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RESEARCH ARTICLE

Influence of NPK I5:15:15 fertilizer rates and vine training on profitability of Lima bean (*Phaseolus lunatus* L.) in Savanna zones, Nigeria

Y. A. Nasidi[1*], J. A. Y. Shebayan[1], U. Ibrahim[1], T. T. Bello[2], and R. Dahiru[3]

[1]Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Agronomy, Faculty of Agriculture, Bayero University, Kano, Nigeria
[3]Binyaminu Usman Polytechnic, Hadejia, Jigawa State, Nigeria

Edited by:

Dr. Kabiru Dawaki Dauda, Ph.D.,
Kano University of Science and Technology, Wudil, Kano-Nigeria.

Reviewed by:

Dr. U. O. Dominic, Ph.D.,
University of Mohammed VI Polytechnic, Benguerir, Morocco.

Dr. Y. Y. Mohammad, Ph.D.,
University of Mohammed VI Polytechnic, Benguerir, Morocco.

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ABSTRACT

The study objective was to see how profitable it was to grow climbing bean cultivars with NPK 15:15:15 application rates in Nigeria's northern Guinea and Sudan Savanna zones. Field trials were done at the Institute for Agricultural Research Samaru, Ahmadu Bello University Zaria and National Horticultural Research Institute (NIHORT), Bagauda sub-station research farm throughout the 2018 wet season (from the final week of May as rain began to the last week of November).The treatments consisted of two cultivars of lima bean (Ex-Manchok Brown and Ex-Manchok Cream), training (trained and non-trained) and four levels of fertilizer NPK 15:15:15 with rates (0, 150, 300 and 450 kg ha^{-1}). The treatments were laid out in a RCBD with r three replications. All lima bean production options were profitable at Samaru with trained Ex-Manchok Cream without fertilizer being most profitable (₦476,858.4 ha^{-1}) with net return of ₦ 2.84 per naira invested. At Bagauda all production options were unprofitable due to low crop yields (105-237 kg ha^{-1}): fertilizer and its application costs which accounted for 13.4 to 28.9% of total production cost in trained crop and 19.8 to 38.7% in non-trained. From this study it can be concluded that profitable and sustainable lima bean production, requires training of an adapted cultivar and application of 450 kg ha^{-1} of NPK 15:15:15.

Keywords: Lima bean; NPK; Training; Cultivar; Profitability

*Corresponding author e-mail: yusufahmad9870@gmail.com (Nasidi, Y.A)

INTRODUCTION

The legume plant lima bean (Phaseolus lunatus L.) is extensively consumed in the United States, Europe, Asia and Latin America. It can be found in all Brazilian biomes and has a widespread distribution throughout the country. It is, however, mostly grown in the Northeast, where it has adapted well to the semi-arid climate (Oliveira et al., 2011). Photosynthetic activity is responsible for roughly 90% of a plant's biological output. Increased stomatal diffusive resistance may result in a decrease in net photosynthesis (Silva et al., 2015). Because a decrease the plant growth could be linked with a reducing photosynthetic activity, which is restricted over abiotic circumstances specific to the cultivation site, gas exchange measurement is a helpful approach for monitoring plant adaptation and stability in various contexts (Caron et al., 2014).

Lima bean seeds are farmed largely in Nigeria. In addition to being a good protein source, it also enhances the fertility of soil. It has flourished in southern Nigeria's humid rain forests. Despite its vast potential, lima bean is underutilized in Nigeria, and little attention has been paid to crop improvement, so farmers continue to plant indigenous types. Lima bean has not been subjected to the same intensive research as soybean and cowpea (Lyman et al., 1985). It is grown on just about 4% of the land in south west Nigeria dedicated to grain legume production, and yields are low due to a lack of innovative technologies aimed at the crop's development. Intercropping of maize, cassava, cocoyam, yam, and pepper is frequent. It is mostly farmed for human consumption and sold about 35 per cent of the grain (Saka et al., 2004). (Saka et al., 2004).

Climbing beans are popular among farmers, but they have one major disadvantage: they need stakes to keep growing and should be planted with other climbing crops. In the growth of climbing beans, staking is a significant agronomic practise (Lwakuba et al., 2003). Staking benefits the crop by allowing the plant's natural growth propensity (vegetative adaptation) to develop, allowing the crop to spread more quickly. They also allow for reproductive adaptation, resulting in increased yield per unit area.

In addition, since the stake is vertically positioned, the crop grows upward and produces fresh, healthy leaves (forage, veggies, and seeds). The beans have better aeration than bush beans, which lowers the impact of insects and disease. In contrast, the stakes are utilised as fuel after they become rusted and corroded (fire wood). Because of this, climbing beans are projected to give the subsequent merits in terms of stake placement: Four-metre-high climbers make the most of limited space as well as local, regional, and international markets (Katungi et al., 2009; Checa and Blair, 2012; Ramaekers et al., 2013). Bush beans offer a two-to-three-times higher yield potential (Katungi et al., 2009; Checa and Blair, 2012; Ramaekers et al., 2013). As a result, this study was conducted in Nigeria's northern Guinea and Sudan Savanna zones to investigate the profitability of climbing bean cultivars with NPK 15:15:15 treatment rates and the accompanying ecological management measures.

MATERIALS AND METHODS

Materials

Two lima bean (*Phaseolus lunatus* L.) cultivars were examined throughout the 2018 wet season at Samaru and NIHORT in Bagauda. Table 1 summarises the details of seed suppliers and market class.

Table 1. Source, seed colour details of Cultivars

Cultivars	Seed color	100-seed weight	Source(state)
Ex-Manchok Brown	brown in colour	27g	Kaduna
Ex-Manchok Cream	creamy in colour	30g	Kaduna

Experimental site, season, edaphic and climatic condition

In the northern Guinea and Sudan Savanna ecological zones, the trials were conducted simultaneously at two locations, namely the Institute for Agricultural Research (IAR) in Samaru and the National Institute for Horticultural Research (NIHORT) in Bagauda, during the 2018 cropping season. Physical and chemical properties of the soil at the test site were investigated before the experiment. Throughout the trial, meteorological data was collected from both locations. Land was ploughed, harrowed and prepared into ridges 75cm wide before planting. Gross plot comprised 6 ridges, each 5.0m long (22.5m^2), while net plot comprised of 4 inner ridges each 4.0m long (12.0m^2). Planting was done immediately after land preparation

Measurement

Seeds were dressed with Apron Star (R) 50DS (Mefenaxon-200 g kg^{-1}, Difenoconazole-20 g kg^{-1} and Thiamethoxam-200 g kg^{-1}) at the rate of one sachet (10grams) per 4kg of seed. Three dressed seed were sown per stand. Sowing was done on 30 May, 2018. At two weeks after sowing (2WAS) the crop were thinned to 2 plants per stands. A pre-emergence herbicide, pendimethelin (Stomp(R)455 g l^{-1}), at 4.0 L ha^{-1} was mixed with paraquat (Gramoxone (R)200 g l^{-1}) at 4.0 L ha^{-1} was applied on the day of sowing. All herbicides were applied using CP3 knapsack sprayer to deliver 250L of spray solution per hectare.

The crop was fertilized basal, according to treatment, using NPK @ 15:15:15 in holes 5cm deep made between each two stands. The stakes were installed according to treatment at six weeks after sowing and connected with polyethene rope. The lima bean was trailed to the polyethene rope and poles using plastic twines. Every plot had nine stakes each 2m long. The poles were placed on the stakes while polyethene rope was used to connect the poles. At 6 WAS the crop was given a prophylactic spray of a mixture of recommended insecticides and fungicides at recommended rates. Further sprays were done at fortnightly intervals until completion of harvest. The crop was continuously harvested as pod mature, dried and processed to collect the data on yield and yield components.

Data recorded

The partial budget approach was used to establish the treatment that provided farmers with acceptable returns while posing little risk (CIMMYT, 1988). The current market prices of inputs, operations, and outputs were used to calculate gross margins. On the partial budget analysis, the following notion was used: The product of the average lima bean price and grain yield for each treatment is gross revenue (GR). Total variable cost is the cost of inputs such as labour, fertilisers, and stakes/twines (TVC). By reducing the entire variable cost from the gross revenue, gross margin is derived (GM)

Experimental treatment and software used

Training (Trained, Non-Trained), two cultivars (Ex-Manchok Brown, Ex-Manchok Cream), and four fertiliser rates were employed as treatment components (0, 150, 300 and 450 kg ha-1 NPK 15:15:15). The treatments were spread out in a RCBD, which was reproduced three times. Duncan Multiple Range Test was used to distinguish the means. Statistics were calculated using SAS version 9.3 (Statistical Analysis Software) (SAS Institute, 2011).

RESULTS

The result of physical and chemical properties of the soil samples at both Samaru and Bagauda presented in Table 2 indicated loamy and sandy loam textures, respectively. The soil pH was slightly acidic at both locations. Samaru soil contained medium level of phosphorus but slightly higher at Samaru. Total nitrogen was lower in both locations. The exchangeable bases were medium and similar in both locations (using soil analysis interpretation chart).

Table 2. Physical, Biological and Chemical Properties of Soils at the Experimental Sites 2018 Wet Season

	SAMARU	BAGAUDA
Physical properties (g kg^{-1})		
Clay	110	160
Silt	455	220
Sand	435	620
Textural Class	Loam	Sandy loam
Chemical Properties		
pH (H_2O) 1:2.5	6.24	5.98
pH 0.01M ($CaCl_2$) 1:2.5	5.27	5.27
Total Nitrogen (g kg^{-1})	0.72	0.90
Available P (mg kg^{-1})	10.25	8.56
Organic Carbon (g kg^{-1})	12.51	13.10
Exchangeable Cations (cmol kg^{-1})		
Calcium (Ca^{2+})	3.97	3.89
Magnesium (Mg^{2+})	0.53	0.56
Potassium (K^+)	0.20	0.21
Sodium (Na^+)	0.17	0.19
CEC	4.87	4.85

Table 3. Effect of training and NPK frates on profitability of lima bean cultivars at Samaru, 2018 wet season

Treatments	grain yield (kg)	Revenue from grain (₦)	Total revenue (₦)	Total fixed cost (₦)	Total variable cost (₦)	Total cost (₦)	Net farm income (₦)	Net return/₦ invested
TIC1F1	1085.11	303,830.8	303,830.8	88,000	79,500	167,500	136,330.8	0.81
T1C1F2	1384.70	387,716	387,716	88,000	105,500	193,500	194,216	1.00
T1C1F3	1732.70	485,156	485,156	88,000	126,500	214,500	270,656	1.26
TICIF4	2131.89	594,129.2	594,129.2	88,000	147,500	235,500	358,629.2	1.52
T1C2F1	2301.28	644,358.4	644,358.4	88,000	79,500	167,500	476,858.4	2.84
T1C2F2	1955.67	547,587.6	547,587.6	88,000	105,500	193,500	354,087.6	1.82
T1C2F3	2264.31	634,006.8	634,006.8	88,000	126,500	214,500	419,506.8	1.95
T1C2F4	3038.06	850,656.8	850,656.8	88,000	147,500	235,500	615,156.8	2.61
T2C1F1	966.58	270,642.4	270,642.4	88,000	19,500	107,500	163,142.4	1.51
T2C1F2	1671.14	467,919.2	467,919.2	88,000	45,500	133,500	334,419.2	2.50
T2C1F3	1519.97	425,591.6	425,591.6	88,000	66,500	154,500	271,091.6	1.75
T2C1F4	1398.40	391,552	391,552	88,000	87,500	175,500	216,052	1.23
T2C2F1	1430.00	400,400	400,400	88,000	19,500	107,500	292,900	2.72
T2C2F2	1660.17	464,847.6	464,847.6	88,000	45,500	133,500	331,347.6	2.48
T2C2F3	1684.61	471,690.8	471,690.8	88,000	66,500	154,500	317,190.8	2.05
T2C2F4	1945.80	544,824	544,824	88,000	87,500	175,500	369,324	2.10

T1=training, T2=non-training, C1= Ex-Manchok Brown, C2= Ex-Manchok Cream, NPK 15:15:15(F1=control, F2=150 kg ha^{-1}, F3=300 kg ha^{-1} and F4=450 kg ha^{-1}) produce = ₦ 280kg^{-1}

Table 4. Effect of training and NPK fertilizer rates on profitability of lima bean cultivars at Bagauda, 2018 wet season

Treatments	Grain yield (kg)	Revenue from grain (₦)	Total revenue (₦)	Total fixed cost (₦)	Total variable cost (₦)	Total cost (₦)	Net farm income (₦)	Net return/₦ invested
TIC1F1	88.47	24,771.6	24,771.6	88,000	79,500	167,500	-142,728.4	-0.85
T1C1F2	71.97	20,151.6	20,151.6	88,000	105,500	193,500	-173,348.4	-0.89
T1C1F3	304.89	85,369.2	85,369.2	88,000	126,500	214,500	-129,130.8	-0.60
TICIF4	248.64	69,619.2	69,619.2	88,000	147,500	235,500	-165,880.8	-0.70
T1C2F1	85.19	23,853.2	23,853.2	88,000	79,500	167,500	-143,646.8	-0.85
T1C2F2	211.61	59,250.8	59,250.8	88,000	105,500	193,500	-134,149.2	-0.69
T1C2F3	236.94	66,343.2	66,343.2	88,000	126,500	214,500	-148,156.8	-0.69
T1C2F4	654.89	183,369.2	183,369.2	88,000	147,500	235,500	-52,130.3	-0.22
T2C1F1	49.97	13,991.6	13,991.6	88,000	19,500	107,500	-93,508.4	-0.86
T2C1F2	54.42	15,237.6	15,237.6	88,000	45,500	133,500	-118,262.4	-0.88
T2C1F3	74.25	20,790	20,790	88,000	66,500	154,500	-133,710	-0.86
T2C1F4	58.47	16,371.6	16,371.6	88,000	87,500	175,500	-159,128.4	-0.90
T2C2F1	40.44	11,323.2	11,323.2	88,000	19,500	107,500	-96,176.8	-0.89
T2C2F2	35.14	9,839.2	9,839.2	88,000	45,500	133,500	-123,660.8	-0.92
T2C2F3	225.36	63,100.8	63,100.8	88,000	66,500	154,500	-91,399.2	-0.59
T2C2F4	266.31	74,566.8	74,566.8	88,000	87,500	175,500	-100,933.2	-0.57

T1=training, T2=non-training, C1= Ex-Manchok Brown, C2= Ex-Manchok Cream, NPK 15:15:15(F1=control, F2=150 kg ha^{-1}, F3=300 kg ha^{-1} and F4=450 kg ha^{-1}) produce = ₦ 280 kg^{-1}

Effect of training at different NPK fertilizer rates on the profitability of lima bean cultivars at Samaru and Bagauda 2018 wet season are presented in Tables 3 and 4. At Samaru all production options were profitable as yield range from 966.58 kg ha^{-1} to 3038.06 kg ha^{-1}. The highest return per naira invested (₦ 2.84) was from trained Ex-Manchok Cream non-treated to fertilizer, this was followed by same cultivar non-trained and non-fertilized having a net return per naira invested of ₦ 2.72. However, at Bagauda, all production options were unprofitable as grain yield were low (35.14 kg ha^{-1} - 654.89 kg ha^{-1}) due to cost of fertilizers and training were high.

DISCUSSION

Lima bean is a leguminous crop that has ability to fix nitrogen. The soil fertility status at study area, classified as moderately fertile may have been responsible for good performance of the crop (Table 1). Even in plots where NPK fertilizer was not applied the crop performed relatively well compared to fertilized crops. According to Matsushiro (1971), lima bean on nitrogen (N) fertilizer is substantially greater than that of soya bean. Low nitrogen fixation in Phaseolus spp. may be due to delayed nodule emergence on root system (De Jauregui, 2019).

Crop performances were generally lush and robust throughout the experimental period at Samaru. Despite the favourable conditions at Samaru, the maximum yield obtained was 1.986 tonnes ha^{-1} which was low compared to the potential yield of 3.0 tonnes ha^{-1} for lima bean. This corroborates with the finding of (Baudoin, 2006) yields of dry seed may reach 3.0 to 4.0 t ha^{-1} from climbing types depending on management. In Western Nigeria, when intercropped, a yield of 200 to 600 kg ha^{-1} could be attained (Ibeawuchi, 2007). This could be due to the genetic potential of the cultivars used, early cessation of rain and crop vine pruning during weeding. Also, few incidences of root rot in few plants were observed at both locations at early stage of growth and drainage was constructed immediately to allow stagnant water flow out of the furrows. Pest (birds) was observed in both locations and bird scares including video tapes were used for their elimination. Furthermore, low yield in Bagauda might be due sandy loam with lower water holding capacity than loam at Samaru, soil texture lower $_{p}$H, leaching, erratic and insufficient rainfall during grain-fill period. Similarly, the good environmental factors (rainfall pattern, temperatures, sunshine and relative humidity) recorded in Samaru which fall within the optimum range for lima bean production may also have contributed to the good performance of the crop in general.

The result from gross margin and cost benefit analysis indicated that lima bean production options were profitable in Samaru location but unprofitable in Bagauda due to erratic and insufficient rainfall, lower soil pH and light soil texture (sandy loam) in the latter. The high cost of fertilizer with its application cost (13.4 to 28.9% of total cost for trained crop and 19.8 to 38.7% in non-trained) accounted for the lower gross margin of all treatments that received this input despite the higher revenue generated.

CONCLUSION

Lima bean production in northern Guinea savanna, requires vine training of Ex-Manchok Cream cultivar with or without NPK 15:15:15 compound fertilizer rate, despite the higher revenue generated obtained from application of 450 kg ha^{-1} of NPK 15:15:15 fertilizer rate due to cost of fertilizer and its application cost per naira invested for maximum profit and sustainable yield production

DISCLOSURE STATEMENT

The author declares no competing interests

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