and in new cultivation region is one of the main purposes. It is a high nutrient demanding species (Hester et al., 1951). Increase in both common and lima beans yield as consequence of mineral fertilization is largely documented (Nleya et al., 1989; Vieira et al., 1992; Kalyano, 1996; Frazão et al., 2004; Oliveira et al., 2004; Adriana et al., 2008 and El-Tohamy et al., 2009).

This investigation designed as a trail to spread of lima bean as a rare vegetable crop in new cultivation regions and reducing the dependence on common beans, and extend the farmers in Upper Egypt by basic knowledge and suitable agricultural practices.

MATERIAL AND METHODS

The present study was carried out during the summer seasons of 2008 and 2009 at the Experimental Farm, Faculty of Agriculture, Sohag University, Sohag, Egypt where the soil is newly reclaimed (Sandy Clay Loam as show in Table 1).

Lima bean seeds cultivar 'Raio de sol' was used in this study.

Three population densities were used in this study i.e., 17.1, 11.4 and 9.1 plant/m^2 resulted in sowing lima bean seeds on ridges 60 cm apart and sowing two seeds per hill in distance 20, 30 and 40 cm between hills, respectively.

Mineral NPK fertilizers were applied at four equations i.e., NPK1 (119.6-55.3-59.5), NPK2 (159.5-73.8-119.0), NPK3 (199.3-92.2-178.5) and NPK4 (239.2-110.7-238.0) Kg/ha

Nitrogen fertilizer was added in the form of ammonium nitrate (33.5% N), at three equal doses, the first was after three weeks from sowing and the others after two weeks intervals. Phosphorus fertilizer was added during soil preparation in the form of triple super phosphate (37% P_2O_5). Potassium fertilizer was added in the form of potassium sulphate (50% K_2O) at two equal batches the first during the soil preparation and the other one with flowering and start fruits setting.

The treatments were arranged as a split-plot in randomized complete-blocks (RCB) design with four replicates. The three population densities were arranged in the main plots and four mineral NPK fertilizers equations were assigned in the sub-plots.

Each experimental unit was 10.5 m^2 consisted of five ridges 60 cm apart and 3.5 m length. Sowing was done in 5 March in the both seasons. Recommended cultural procedures other than the applied treatments were followed. At harvest time the following characteristics were determined:

1. Vegetative Growth Characteristics. Ten guarded plants were taken at random from inner ridges of each plot to measure the following:

1. Plant height (cm) (at the end of harvesting).
2. Number of branches/plant (at the end of harvesting).

2. Yield and Its Components.

3. Number of pods/plant.
4. Pod length (cm) (average 30 dry pods from each plot).
5. Pod width (cm) (average 30 dry pods from each plot).
6. Number of seeds/pod (average 30 dry pods from each plot).
7. Weight of 100 seeds (g)
8. Total seeds yield (t/ha)

3. Quality Characteristics. Random samples of seeds from each treatment were taken after harvesting and dried at 70°C. The dried samples were ground and used for the determination of protein, Phosphorus and Potassium percentage as well as vitamin B1 (thiamin mg/100 g) according to method described as recommended by A.O.A.C (2000).

Statistical Analysis

Data obtained during the two seasons of the study were statistically analyzed and treatments means were compared using the Duncan's multiple range tests (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Vegetative Growth Characteristics

Data presented in Table 2 clearly show that plant population densities significantly effect on vegetative growth characteristics expressed as plant height (cm) and number of branches/plant. The tallest plants (96.9 and 98.1 cm) were resulted in the highest plant densities i.e., (17.1 plants/m^2) as compared to the other two plant densities in the first and second season respectively. This finding could be attributed to the reduction in light intensity caused by high plant density, encouraged IAA synthesis, which caused cell enlargement and hence plant height. On contrary, the lowest plant densities i.e., (9.1 plants/m^2) recorded the highest number of branches/plant (3.5). This result might be due to the above and below competitions between plants for light, minerals and water. These results are in harmony with those reported by Hornzy (1988) and Abubaker (2008).

Plant height (cm) and number of branches/plant had gradually significant increased from the lowest up to the highest NPK application rates in both seasons. This might be due to the high nutritional status produced by the highest NPK rate. These results are in agreements with those reported by Adriana et al. (2008).

The interaction between the two studied factors significantly effect on plant height and number of branches in both seasons. However, the combination between the highest plant density i.e., (17.1 plants/m^2) and the highest NPK rates (239.2-110.7 -238.0) kg/ha produced the highest plant height. On the other hand, the interaction between the lowest plant density i.e., (9.1 plants/m^2) and the highest NPK rates achieved the highest number of branches. These results held well in both seasons.

Yield and Its Components

Results illustrated in Tables 2 and 3 reveal that plant densities significantly effect on yield and its components expressed as number of pods/plant, pod length (cm), pod width (cm), number of seeds/pod, weight of 100-seeds (g) and total seeds yield (t/ha). Furthermore, the medium plant density i.e., (11.4 plant/m^2) resulted in the highest total seeds yield i.e., (2.004 and 2.011 t/ha) in the first and second season, respectively. This result may be attributed to that the greater amount of light energy intercepted by foliage in optimum plant density might in turn results in the increase the amount of metabolites synthesized by plants, consequently the total seed yield per unit area became greater in medium plant density than the highest or the lowest one. These findings are line with those found by Samali and Rweyemau (1987), Hornzy (1988) and Abubaker (2008).

Regarding the effect of varying applied rates of NPK, the obtained results indicate that NPK rates significantly increased yield and its components in the two experimental seasons. Meanwhile, the highest values were recorded by the highest NPK rate i.e., (239.2-110.7-238 Kg N-P-K/ha) as compared to the lowest values produced by the lowest NPK rate i.e., (119.6-55.3-59.5 Kg N-P-K/ha). These results held well in the two experimental seasons. These results are coinciding with those reported by Vieira et al. (1992) and Kalyano (1996).

Concerning the interaction between the two studied factors data listed in Tables 2 and 3 obviously show that the interaction significantly increased yield and its components in both seasons. Moreover, the interaction between medium plant density (11.4 plants/

m^2) and NPK rates of (199.3-92.2-178.5 Kg N-P-K/ha) achieved the highest plant pod length, number of seeds/ pod, weight of 100-seeds (g) and total seeds yield (t/ha) in both seasons.

Quality Characteristics

Data tabulated in Table 4 indicate that plant densities significantly increased quality characteristics i.e., (protein, phosphorus and potassium) percentages as well as vitamin B1 (thiamin mg/100 g). However, the medium plant densities (11.4 plant/m^2) gave the highest values for all quality characteristics as compared to other two plant densities in both seasons. These results are in general trend with those reported by Abubaker (2008).

Fertilizing lima bean plants with NPK application rates significantly affect on quality characteristics. In addition, NPK rates of 199.3-92.2-178.5 Kg N-P-K/ha resulted in the highest values of protein and phosphorus percentages. While, the highest NPK rate i.e., (239.2-110.7-238 Kg N-P-K/ha) produced the highest values of potassium percentage and vitamin B1 (thiamin mg/100 g) in both seasons. These results are confirmed by Filgueira (2000).

The interaction between plant densities and NPK application rates significantly affect on all quality characteristics in both seasons. Furthermore, the interaction between medium plant density (11.4 plants/ m^2) and NPK rates of 199.3-92.2-178.5 Kg N-P-K/ha recorded the highest values for all quality characteristics in both seasons.

CONCLUSION

It could be concluded that sowing lima bean at medium plant density (11.4 plants/ m^2) and fertilized with proper NPK rates of (199.3-92.2-178.5 Kg N-P-K/ ha) give the highest yield and quality under such conditions.

Literature Cited

A.O.A.C. 2000. Association of Official and Agriculture Chemists. Official and Tentative Methods of Analysis, 17th ed. Washington, D.C.

Abubaker, S. 2008. Effect of plant density on flowering date, yield and quality attribute of bush. Beans (*Phaseolus vulgaris* L.) under center pivot irrigation system. American Journal of Agricultural and Biological Sciences 3(4):666-668.

Adriana, U.A., Ademar, P.O., Anarlete, U.A., Carina, S.M.D., Edna, U.A., Edson, A., Arnaldo, N.P.O. and Iordan, S.C. 2008. Lima beans production and economic revenue as function of organic and mineral fertilization. Hortic. Bras. 26(2):251-254.

Aranenda, Mc.Del, R. 1981. Effect of sex plant densities on growth and development of two beans cultivars. Abstracts on field beans (*Phaseolus vulgaris* L.). X 48.

Delvin, R.M. and Withman, F.H.. 1986. Plant physiology. 4th ed. CBS Publishers and Distributors, 485 Jain Bhawan, Shadhara, Delhi, India.

El-Tohamy, W.A., Ghoname, A.A., Riad, G.S. and Abou-Hussein, S.D. 2009. The influence of slow release fertilizer on bean plants (*Phaseolus vulgaris* L.) grown in sandy soils. Australian Journal of Basic and Applied Sciences, 3(2):966-969.

Ensminger, A.H. and Esminger, M.K. 1986. Food for Health: A Nutrition Encyclopedia. Clovis, California: Pegus Press; PMID: 15210.

Filgueira, F.A.R. 2000. Novo manual deolericultura. Viçosa: UFV. 402p.

Fraazao, J.E.M., Santos, D., Ferreira, F.M.B., Oliveira, F.P., Pereira, W.E. and Souza, A.P. 2004. Crescimento da fava em resposta a níveis de fósforo na presença e ausência de calagemem Latossolo Amarelo. In: FERTBIO, Anais Lages: SBCS (CD-ROM).

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural. Research. 2nd ed. John Wiley and Sons, Inc., New York. 680p.

Hester, J.B., Shelton, F.A. and Isaacs, J.R. 1951. The rate and amount of plant nutrients absorbed by various vegetables. Journal of the American Society for Horticultural Sciences 57:249-251.

Hornzy, P. 1988. Planting methods and placement in dry beans. Row spacing studies Michigan Dry Beans Digest. 12(2):15. c.f.: Abstracts on field beans (*Phaseolus vulgaris* L.). XV: 34596.
Kalyano, M.N., Singh, R.N., Bohra, J.S. and Singh, K.S. 1996. Fertilizer and irrigation studies on yield economy and NPK uptake of French bean (*Phaseolus vulgaris* L.). Fertilizer News 41(5):39-42.
Matthews, W.A. 1933. The influence of planting distance on the yield of snap and lima beans. Proc. A.S.H.S. 30:567-570.
Nleya. T.M. 1989. Response of dry beans (*Phaseolus vulgaris* L.) to varying levels of NPK fertilizers. J. Agric. Res. 27(2):149-151.
Oliveira, A.P., Alves, E.U., Alves A.U., Dornelas, C.S.M., Silva, J.A., Porto, M.L. and Alves, A.U. 2004. Produção de feijão-fava emfunção do uso de doses de fósforo. Horticultura Brasileira 22:543-546.
Samali, S.N. and Rweyemamu, C.L. 1987. Effect of plant population on four bean (*Phaseolus vulgaris* L.) cultivars yield and yield components. p.136-143. In: Salema and Minjas (eds.), Bean Research Vol. 2. Peramiho Printing Press, Tanzania.
Vieira, C. 1992. Leguminosas de grãos:importância econômica na agricultura e naalimentação humana. Informe Agropecuário16:5-11.
Vieira, R.F., Vieira, C. and Andrade, G.A. 1992. Comparações agronômicas de feijões dos gêneros Vigna e Phaseolus com o feijãocomum (*Phaseolus vulgaris* L.). Pesquisa Agropecuária Brasileira 27:841-850.

Tables

Table 1. Soil characterization of the experimental site.

Sampling depth	E.C. (1:5) dSm^{-1}	pH (H_2O) (1:2.5)	O.M %	$CaCO_3$ %	Clay %	Silt %	Sand %	Soil Texture	Total N (%)	$NaHCO_3$-P ppm	Available K ppm
0 - 25	0.21	7.35	2.51	11.27	29.70	23.12	47.18	SCL	0.199	8.3	374
25 - 45	0.15	7.73	0.09	52.15	3.19	6.00	90.81	S	0.053	19.5	178
45 - 65	0.19	7.90	0.40	55.49	2.90	7.18	89.92	S	0.004	19.9	144
65 - 80	0.20	7.85	0.31	22.50	2.60	7.22	90.18	S	0.004	6.5	102

SCL= Sandy Clay Loam, S= Sand, $NaHCO_3$-P= $NaHCO_3$-P extractable-P.

Table 2. Effect of plant densities, NPK applications and their interaction on plant height, number of branches/plant, number of pods/plant and pod length in both growing seasons.

Treatments		Plant height (cm)		Number of branches/plant		No. of pods/plant		Pod length (cm)	
Densities No. plants/m^2	NPK Rates	2008	2009	2008	2009	2008	2009	2008	2009
17.1	NPK 1	89.0F	90.1H	2.1I	2.1I	5.2J	5.3I	27.4H	27.4H
	NPK 2	95.2D	94.8EF	2.4H	2.3H	5.6I	5.7H	28.0G	28.0G
	NPK 3	98.5C	99.2C	2.5GH	2.5GH	6.9F	6.9F	28.5EF	28.5F
	NPK 4	105.0A	108.0A	2.6GH	2.6FG	7.6E	7.7E	29.2CD	29.2DE
Mean		96.9A	98.1A	2.4C	2.4C	6.3C	6.4C	28.3B	28.3B
11.4	NPK 1	91.3E	92.4GH	2.7FG	2.7FG	6.3H	6.5G	28.2FG	28.1G
	NPK 2	95.0D	93.8FG	2.8EF	2.8F	7.8D	7.9D	29.6C	29.6C
	NPK 3	98.3C	97.2CD	3.1CD	3.1DE	9.5B	9.5B	30.7A	30.9A
	NPK 4	101.3B	103.0B	3.6B	3.5BC	9.5B	9.5B	30.5AB	30.7A
Mean		96.5A	96.7B	3.1B	3.0B	8.3B	8.4B	29.7A	29.8A
9.1	NPK 1	85.4G	83.4I	3.0DE	3.1E	9.5G	6.8F	28.9DE	29.0E
	NPK 2	90.8E	90.7H	3.3C	3.3CD	8.2C	8.5C	29.5C	29.5CD
	NPK 3	95.5D	96.4DE	3.7AB	3.7AB	9.9A	9.8A	30.3B	30.3B
	NPK 4	97.9C	99.1C	3.9A	3.8A	10.0A	10.0A	30.7A	30.6AB
Mean		92.4B	92.4C	3.5A	3.5A	8.6A	8.8A	29.9A	29.8A
Mean of NPK rates	NPK 1	88.6D	88.6D	2.6D	2.6D	6.0D	6.2D	28.2D	28.1D
	NPK 2	93.7C	93.1C	2.9C	2.8C	7.2C	7.4C	29.0C	29.0C
	NPK 3	97.9B	97.6B	3.1B	3.1B	8.8B	8.7B	29.8B	29.9B
	NPK 4	101.4A	103.0A	3.4A	3.3A	9.0A	9.1A	30.1A	30.1A

Table 3. Effect of plant densities, NPK applications and their interaction on pod width, number of seeds/pod, weight of 100 seeds and total seeds yield in both growing seasons.

Treatments		Pod width (cm)		Number of seeds/pod		Weight of 100 seeds (g)		Total seeds yield (t/ha)	
Densities No. plants/m^2	NPK Rates	2008	2009	2008	2009	2008	2009	2008	2009
17.1	NPK 1	2.2H	2.1E	7.3G	7.3H	84.0F	84.3D	1.516I	1.761F
	NPK 2	2.3G	2.4D	7.8F	7.8G	87.3E	87.1CD	1.659G	1.709EF
	NPK 3	2.5EF	2.4D	8.5E	8.6F	94.3D	85.9D	1.816DE	1.835CD
	NPK 4	2.6DE	2.6C	9.5D	6.9E	97.6C	97.5AB	1.968B	1.968B
Mean		2.4C	2.4C	8.3C	8.3C	90.8C	88.7B	1.740B	1.773B
11.4	NPK 1	2.4F	2.4D	8.7E	8.7F	87.0E	87.8CD	1.709F	1.733DE
	NPK 2	2.6D	2.6C	10.0C	9.9D	92.9D	94.3B	1.897C	1.897BC
	NPK 3	2.8BC	2.9B	11.6A	11.6AB	103.3A	103.3A	2.213A	2.206A
	NPK 4	2.8BC	2.9B	11.6A	11.4B	102.8A	102.9A	2.194A	2.206A
Mean		2.7B	2.7B	10.5B	10.4B	96.5A	97.1A	2.004A	2.011A
9.1	NPK 1	2.6D	2.6C	9.8CD	10.2D	87.2E	87.9CD	1.578H	1.421G
	NPK 2	2.7C	2.8B	10.9B	11.1C	92.4D	92.3BC	1.709F	1.704EF
	NPK 3	2.9AB	2.9B	11.3A	11.6AB	100.7B	102.2A	1.806E	1.802CDE
	NPK 4	3.0A	3.1A	11.6A	11.8A	101.4B	103.3A	1.849D	1.852BCD
Mean		2.8A	2.9A	10.9A	11.2A	95.4B	96.4A	1.735B	1.694C
Mean of NPK rates	NPK 1	2.4C	2.4D	8.6D	8.7D	66.1D	86.7D	1.601D	1.587C
	NPK 2	2.5B	2.6C	9.5C	8.6C	90.8C	91.2C	1.754C	1.764B
	NPK 3	2.7A	2.7B	10.5B	10.6B	99.4B	97.1B	1.944B	1.947A
	NPK 4	2.8A	2.8A	10.9A	10.9A	100.6A	101. 2A	2.000A	3.929A

Table 4. Effect of plant densities, NPK applications and their interaction on protein, phosphorus, potassium and vitamin B1 contents in both growing seasons.

Treatments		Protein %		Phosphorus %		Potassium %		Vitamin B1 (mg/100g)	
Densities No. plants/m^2	NPK Rates	2008	2009	2008	2009	2008	2009	2008	2009
17.1	NPK 1	27.04J	26.89F	0.362I	0.364H	1.127H	1.128D	0.396J	0.398J
	NPK 2	27.69H	28.06DE	0.383H	0.385G	1.181G	1.173D	0.419I	0.419I
	NPK 3	29.67F	29.70C	0.411E	0.412E	1.225F	1.227BCD	0.446F	0.446E
	NPK 4	30.26D	30.12C	0.417DE	0.419D	1.328C	1.328BC	0.465D	0.465C
Mean		28.67C	28.69C	0.393C	0.395C	1.215C	1.214B	0.431C	0.432C
11.4	NPK 1	27.79H	27.88E	0.391G	0.383G	1.218F	1.221BCD	0.432H	0.432H
	NPK 2	29.87E	29.90C	0.418D	0.416DE	1.267D	1.263BCD	0.461E	0.458D
	NPK 3	31.94A	31.97A	0.459A	0.459A	1.365A	1.364B	0.490A	0.489A
	NPK 4	31.91A	31.95A	0.441C	0.444C	1.360A	1.515A	0.488B	0.488A
Mean		30.38A	30.42A	0.427A	0.425A	1.303A	1.340A	0.468A	0.467A
9.1	NPK 1	27.18I	27.23F	0.383H	0.384G	1.218F	1.212CD	0.432H	0.434G
	NPK 2	28.38J	28.44D	0.403F	0.404F	1.250E	1.248BCD	0.441G	0.440F
	NPK 3	31.48B	31.75A	0.450B	0.451B	1.341B	1.342BC	0.482C	0.483B
	NPK 4	31.08C	31.08B	0.444C	0.443C	1.349B	1.342BC	0.482C	0.482B
Mean		29.53B	29.63B	0.420B	0.421B	1.289B	1.286AB	0.459B	0.460B
Mean of NPK rates	NPK 1	27.33C	27.33C	0.379D	0.377D	1.188D	1.187C	0.420D	0.421D
	NPK 2	28.65B	28.80B	0.401C	0.402C	1.233C	1.228C	0.440C	0.439C
	NPK 3	31.03A	31.14A	0.440A	0.440A	1.311B	1.311B	0.473B	0.473B
	NPK 4	31.09A	31.05A	0.434B	0.435B	1.346A	1.395A	0.478A	0.478A