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Production and Economic Returns of Green Bean (*Phaseolus vulgaris* L) Varieties under Rates of Nitrogen and Phosphorus Application In Sudan Savanna of Nigeria

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Abstract

Green bean varieties respond much better to N and P fertilizers application because of the absence of nodule forming bacteria in the soil and low soil fertility. This study to assess the production and economic returns of green bean applied four rates of N, three rates of P fertilizer and three varieties of green bean and it was observed that N and P fertilizer significantly increased marketable yield of green bean. Economic benefits base on gross margin analysis revealed that application of N fertilizer at the highest rate of 60 kg N ha⁻¹ and P at 22.5 kg P ha⁻¹ gave the best economic returns of N1,084,500 and N1,101,784 with Dangora and Yar-Helina and higher marketable fresh pod yield. Therefore, farmers in the Sudan savannah agro-ecological zone can adopt the application of 60 kg N ha⁻¹, 22.5 kg P ha⁻¹ fertilizer with Dangon or Yar-Helina varieties.

Keywords: Production, Economic Returns, *Phaseolus vulgaris* L, Nitrogen, Phosphorus

Introduction

Green bean is of subtropical origin, and is cultivated today in many parts of the world under a wide range of climatic conditions (Brian, 1971). Green bean is globally cultivated annually on nearly 1.5 million hectares (ha) of land to produce about 20.7 million metric tons of fresh pods yield with an average yield of 13.5 t ha⁻¹, its production in Africa was 0.6 million metric tons cultivated on 71341 ha giving an average of 9.0 t ha⁻¹ (FAO, 2012). Green bean is grown as a cash crop by large and small holder farmers (CIAT, 2006). The beans are marketed canned, frozen and fresh; they are often steamed, boiled or baked. *P. vulgaris* is the second most important source of human dietary protein and the third most important source of calories for over 100 million people in rural and poor Urban Communities in Africa. Its protein is cheaper than animal protein, making it highly competitive and important to the dietary regimes of people in Africa (CIAT, 2006). In most countries, common bean is considered an elite vegetable because its consumption is affected not only by increasing income, but by urbanization. Thus, the majority of green bean farms in developing countries are located near urban centres. The crop is generally cultivated by small holder farmers on an average farm size of less than one hectare. With increasing demand in urban markets, production systems with pure/sole crop stand are becoming common. Generally, growth and development of green bean depends on the variety and environmental factors like soil type, soil

fertility, soil moisture, soil pH and temperature. Researches elsewhere showed that green bean varieties respond much better to the application of N and P fertilizers as yield increased from 0.5 t ha⁻¹ without fertilizer to 2.2 – 3 t ha⁻¹ with fertilizer application, because of the increase intensity of cropping which led to serious nutrient mining of the soil, through continuous crop removal and erosion without adequate compensatory replacement with fertilizers or organic manure. The crop response also could be as a result of the absence of nodule forming bacteria in some soils (Brian, 1971; Messiaen, 1992). The N and P requirement for the production of green bean is different from other pulse crops. The low fertility status of the soil in the Nigerian Savannah has been identified as the major factor limiting green bean production (Maurya, et al., 1995). Thus the need to apply fertilizer to the crop become imperative, therefore, there is need to evaluate the performance of the available varieties to N and P fertilizer to determine the combination of variety, N and P suited to savannah ecology to boost green bean production and economic benefits.

Materials and Methods

The experiment was conducted at Kadawa Irrigation Research Station of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, during the dry seasons of 2009/2010, 2010/2011, and 2011/2012. Kadawa is located at 11°39'N; 08°02'E at altitude of 500 m in the Sudan Savanna ecological zone of Nigeria, The treatment consisted of three varieties of green bean (Ex-Brown, Dangora and Yar-Helina), four levels of nitrogen (0, 20, 40, and 60 kg N ha⁻¹) and three levels of phosphorus (0, 22.5, and 45 kg P ha⁻¹). Factorial combinations of varieties and nitrogen were assigned to the main plots, while P was assigned to the sub-plots, arrange in a split plot design and replicated three times. The gross sub-plot area was 12 m² consisting of 4 rows of 4 m length and a width of 3 m (4 mx3 m). The experimental site in each of the three years research was cleared, harrowed to produce a fine tilt and then ridged at 75 cm apart with a tractor. The area was then marked out into plots with a length of 4 m and a width of 3 m (12 m²). Each plot was separated from the other by a bund of 0.5 m.

Seeds were sown manually at the rate of two seeds per hole, at an intra-row spacing of 30 cm and inter-row spacing of 75 cm, Urea (46% N) and Single Super Phosphate (18% P₂O₅) was used as source of N and P fertilizer and was applied as per treatment to the plots. N was split applied at two and six weeks after sowing (WAS) by band placement while the P doses were applied once at sowing. Weeds observed on the experimental plot were controlled manually by hoeing at 3, 5 and 7 WAS in order to keep the plots weed free. The use of dimethoate at 1.5 kg a.i ha⁻¹ controlled Aphids (*Aphis craccivora*), Spider mites (*Tetranychus urticae*) and grasshoppers (*Zoonecerous variegatus*). Green coloured and immature pods (easily snap-break) were hand-picked while the seeds were small and before the seeds were large enough to cause the pod to bulge around the seed, since the market price is

much lower when seed development is visible externally. Harvesting was done by hand picking from the net plot. Data were collected on marketable fresh podweight per plot and per hectare. The data collected were subjected to analysis of variance (ANOVA) for a split plot design as described by Snedecor and Cochran (1967). Duncan Multiple Range Test (DMRT) was used to separate differences among treatment means (Duncan, 1955). To evaluate the economic implication of varying the rates of application of nitrogen and phosphorus on green bean varieties, gross margin approach as described by Olukosi and Erhabor (1988) was adopted which is the total revenue minus the total variable costs in naira ha⁻¹ (US \$ =)

Results

The result in table 1 showed that, Dangora produced significantly heavier fresh pod per plot than Yar-Helina with Ex-Brown producing lower weight in 2009/2010 and combined mean. In 2010/2011, Dangora and Yar-Helina were statistically similar and had significantly more pod weight per plot than Ex-Brown. In 2011/2012, Ex-Brown produced heavier pods than Dangora and Yar-Helina which were statistically similar.

Table 1: Effect of nitrogen and phosphorus on marketable pods weight plot⁻¹ (g) of green bean Varieties during 2009/2010-2011/2012 dry seasons at Kadawa

Treatment	2009/2010	2010/2011	2011/2012	Combined mean
Variety				
Ex-Brown	1201.33c	1245.7b	2466.0a	1637.68c
Dangora	2957.37a	1694.7a	2105.6b	2252.62a
Yar-Helina	2532.97b	1480.2a	2118.2b	2043.78b
SE±	43.66	77.79	84.03	64.20
Nitrogen rate (kg N ha⁻¹)				
0	1267.30d	689.4c	1413.8d	1123.5d
20	2034.94c	935.7c	1880.2c	1617.0c
40	2551.44b	1754.9b	2542.5b	2282.9b
60	3068.54a	2514.4a	3083.2a	2888.7a
SE±	50.41	89.83	97.03	74.20
Phosphorus rate (kg P ha⁻¹)				
0	2018.86b	1255.8b	2052.7b	1775.77b
22.5	2335.43a	1525.5a	2377.0a	2075.96a
45	2347.37a	1639.6a	2260.2ab	2082.37a
SE±	43.66	77.79	84.03	64.20
Interaction				
V x N	NS	NS	NS	NS
V x P	NS	NS	NS	NS
N x P	NS	NS	NS	NS
V x N x P	NS	NS	NS	NS

Means followed by same letter(s) in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant.

As nitrogen rate increased in 2009/2010, 2011/2012 and the combined mean, marketable weight per plot significantly increased but in 2010/2011, application of 60 kg N ha⁻¹ produced significantly heavier pods than 40 kg N ha⁻¹, however 0 and 20 kg N ha⁻¹ were statistically similar with lower pod weight compared to 40 kg N ha⁻¹. Phosphorus rates of 22.5 and 45 kg P ha⁻¹ were statistically similar and produced significantly higher marketable weight than 0 kg P ha⁻¹. No significant treatment interactions were observed among the factors in all the years and the combined mean. Table 2 shows nitrogen and phosphorous influence on marketable fresh pods yield per hectare of green bean varieties. In all the years and the combined mean, the result followed similar trend as the result of marketable pod weight per plot (Table 1).

Table 2: Influence of nitrogen and phosphorus on marketable pods yield ha⁻¹ (kg) of green bean varieties during 2009/2010-2011/2012 dry seasons at Kadawa

Treatment	2009/2010	2010/2011	2011/2012	Combined Mean
Variety				
Ex-Brown	2002.2c	2076.2b	4110.0a	2729.5c
Dangora	4929.0a	2824.8a	3509.4b	3754.4a
Yar-Helina	4221.6b	2467.0a	3530.3b	3406.3b
SE±	72.76	129.66	140.05	107.00
Nitrogen rate (kg N ha⁻¹)				
0	2112.2d	1149.1c	2356.4d	1872.5d
20	3391.6c	1559.5c	3133.7c	2694.9c
40	4252.4b	2924.9b	4237.4b	3804.9b
60	5114.2a	4190.7a	5138.8a	4814.6a
SE±	84.02	149.72	161.72	123.56
Phosphorus rate (kg P ha⁻¹)				
0	3364.8b	2093.0b	3421.1b	2959.6b
22.5	3875.7a	2542.4a	3961.6a	3459.9a
45	3912.3a	2732.7a	3766.9ab	3470.6a
SE±	72.76	129.66	140.05	107.00
Interaction				
V x N	NS	NS	NS	NS
V x P	NS	NS	NS	NS
N x P	NS	NS	NS	NS
V x N x P	NS	NS	NS	NS

Means followed by same letter(s) in a column and treatment group are not statistically different at 5% level of probability using DMRT, NS = Not significant.

In 2009 (Table 3), non application of fertilizer resulted in significantly lower returns per Naira invested of 9.44, 15.6, 10.16 for Ex-Brown, Dangora and Yar-Helina. Increasing application of N and P rates increased economic returns up to 60 Kg N ha⁻¹ and 22.5 Kg P ha⁻¹ with a return of 30.22, 43.08 and 41.52 for Ex-Brown, Dangora and Yar-Helina. Nitrogen rates with 0 Kg P ha⁻¹ produced significantly

lower return compared with treatments having P. Dangora and Yar-Helina produced significantly better return per naira invested of 43.08, 41.52 than Ex-Brown with a return of 30.45.

Table 3 Cost benefit and return analysis on investment of growing green bean varieties using nitrogen and phosphorus fertilizer rates, during 2009 dry season at Kadawa

FACTOR			YIELD (kg ha ⁻¹)	Average Price/K g (N)	Gross Revenue (GR) (N ha ⁻¹)	Total Variable Cost (N ha ⁻¹)	Gross Margin (GR- TVC) (N ha ⁻¹)	Cost benefit ratio (N)
Nitrogen	Variety	Phosphorus						
0	Ex-Brown	0	1041.24	200	208248	19940	188308	9.44
0	Ex-Brown	22.5	1285.56	200	257112	23540	233572	9.92
0	Ex-Brown	45	1512.82	200	302564	26540	276024	10.40
0	Dangora	0	1713.12	200	342624	20640	321984	15.6
0	Dangora	22.5	2544.29	200	508858	24240	484618	19.99
0	Dangora	45	3002.04	200	600408	27240	573168	21.04
0	Yar-Helina	0	1179.41	200	235882	21140	214742	10.16
0	Yar-Helina	22.5	1594.65	200	318930	24740	294190	11.89
0	Yar-Helina	45	1936.42	200	387284	27740	359544	12.96
20	Ex-Brown	0	1589.13	200	317826	24040	293786	12.22
20	Ex-Brown	22.5	1949.83	200	389966	27040	362926	13.42
20	Ex-Brown	45	2439.01	200	487802	30040	457762	15.24
20	Dangora	0	2232.66	200	446532	24740	421792	17.05
20	Dangora	22.5	3027.24	200	605448	27740	577708	20.83
20	Dangora	45	3517.01	200	703402	30740	672662	21.88
20	Yar-Helina	0	1850.41	200	370082	25240	344842	13.66
20	Yar-Helina	22.5	2398.71	200	479742	28240	451502	15.99
20	Yar-Helina	45	3220.16	200	644032	31240	612792	19.62
40	Ex-Brown	0	2618.57	200	523714	27540	496174	18.02
40	Ex-Brown	22.5	3869.91	200	773982	31040	742942	23.93
40	Ex-Brown	45	4288.21	200	857642	34040	823602	24.2
40	Dangora	0	3567.96	200	713592	28240	685352	24.27
40	Dangora	22.5	4153.31	200	830662	31740	798922	25.17
40	Dangora	45	5115.64	200	1023128	34740	988388	28.45
40	Yar-Helina	0	3070.88	200	614176	28740	585436	20.37
40	Yar-Helina	22.5	4385.54	200	877108	32240	844868	26.20
40	Yar-Helina	45	5501.66	200	1100332	35240	1065092	30.22
60	Ex-Brown	0	3707.95	200	741590	31040	710550	22.89
60	Ex-Brown	22.5	5352.04	200	1070408	34040	1036368	30.45
60	Ex-Brown	45	5672.28	200	1134456	37040	1097416	29.63
60	Dangora	0	4751.71	200	950342	31740	198602	28.94
60	Dangora	22.5	7655.86	200	1531172	34740	1496432	43.08
60	Dangora	45	5966.73	200	1193346	37740	1155606	30.62
60	Yar-Helina	0	5754.27	200	1150854	32240	1118614	34.7
60	Yar-Helina	22.5	7491.8	200	1498360	35240	1463120	41.52
60	Yar-Helina	45	7375.58	200	1475116	38240	1436876	37.58

Calculation of total revenue is base on N200 kg⁻¹ of green bean at Kadawa

In 2010 (Table 4), the trend followed a similar order as in Table 3 with best return of 31.38 per Naira invested from Yar-Helina and then Dangora with a return of 30.24.

Table 4 Cost benefit and return analysis on investment of growing green bean varieties using nitrogen and phosphorus fertilizer rates, during 2010 dry season at Kadawa

FACTOR			YIELD (kg ha ⁻¹)	Average Price/Kg (N)	Gross Revenue (GR) (N ha ⁻¹)	Total Variable Cost (N ha ⁻¹)	Gross Margin (GR- TVC) (N ha ⁻¹)	Cost benefit ratio (N)	
Nitrogen	Variety	Phosphorus							
	0	Ex-Brown	0	1113.15	200	222630	19940	202690	10.16
	0	Ex-Brown	22.5	1371.82	200	274364	23540	250884	10.66
	0	Ex-Brown	45	1554.53	200	310906	26540	284366	10.71
	0	Dangora	0	723.93	200	144786	20640	124146	6.01
	0	Dangora	22.5	881.82	200	176364	24240	152124	6.28
	0	Dangora	45	1008.65	200	201730	27240	174490	6.41
	0	Yar-Helina	0	488.4	200	97680	21140	76540	3.62
	0	Yar-Helina	22.5	1526.36	200	305272	24740	280532	11.34
	0	Yar-Helina	45	1852.81	200	370562	27740	342822	12.36
	20	Ex-Brown	0	1624.39	200	324878	24040	300838	12.51
	20	Ex-Brown	22.5	1736.75	200	347350	27040	320310	11.85
	20	Ex-Brown	45	1881.04	200	376208	30040	346168	11.52
	20	Dangora	0	980.4	200	196080	24740	171340	6.93
	20	Dangora	22.5	1134.41	200	226882	27740	199142	7.18
	20	Dangora	45	1941.61	200	388322	30740	357582	11.63
	20	Yar-Helina	0	1308.85	200	261770	25240	236530	9.37
	20	Yar-Helina	22.5	1878.65	200	375730	28240	347490	12.30
	20	Yar-Helina	45	2709.29	200	541858	31240	510618	16.35
	40	Ex-Brown	0	2078.91	200	415782	27540	388242	14.1
	40	Ex-Brown	22.5	2388.88	200	477776	31040	446736	14.39
	40	Ex-Brown	45	2750.05	200	550010	34040	515970	15.16
	40	Dangora	0	2032.97	200	406594	28240	378354	13.4
	40	Dangora	22.5	2961.93	200	592386	31740	560646	17.66
40	Dangora	45	4029.4	200	805880	34740	771140	22.2	
40	Yar-Helina	0	2733.54	200	546708	28740	517968	18.02	
40	Yar-Helina	22.5	3486.68	200	697336	32240	665096	20.63	
40	Yar-Helina	45	4261.38	200	852276	35240	819036	23.18	
60	Ex-Brown	0	3758.45	200	751690	31040	720650	23.22	
60	Ex-Brown	22.5	4494.84	200	898968	34040	864928	25.41	
60	Ex-Brown	45	4631.96	200	926392	37040	889352	24.01	
60	Dangora	0	4351.54	200	870308	31740	838568	26.42	
60	Dangora	22.5	5441.05	200	1088210	34740	1053470	30.24	
60	Dangora	45	5410.08	200	1082016	37740	1044276	27.67	
60	Yar-Helina	0	4580.87	200	916174	32240	883934	27.42	
60	Yar-Helina	22.5	5705.98	200	1141196	35240	1105956	31.38	
60	Yar-Helina	45	5871.19	200	1174238	38240	1135998	29.71	

Calculation of total revenue is base on N200 kg⁻¹ of green bean at Kadawa

In 2011 (Table 5), followed similar trend as Table 3, best return per Naira invested were obtained from Yar-Helina (31.27), Dangora (31.22) and Ex-Brown (30.42); with a nitrogen and phosphorus combination of 60 Kg N ha⁻¹ and 22.5 Kg P ha⁻¹.

Table 5 Cost benefit and return analysis on investment of growing green bean varieties using nitrogen and phosphorus fertilizer rates, during 2011 dry season at Kadawa

FACTOR			YIELD (kg ha ⁻¹)	Average Price/Kg (N)	Gross Revenue (GR) (N ha ⁻¹)	Total Variable Cost (TVC) (N ha ⁻¹)	Gross Margin (GR-TVC) (N ha ⁻¹)	Cost benefit ratio (N)
Nitrogen	Variety	Phosphorus						
0	Ex-Brown	0	1908.76	200	381752	19940	361812	18.15
0	Ex-Brown	22.5	2262.6	200	452520	23540	428980	18.22
0	Ex-Brown	45	2766.66	200	553332	26540	526792	19.85
0	Dangora	0	1440.16	200	288032	20640	267392	13
0	Dangora	22.5	1877.71	200	375542	24240	351302	14.49
0	Dangora	45	2117.52	200	423504	27240	396264	14.55
0	Yar-Helina	0	2287.26	200	457452	21140	436312	20.64
0	Yar-Helina	22.5	2657.41	200	531482	24740	506742	20.48
0	Yar-Helina	45	3089.27	200	617854	27740	590114	21.27
20	Ex-Brown	0	2687.64	200	537528	24040	513488	21.36
20	Ex-Brown	22.5	3227.36	200	645472	27040	618432	22.87
20	Ex-Brown	45	3714.37	200	742874	30040	712834	23.73
20	Dangora	0	2104.52	200	420904	24740	396164	16.01
20	Dangora	22.5	2766.97	200	553394	27740	525654	18.95
20	Dangora	45	3291.52	200	658304	30740	627564	20.42
20	Yar-Helina	0	3146.77	200	629354	25240	604114	23.93
20	Yar-Helina	22.5	3702.53	200	740506	28240	712266	25.22
20	Yar-Helina	45	3961.67	200	792334	31240	761094	24.36
40	Ex-Brown	0	3298.23	200	659646	27540	632106	22.95
40	Ex-Brown	22.5	3880.07	200	776014	31040	744974	24.01
40	Ex-Brown	45	4490.8	200	898160	34040	864120	25.39
40	Dangora	0	3642.13	200	728426	28240	700186	24.79
40	Dangora	22.5	4184.57	200	836914	31740	805174	25.37
40	Dangora	45	4696.26	200	939252	34740	904512	26.04
40	Yar-Helina	0	4005.56	200	801112	28740	772372	26.87
40	Yar-Helina	22.5	4530.55	200	906110	32240	873870	27.11
40	Yar-Helina	45	5008.8	200	1001760	35240	966520	27.43
60	Ex-Brown	0	4211.35	200	842270	31040	811230	26.13
60	Ex-Brown	22.5	5348.64	200	1069728	34040	1035688	30.42
60	Ex-Brown	45	5623.38	200	1124676	37040	1087636	29.36
60	Dangora	0	4436.79	200	887358	31740	855618	26.96
60	Dangora	22.5	5596.2	200	1119240	34740	1084500	31.22
60	Dangora	45	5258.5	200	1051700	37740	1013960	26.87
60	Yar-Helina	0	4684.47	200	936894	32240	904654	28.06
60	Yar-Helina	22.5	5685.12	200	1139024	35240	1103784	31.27
60	Yar-Helina	45	5584.35	200	1116870	38240	1078630	28.21

Calculation of total revenue is base on N200 kg⁻¹ of green bean at Kadawa

Discussion

The increased in net return of green bean production as a result of nitrogen fertilizer application could be due to increased in marketable pod yield and crop performance. Optimum nitrogen fertilizer promotes growth while insufficient N leads to reduced growth, reduced light interception and development of yield potentials; crop requires fertilizer in sufficient amount for maximum economic yield because number of pods per plant, number of pods per ha⁻¹, fresh pod weight per plant and fresh pod yield ha⁻¹ increased with N rates, nitrogen application enhance the chlorophyll content thereby improving photosynthetic activity that promotes assimilate production which resulted in increment of the final yield El-Awade *et al.* (2011) reported increase in number of pod and pod yield with increased N rate. These depend on the cost of fertilizer, the yield increase obtained and the local selling price. Dwivede *et al.* (1994) recorded higher mean net returns and benefit cost ratio due to N application of 100 kg N ha⁻¹ similar beneficial effect of N on economic returns was also reported by Singh and Singh (2000), Rajesh *et al.* (2006) in green bean.

The application of 22.5 kg P ha⁻¹ based on this finding increased the net return in green bean production over the control; Singh and Abidi (1995), Singh *et al.* (1996), who reported highest return from green bean with 19.62 and 26.16 kg P ha⁻¹ fertilizers in sufficient amount to give the maximum economic yield. It leads to yield increase as a result of the development of its reproductive parts. The interaction of N x P on economic return in this study revealed that the highest level of N (60 kg N ha⁻¹) and P at 22.5 kg P ha⁻¹ produced the highest returns in all the years. Better economic return of N1,084,500 and N1,101,784 was at 60 kg N ha⁻¹ and 22.5 kg P ha⁻¹ with Dangora and Yar-Helina. Rahman *et al.* (2007) recorded highest gross margin of TK 166,684 ha⁻¹ (N380, 992) with N at 150 and P at 40 kg ha⁻¹.

Based on the results obtained in this study, good yield were obtained from Dangora and Yar-Helina with the highest N fertilizer rate of 60 Kg N ha⁻¹ and phosphorus rate of 22.5 Kg P ha⁻¹. Therefore farmers in the Sudan savannah can adopt the application of 60 kg N ha⁻¹, 22.5 kg P ha⁻¹ with Dangora or Yar-Helina varieties since they gave the best yield of the crop and better economic return on green bean production.

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