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Introducing Lima Bean as Non-Traditional Food Crop to Upper Egypt Growers

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Abstract: This investigation aimed to determine the suitable field management of plant density and NPK fertilizer application for lima bean to introduce it as alternative legume vegetable of common bean in new reclaimed sandy soil of Upper Egypt. Two field experiments were carried out during 2008 and 2009 summer seasons, at the Experimental Farm of Agriculture Faculty, Sohag University Egypt. The influence of three plant densities and four NPK applications rates on productivity and quality of lima bean cv. Raio de sol was studied. Plant densities of (38400, 48000 and 72000 plant/fed.) and fertilization rates of (50.25: 23.25: 25.00), (67.00: 31.00: 50.00), (83.75: 38.75: 75.00) and (100.50: 46.50: 100.00) kg NPK/fed were applied. The obtained results showed that, plant densities, NPK application rates and their interaction significantly affected lima bean vegetative growth, number of pods/plant, pod dimension, number of seeds/pod, seeds weight index and total seeds yield as well as seeds nutrient values i.e. (protein, phosphorus, potassium percentages and thiamin "V B1"). The medium plant densities (48000 plant/fed) resulted in the highest values of pod length, seeds weight index and total seeds yield (ton/ fed), in both seasons. Increasing NPK rates significantly increased all studied characteristics in the two experimental seasons. Whereas the plants received the highest rate (100.50: 46.50: 100.00 kg NPK/fed.) gave the highest values for all studied characteristics as compared to other NPK application rates. Meanwhile, the combinations between (48000 plant/fed. and 83.75: 38.75: 75.00 kg NPK/fed.) recorded the highest values for pod length (cm), number of seeds/pod, seeds weight index and total seeds yield (kg/fed.), as well as seeds nutrient values in both seasons.

Key words: *Phaseolus lunatus* L. plant density · NPK fertilization · Vegetative growth · Yield and its components · Quality

INTRODUCTION

Upper Egypt growers face many challenges in producing summer common bean, such as high temperatures, soil salinity and dryness as well as weakness of nodulation [1]. The increased of population especially in Upper Egypt forcing the growers to increase both cultivation area and productivity per area unit, in order to cover the increasing consumption. Lima beans (*Phaseolus lunatus* L.) is probably more adaptable to Upper Egypt conditions than common bean since it was ranked among the most popular legumes in tropical regions due to its ample adaptation and good protein production [2]. Moreover, lima bean ontogeny revealed more than one flower cluster at a single node in an inflorescence [3]. As consequence, the specie is a pragmatic option to reduce the dependence on common beans especially with the complicated problems faced the cultivation and production of common beans [4].

Lima beans are alternative food consumed processed, either as canned or frozen green grains. It considered as very good source of cholesterol-lowering and high fiber content preventing blood sugar making it a good choice for individuals with diabetes, insulin resistance or hypoglycemia [2]. Lima bean grows well in sandy or medium texture soils [5].

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

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of the over increasing population of the world, especially, in the developing countries. In this connection, high density sowing offers 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 [6-10].

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 plays an important role in promising enzymes activity and enhancing the translocation of assimilates and protein synthesis [11].

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 specie [12]. Increase in both common and lima beans yield as consequence of mineral fertilization is largely documented [13-19].

This investigation designed as a trail to diffuse lima bean as a rare vegetable crop in new cultivation regions, reduce 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 in new reclaimed sand soil during the summer seasons of 2008 and 2009 at the Experimental Farm, Agriculture Faculty, Sohag University, Egypt. Lima bean seeds cultivar Raio de sole was used in this study. Experimental soil properties are tabulated in Table (1).

Three population densities were used in this study i.e. (38400, 48000 and 72000 plant/fed) 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 rates i.e. (50.25: 23.25: 25.00), (67.00: 31.00: 50.00), (83.75: 38.75: 75.00) and (100.50: 46.50: 100.00) kg NPK/fed. 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 at two weeks intervals later. 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 at flowering and fruits setting stage.

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 the four mineral NPK fertilizers rates were assigned in the sub-plots. Each experimental unit was 10.5 m^2 consisted of five ridges of 3.5 m length and 60 cm apart. 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:

At the end of harvest, ten guarded plants were taken at random of inner ridges from each plot to measure plant height (cm.) and number of branches/plant. Moreover, number of pods/plant, pod length, pod width (cm), number of seeds/pod, seed weight index "weight of 100 seeds (g)" and total seeds yield (ton/fed.) were recorded. In order to determine seed nutrient value, random samples of seeds were taken from each treatment. The dried samples (70°C) were ground and used for the determination of protein, Phosphorus and Potassium percentages as well as vitamin B1 (thiamin) according to method described as recommended by A.O.A.C [20]. Recorded data were statistically analyzed and treatments means were compared using the Duncan's multiple range tests [21].

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 %
0 - 25	0.21	7.35	2.51	11.27	29.70	23.12	47.18
25 - 45	0.15	7.73	0.09	52.15	3.19	6.00	90.81
45 - 65	0.19	7.90	0.40	55.49	2.90	7.18	89.92
65 - 80	0.20	7.85	0.31	22.50	2.60	7.22	90.18

RESULTS AND DISCUSSION

Vegetative Growth Characteristics: Data presented in Table (2) clearly show that plant population densities significantly affected vegetative growth characteristics expressed as plant height (cm) and number of branches/plant. The tallest plants (96.9 and 98.1 cm) were resulted with the highest plant densities i.e. (72000 plants/fed.) 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. (38400 plants/fed.) 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 [9] and Samih Abubaker [10].

Plant height (cm) and number of branches/plant significantly 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 agreement with those reported by Adriana *et al.* [18].

The interaction between the two studied factors significantly affected plant height and number of branches in both seasons. However, the combination between the highest plant density i.e. (72000 plants/fed.) and the highest NPK rates (100.50 : 46.50 : 100.00) kg NPK/fed. produced the highest plant height. On the other hand, the interaction between the lowest plant density i.e. (38400 plants/fed.) 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 affected 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 (kg/fed.). Furthermore, the medium plant density i.e. (48000 plant/fed.) resulted in the highest total seeds yield i.e. (841.7 and 844.7 kg/fed.) in the first and second season, respectively. This result may be attributed to that the grater amount of light energy intercepted by foliage in optimum plant density might in turn resulted in the increase of the amount of metabolites synthesized by plants and consequently the total seed yield per unit area became greeter in medium plant density than the highest

Table 2: Effect of plant densities, NPK applications and their interaction on plant height (cm), number of branches/plant, number of pods/plant and pod length (cm) in 2008 and 2009 seasons

Treatments		Plant height (cm)		Number of branches/plant		No. of pods/plant		Pod length (cm)	
Plant densities/Fed.*	NPK Rates	2008	2009	2008	2009	2008	2009	2008	2009
38400	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
48000	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
72000	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
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

Values followed by the same letter or letters are not significantly different at 5% level.

Table 3: Effect of plant densities, NPK applications and their interaction on pod width (cm), number of seeds/pod, weight of 100 seeds (g) and total seeds yield (kg/fed.) in 2008 and 2009 seasons

Treatments		Pod width (cm)		Number of seeds/pod		Weight of 100 seeds (g)		Total seeds yield (kg/fed.)	
Plant densities/Fed.	NPKRates	2008	2009	2008	2009	2008	2009	2008	2009
384000	NPK 1	2.6D	2.6C	9.8CD	10.2D	87.2E	87.9CD	663.0 H	597.1 G
	NPK 2	2.7C	2.8B	10.9B	11.1C	92.4D	92.3BC	718.1 F	716.0 EF
	NPK 3	2.9AB	2.9B	11.3A	11.6AB	100.7B	102.2A	758.8 E	757.1 CDE
	NPK 4	3.0A	3.1A	11.6A	11.8A	101.4B	103.3A	776.9 D	778.2BCD
Mean		2.8A	2.9A	10.9A	11.2A	95.4B	96.4A	729.2 B	712.1 C
48000	NPK 1	2.4F	2.4D	8.7E	8.7F	87.0E	87.8CD	718.1F	728.0 DE
	NPK 2	2.6D	2.6C	10.0C	9.9D	92.9D	94.3B	797.1 C	797.1 BC
	NPK 3	2.8BC	2.9B	11.6A	11.6AB	103.3	103.3A	929.8 A	926.9 A
	NPK 4	2.8BC	2.9B	11.6A	11.4B	A102.8A	102.9A	921.8 A	926.9 A
Mean		2.7B	2.7B	10.5B	10.4B	96.5A	97.1A	841.7 A	844.7 A
72000	NPK 1	2.2H	2.1E	7.3G	7.3H	84.0F	84.3D	637.0I	739.0 F
	NPK 2	2.3G	2.4D	7.8F	7.8G	87.3E	87.1CD	697.1 G	718.0 EF
	NPK 3	2.5EF	2.4D	8.5E	8.6F	94.3D	85.9D	763.0D	771.0 CD
	NPK 4	2.6DE	2.6C	9.5D	6.9E	97.6C	97.5AB	E826.9 B	826.8 B
Mean		2.4C	2.4C	8.3C	8.3C	90.8C	88.7B	731.0 B	763.7 B
Mean of NPKrates	NPK 1	2.4C	2.4D	8.6D	8.7D	66.1D	86.7D	672.7 D	688.0 C
	NPK 2	2.5B	2.6C	9.5C	8.6C	90.8C	91.2C	737.4 C	743.7 B
	NPK 3	2.7A	2.7B	10.5B	10.6B	99.4B	97.1B	817.2B	818.3 A
	NPK 4	2.8A	2.8A	10.9A	10.9A	100.6A	101. 2A	841.9 A	844.0 A

Values followed by the same letter or letters are not significantly different at 5% level.

Table 4: Effect of plant densities, NPK applications and their interaction on protein, phosphorus, potassium percentages and vitamin B1 in 2008 and 2009 seasons:

Treatments		Protein (%)		Phosphorus (%)		Potassium (%)		Vitamin B1	
Plant densities/Fed.	NPK Rates	2008	2009	2008	2009	2008	2009	2008	2009
384000	NPK 1	27.18I	27.23F	19.13H	19.19G	26.47F	26.34CD	19.63H	19.73G
	NPK 2	28.38J	28.44D	20.15F	20.22F	27.17E	29.17BC	20.05G	20.02F
	NPK 3	31.48B	31.75A	22.52B	22.55B	29.16B	29.17BC	21.92C	21.95B
	NPK 4	31.08C	31.08B	22.18C	22.16C	29.32B	29.17BC	21.90C	21.90B
Mean		29.53B	29.63B	20.99B	21.03B	28.03B	27.95AB	20.88B	20.90B
48000	NPK 1	27.79H	27.88E	19.55G	19.17G	26.47F	26.54BCD	19.62H	19.62H
	NPK 2	29.87E	29.90C	20.90D	20.81DE	27.55D	27.45BCD	20.94E	20.81D
	NPK 3	31.94A	31.97A	22.95A	22.94A	29.68A	29.66B	22.28A	22.23A
	NPK 4	31.91A	31.95A	22.07C	22.18C	29.57A	32.93A	22.19B	22.18A
Mean	30.38A	30.42A	21.37A	21.27A	28.32A	29.14A	21.26A	21.21A	
72000	NPK 1	27.04J	26.89F	18.12I	18.19H	24.51H	24.52D	18.02J	18.07J
	NPK 2	27.69H	28.06DE	19.16H	19.26G	25.67G	25.51D	19.06I	19.06I
	NPK 3	29.67F	29.70C	20.54E	20.58E	26.63F	26.67BCD	20.25F	20.28E
	NPK 4	30.26D	30.12C	20.83DE	20.97D	28.88C	28.86BC	21.12D	21.12C
Mean	28.67C	28.69C	19.66C	19.75C	26.42C	26.39B	19.61C	19.63C	
Mean of NPKrates	NPK 1	27.33C	27.33C	18.93D	18.85D	25.82D	25.80C	19.09D	19.14D
	NPK 2	28.65B	28.80B	20.07C	20.10C	26.80C	26.70C	20.02C	19.97C
	NPK 3	31.03A	31.14A	22.00A	22.02A	28.49B	28.50B	21.48B	21.48B
	NPK 4	31.09A	31.05A	21.69B	21.77B	29.26A	30.32A	21.74A	21.73A

Values followed by the same letter or letters are not significantly different at 5% level.

or the lowest one. These findings are line with those found by Samali and Rweyemau [8], Hornzy [9] and Samih Abubaker [10].

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. (100.50: 46.50: 100.00) kg NPK/fed. as compared to the lowest values produced by the lowest NPK rate i.e. (50.25 : 23.25 : 25.00) kg NPK/fed. These results held well in the two experimental seasons. These results are coinciding with those reported by Vieira, *et al.* [4] and Kalyano [15].

Concerning the interaction between the two studied factors data listed in Table (2 and 3) obviously show that the interaction significantly increased yield and its components in both seasons. Moreover, the interaction between medium plant density (48000 plants/fed.) and NPK rates of (83.75: 38.75: 75.00) kg NPK/ fed. achieved the highest plant pod length, number of seeds/ pod, weight of 100-seeds (g) and total seeds yield (kg/fed.) 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). However, the medium plant densities (48000 plants/fed.) 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 Samih Abubaker [10].

Fertilizing lima bean plants with NPK application rates significantly affected quality characteristics. In addition, NPK rates of (83.75: 38.75: 75.00) kg NPK/fed. resulted in the highest values of protein and phosphorus percentages. While, the highest NPK rate i.e. (100.50: 46.50: 100.00) kg NPK/fed. produced the highest values of potassium percentage and vitamin B1 (thiamin) in both seasons. These results are confirmed by Filgueira [5].

The interaction between plant densities and NPK application rates significantly affected all quality characteristics in both seasons. Furthermore, the interaction between medium plant density (48000 plants/ fed.) and NPK rates of (83.75: 38.75: 75.00) kg NPK/fed. recorded the highest values for all quality characteristics in both seasons.

CONCLUSION

It could be concluded that sowing lima bean at medium plant density (48000 plants/fed.) and fertilizing it with proper NPK rates of (83.75: 38.75: 75.00) kg NPK/fed. give the highest yield and quality under such conditions.

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