Response of Snap Bean to Nitrogen and Phosphorous at Koga and Rib under Irrigation

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Abstract

A Field experiment was conducted for two years (2011 and 2012) to determine the optimum rate of nitrogen and phosphorus for snap bean green pod production at Rib and Koga schemes under irrigation. The experiment was composed of a factorially combination of three levels of nitrogen (46, 69, 92 kg N ha^{-1}) and five levels of phosphorus (10, 20, 30, 40 and 50 kg P ha^{-1}) and arranged in a randomized complete block design (RCBD) with three replications . Agronomic data were collected and subjected to analysis of variance using SAS software while LSD was used for mean separation whenever there was significant difference among/between the treatments. The result at Rib showed that nitrogen and phosphorous have significantly ($P<0.05$) affected pod diameter, marketable and total yields in 2011 whereas in 2012, there was significant difference in marketable and total pod yields against nitrogen rates and the interaction of N and P. Similarly, at Koga, nitrogen and phosphorus significantly affected marketable yield, total yield and other yield components. The partial budget analysis for Rib showed that 46 kg N ha^{-1}and 20 kg P ha^{-1} had the highest net benefit (146429.9 Eth. Birr ha^{-1}) with 6804% marginal rate of return (MRR) and for Koga 92 kg N ha^{-1} and 50 kg P ha^{-1} had the highest net benefit (95692.26 ETB ha^{-1}) with 1991 % marginal rate of return (MRR) .

Key Words: Snap bean, nitrogen, phosphorus, marketable yield, total yield

Introduction

Snap bean (*Phaseolus vulgaris* L.) is belonged to the family of Fabaceae. It is commonly called French bean, kidney bean, navy bean and green bean or string bean. It is an important short duration leguminous pod vegetable grown for its tender green pods (ARC, 2002). Although other types of beans can be grown (Lima, horticultural, edible soybeans, etc.), the greatest consumer demand is for those commonly called "green beans" or snap beans (Marr *et. al*., 1995). Rashid (1993) and ARC (2002) stated the nutritional value of such crops that the edible green pods supply protein, carbohydrate, fat, fiber, thiamin, riboflavin, Ca and Fe, and the seed contains significant amount of thiamin, niacin, folic acid as well as fiber. The crop commands high marketability both at home in Ethiopia (especially in urban areas) and abroad. It can suitably be grown at altitudes ranging from 1000-2000m a.s.l (ARC, 2002). A dry climate with irrigation is suitable for bean production as there will be no or little disease incidence in addition to avoiding water logged conditions (ARC, 2002). Even though they are nitrogen fixers, supplying bean plants with nitrogen is essential to obtain high yield. Sustained high yields can be expected with fertilization practices designed to supply crop nutrient requirements and protect the environment from excessive fertilization (Hochmuth & Hanlon, 2010). As Marr *et al.* (1995) stated beans require a regular supply of fertilizer for uniform growth, so one or two side dressings are necessary through the season, especially in wet seasons or in sandy soils. In addition to this, optimum combination of nitrogen and phosphorous may bring about considerable increase in the yield of bush bean due to their complementary effects (Nasrin and Jahan, 2010). Moreover, rationalizing the amounts of N application has a great economical impact for the farmer to minimize the expenses from chemical fertilizers as well as the environmental impact due to the excess of chemical fertilizers such as nitrogen fertilizers that may pollute underground water (Hochmuth and Hanlon, 2010). Over-fertilization will result in excessive foliage growth with little increase in yield and possible salt damage from fertilizer (Marr *et. al*., 1995).

In the production of vegetable crops like snap bean, good fertilizer usage is one of the important management practices, including proper seeding, pest control, adequate irrigation, and timely harvest. Because of the influence of soil type, climatic conditions, and other cultural practices, crop response to fertilizer may not always be accurately predicted. Soil test results, field experience, and knowledge of specific crop requirements help to determine the nutrients needed and the rate of application.

Fertilizer applications for beans should ensure adequate levels of all nutrients. Optimum fertilization is intended to result in top quality and yield, commensurate with maximum returns. However, most of the farmers in irrigated areas apply less or no fertilizer. The fertility status of the soil is depleted by continuous cropping if it goes without fertility restoring actions. Hence, the research was carried out to determine appropriate NP fertilizer rate that enhances the productivity of snap bean and feasible for farmers.

Materials and methods

Description of the study sites

The experiment was conducted at Koga and Rib irrigation schemes. The study site at Koga is situated at 11°25'20'' latitude and 37°10'20" longitude at an altitude of 1960 m a.s.l. It is in Mecha district, West Gojjam admistritive zone. The soil is purely Nitisols with strongly acidic property and high exchangeable acidity and exchangeable Al^{3+} contents (Table 1). According to the classification of Clements and McGowen (1994), the soil has very low, low and medium organic matter, available phosphorus and total nitrogen content respectively (Table 1). The very low available phosphorus content could be due to the high acidity of the soil (Pam and Murphy, 2007). The EC value in soil to water ratio (1:5) is less than 2 ds/m^{-1}.

Table 1. Soil properties for Koga and Rib irrigation schemes

Koga							
pH (H_2O)	Exchangeable Al^{3+} ($cmol_c\ kg^{-1}$)	Exchange able acidity ($cmol_c\ kg^{-1}$)	EC (ds/m^{-1})	Total N (%)	Available P (ppm)	OM(%)	CEC ($cmol_c\ kg^{-1}$)
5.09-5.3	0.92-2.88	1.54-5.23	0.013-0.08	0.18-0.24	3.54-8.69	2.34-4.44	
Rib							
Na	Na	Na	Na	0.003-0.18	24.32-36.73	Na	33.00-36.25

Na = Not available

Rib study site is found in Fogera district and situated at 11^0 41' to 12^0 02' N latitude and 37^0 29' to 37^0 59' E longitude at an altitude of 1800 m a.s.l. The major soil type of the site is Fluvisols. The soil has high phosphorus and very low to low total nitrogen contents (Table 1). The CEC is high according to Pam and Murph (2007) (Table 1).

Snap bean variety Indam-2005 was used for the experiment under furrow irrigation system. The experimental design was factorial RCBD with three replications. The plot size was 3m X 3m and treatments were comprised of three levels of nitrogen (46, 69 and 92 kg ha^{-1}) and five levels of P_2O_5 (23, 46, 69, 92, and 115 Kg ha^{-1}). Absolute control (without input) was used for comparison purpose. Nitrogen was applied by spliting: Half at planting and the other half 30 days after emergence. The whole phoshporus was applied at planting. Spacing between rows and plants were 50 cm and 10 cm respectively. Data on plant height, green pod diameter, and green pod length, marketable pods, unmarketable pods and total yield were collected and analyzed by SAS 2002. Least Significant Difference (LSD) at 5% was used for mean separation. There were three harvesting times during the growth period and the data were collected in each consecutive harvesting time. Fleshy, tender, none shriveled pods, pods with normal length and green pods were considered as marketable while the rest are unmarketable. The sum of the marketable and unmarketable was taken as total yield.

In order to identify economical feasible recommendations partial budget and sensitivity analysis was done based on the CIMMYT economic analysis manual (CIMMYT, 1988). The price of snap been, urea and DAP were 10.00, 11.15 and 14.20 ETB kg^{-1}, respectively. To see whether the benefit is consistent in the worst price condition, Sensitivity analysis was done by increasing the current fertilizer cost by 10% to both urea and DAP.

Results and discussions

Rib study site

The results at Rib indicated that nitrogen and phosphorous significantly (P<0.01) affected pod diameter, marketable and total yields of snap been. The combined analysis over years showed that maximum yield was obtained by applying 46/20 kg N/P ha^{-1} fertilizer rates followed by 69/10 kg N/P ha^{-1} (Table 2). However, there was no statistically significant difference between 46/20 kg N/P ha^{-1} and 69/10 kg N/P ha^{-1} in marketable and total yield. The result was in agreement with the findings of Hochmuth *et.al.* (2009) in Hochmuth and Hanlon (2010) who reported none significant difference in marketable snap bean yield with increasing nitrogen rates. The longest pod length and maximum pod diameter were recorded fom 46/10 kg N/P ha^{-1} whereas the highest plant height was recorded from 46/30 kg N/P ha^{-1} (Table 2). There was no significant difference among fertilizer rates and 0/0 level on most of yield components at Rib except for pod length (Table 2). The relatively lower response of the crop to both nitrogen and phosphorous may be due to its can fix atmospheric nitrogen fixing capacity of the crop and the richness of the experimental soil in available phosphorus (Table 1).

Table 2. Effect of nitrogen and phosphorous on marketable and total yield of snap bean at Rib combined over years

N/P rate	Plant height	Pod diameter	Pod length	Marketable green pod kg ha^{-1}	Total green pod kg ha^{-1}
0/0	94.47^{ab}	0.85^{abc}	9.63^{bc}	8470.69^{c}	10075.69^{c}
46/10	92.76^{abcd}	0.87^{a}	10.73^{a}	12681^{ab}	12988^{ab}
46/20	93.98^{abc}	0.81^{abc}	9.53^{bcdd}	16513^{a}	16789^{a}
46/30	95.67^{a}	0.79^{abc}	9.33^{bcd}e	15182^{ab}	15485^{ab}
46/40	92.49^{abcd}	0.79^{abc}	9.00^{cdef}	11638^{b}	11978^{b}
46/50	89.73^{abcde}	0.73^{c}	8.87^{def}	12360^{b}	12638^{b}
69/10	95.42^{a}	0.89^{a}	9.00^{cdef}	15292^{ab}	15529^{ab}
69/20	88.27^{abcde}	0.84^{abc}	9.13^{bcdef}	11638^{b}	11924^{b}
69/30	95.82^{a}	0.86^{ab}	9.80^{b}	14288^{ab}	14567^{ab}
69/40	90.20^{abcde}	0.87^{a}	9.60^{bcd}	13986^{ab}	14331^{ab}
69/50	89.20^{abcde}	0.79^{abc}	9.60^{bcd}	15222^{ab}	15477^{ab}
92/10	89.36^{abcde}	0.82^{abc}	9.00^{cdef}	13861^{ab}	14145^{ab}
92/20	81.71^{e}	0.91^{a}	9.60^{bcd}	12057^{b}	12364^{b}
92/30	83.60^{cde}	0.73^{d}	8.50^{f}	13211^{ab}	13487^{ab}
92/40	83.87^{bcde}	0.85^{abc}	9.67^{bc}	12479^{b}	12771^{b}
92/50	82.20^{de}	0.87^{a}	8.67^{ef}	12568^{ab}	12838^{ab}
CV(%)	13.49	7.78	6.04	25.73	25.13
LSD(0.05)	10.71	0.13	0.76	4009.1	3997

The partial budget analysis for Rib showed that applying 46 kg N ha^{-1}and 20 kg P ha^{-1} had the highest net benefit (146429.9 ETB ha^{-1}) with MRR of 6803.60 (Table 3). Thus 46 kg ha^{-1} N and 20 kg ha^{-1} P are recommended for snap bean production at Rib irrigation scheme. Farmers and investors can benefit a lot from snap bean production through fertilizer application.

Table 3. Partial budget analysis for the effect of nitrogen fertilizer on the yield of snap bean at Rib

P2O5	N	Yield kg/ha	Ad (10% dawn ward)	Total variable cost	Gross benefit	Net benefit	MRR
0	0	8470.69	7623.62	0	124767	124767	
10	46	12681	11412.9	1687.565	114129	112441.4	
20	46	16513	14861.7	2187.13	148617	146429.9	6803.60
10	69	15292	13762.8	2281.565	137628	135346.4	
30	46	15182	13663.8	2686.696	136638	133951.3	
20	69	11638	10474.2	2781.13	104742	101960.9	
10	92	13861	12474.9	2875.565	124749	121873.4	21086.05
40	46	11638	10474.2	3186.261	104742	101555.7	
30	69	14288	12859.2	3280.696	128592	125311.3	25155.52
20	92	12057	10851.3	3375.13	108513	105137.9	
50	46	12360	11124	3685.826	111240	107554.2	777.71
40	69	13986	12587.4	3780.261	125874	122093.7	15396.41
30	92	13211	11889.9	3874.696	118899	115024.3	
50	69	15222	13699.8	4279.826	136998	132718.2	4367.45
40	92	12479	11231.1	4374.261	112311	107936.7	
50	92	12568	11311.2	4873.826	113112	108238.2	60.34

The sensitivity analysis (Table 4) indicated that application of 46 kg N ha^{-1} and 20 kg P ha^{-1} is feasible even at worst scenarios (146211.2ETB ha^{-1}) with MRR of 6176.00%. Therefore, 46/20 kg N/P ha^{-1} is recommended for snap bean production for Rib irrigation scheme.

Table 4. Sensitivity analysis for the effect of nitrogen fertilizer on the yield of snap bean at Rib irrigation scheme.

P_2O_5	N	Yield kg/ha	Adjusted (10% down wards)	Total variable cost	Gross benefit	Net benefit	MRR
0	0	8470.69	7623.62	0	124767	124767	D
23	46	12681	11412.9	1856.322	114129	112272.7	D
46	46	16513	14861.7	2405.843	148617	146211.2	6176.00
23	69	15292	13762.8	2509.722	137628	135118.3	D
69	46	15182	13663.8	2955.365	136638	133682.6	D
46	69	11638	10474.2	3059.243	104742	101682.8	D
23	92	13861	12474.9	3163.122	124749	121585.9	19160.05
92	46	11638	10474.2	3504.887	104742	101237.1	D
69	69	14288	12859.2	3608.765	128592	124983.2	22859.57
46	92	12057	10851.3	3712.643	108513	104800.4	D
115	46	12360	11124	4054.409	111240	107185.6	697.92
92	69	13986	12587.4	4158.287	125874	121715.7	13987.64
69	92	13211	11889.9	4262.165	118899	114636.8	D
115	69	15222	13699.8	4707.809	136998	132290.2	3961.32
92	92	12479	11231.1	4811.687	112311	107499.3	D
115	92	12568	11311.2	5361.209	113112	107750.8	45.7631

D = Dominated

Koga study site

The result at Koga site showed significant difference among the treatments for all of the parameters with the lowest result obtained from the control (Table 5). The highest pod diameter and plant height were recorded from the combinations of 46/10 kg N/P ha^{-1} while the highest pod length obtained from 46/50 kg N/P ha^{-1} (Table 5). The highest marketable yield was obtained from 92/50 kg N/P ha^{-1} (Table 5). The result is in line with Nasrin and Jahan (2010) who obtained higher green pod yield (18.61 t/ha) and greater seed yield from Bush Bean (*Phaseolus vulgaris* L.) by combining higher rate of nitrogen and intermediate dose of phosphorus in Bangladesh. The high demand of phosphorous for snap bean for high yield at Koga may be attributed to low phosphorus content of the soil due to phosphorus fixation resulted from its acidic nature (Table 1).

Table 5. Effect of nitrogen and phosphorous fertilizer on the yield of snap bean at Koga irrigation scheme

The partial budget analysis (Table 6) showed that applying 92 kg N ha^{-1} and 50 kg P ha^{-1} had the highest net benefit (95692.26 ETB ha^{-1}) and MRR (1990.91 %) followed by 92 kg N ha^{-1} and 30 kg P ha^{-1} with net benefit of 95207.16 ETB ha

] TJ ETBT/F1 12 Tf 1 0 0 1 ... 334.49 Tm[(] 1 0 0 1 504.22 355.13 Tm[( )] TJ310.95BT1 0 0 1 266.81 334.49 Tm[(ET)-7(30(h)

Table 6. Partial budget analysis for the effect of nitrogen fertilizer on the yield of snap bean at Koga irrigation scheme.

N/P	Yield kg/ha	Adjusted yield (10% dawn wards)	Total variable cost	Gross benefit	Net benefit	MRR%
0/0	3406.4	3065.76	0	30657.6	30657.6	
46/10	7267.6	6540.84	1606.848	65408.4	63801.55	2062.67
69/10	8571.9	7714.71	2164.348	77147.1	74982.75	2005.6
92/10	10048.2	9043.38	2721.848	90433.8	87711.95	22832.65
46/20	8351.9	7516.71	2098.696	75167.1	73068.4	D
69/20	8564.4	7707.96	2656.196	77079.6	74423.4	D
92/20	10588.3	9529.47	3213.696	95294.7	92081	3167.28
46/30	10800.2	9720.18	2590.543	97201.8	94611.26	D
69/30	8794.4	7914.96	3148.043	79149.6	76001.56	D
92/30	10990.3	9891.27	3705.543	98912.7	95207.16	3444.95
46/40	8938.7	8044.83	3082.391	80448.3	77365.91	D
69/40	9596.2	8636.58	3639.891	86365.8	82725.91	D
92/40	10177.1	9159.39	4197.391	91593.9	87396.51	837.78
46/50	9874.1	8886.69	3574.239	88866.9	85292.66	D
69/50	9858.3	8872.47	4131.739	88724.7	84592.96	D
92/50	11153.5	10038.15	4689.239	100381.5	95692.26	1990.91

D=Dominated

The sensitivity analysis indicated (Table 7) that under predicted worst economic condition 92 kg N ha^{-1} and 50 kg P ha^{-1} had the highest net benefit (95223.34 ETB ha^{-1}) with MRR of 1800.82%. Based on the sensitivity analysis, the second highest net benefit (94836.6 ETB ha^{-1}) was recorded by applying 92 kg N and 30 kg P ha^{-1}. Therefore, 92/50 and 92/30 kg N/P ha^{-1} are recommended as first and second options economical fertilizer rates respectively for green snap bean production at Koga irrigation scheme.

Table 7. Sensitivity analysis for the effect of nitrogen fertilizer on the yield of snap bean at Koga irrigation scheme.

N/P	Yield kg/ha	Adjusted yield (10% dawn wards)	Total variable cost	Gross benefit	Net benefit	MRR
0/0	3406.4	3065.76	0	30657.6	30657.6	
46/10	7267.6	6540.84	1767.533	65408.4	63640.87	1866.06
69/10	8571.9	7714.71	2380.783	77147.1	74766.32	1814.18
92/10	10048.2	9043.38	2994.033	90433.8	87439.77	2066.60
46/20	8351.9	7516.71	2308.565	75167.1	72858.53	D
69/20	8564.4	7707.96	2921.815	77079.6	74157.78	D
92/20	10588.3	9529.47	3535.065	95294.7	91759.63	2870.26
46/30	10800.2	9720.18	2849.598	97201.8	94352.2	D
69/30	8794.4	7914.96	3462.848	79149.6	75686.75	D
92/30	10990.3	9891.27	4076.098	98912.7	94836.6	3122.68
46/40	8938.7	8044.83	3390.63	80448.3	77057.67	D
69/40	9596.2	8636.58	4003.88	86365.8	82361.92	D
92/40	10177.1	9159.39	4617.13	91593.9	86976.77	752.52
46/50	9874.1	8886.69	3931.663	88866.9	84935.24	D
69/50	9858.3	8872.47	4544.913	88724.7	84179.79	D
92/50	11153.5	10038.15	5158.163	100381.5	95223.34	1800.82

D = Dominated

Conclusion and recommendation

At Rib, application of 46 kg N ha^{-1} and 20 kg P ha^{-1} was economically feasible for green snap bean production. While at Koga irrigation scheme, application of 92 kg N ha^{-1} and 50 kg P ha^{-1} was recommended as the first option for green snap bean production and application of 92 kg N ha^{-1} and 30 kg P ha^{-1} is recommended as a second option. In addition, at Koga irrigation scheme, fertilizer rate study need to be done along with lime application for the soil in the command area is acidic. Moreover, at both locations, interaction of fertilizer especially N with water amount and frequency is a researchable gaps. Furthermore, since the crop is new to the area and has high demand on the urban market linking the farmers with market and introduction and demonstration of different recipes is highly demanding.

References

Adet Research Center (ARC), 2002. *Snap Bean Production*, (Pamphlet produced by the Horticulture Research Division).

ACVC (Advisory Committee on Vegetable Crops), *Beans (Snap): Vegetable Crops Production Guide for the Atlantic Regions*, the USA.

Bruce, R. C. and Rayment G. E. 1982. Analytical methods and interpretations used by the Agricultural Chemistry Branch for Soil and Land Use Surveys. Queensland Department of Primary Industries. Bulletin QB8 (2004), Indooroopilly, Queensland

CIMMYT (International Maize and Wheat Improvement Center). 1988. From agronomic data to farmers' recommendations: An economic work book, Mexico, D.F. CIMMYT.38-60p.

Clements, B. and McGowen I. 1994. Strategic fertilizer use on pastures. NSW Agriculture. Agnote Reg. 4/57, Orange, NSW.

Hochmuth, G. and Hanlon E. 2010. *A Summary of N, P, and K Research with Snap Bean in Florida*, University of Florida IFAS Extension, SL 331.

Marr, Charles W., William L. and Ned Tisserat. 1995. *Snap Beans*, Kansas State University, the USA. 8. Nasrin, S. and Jahan, M. A. 2010. *Effect of Nitrogen and Phosphorus on the Yield of Bush Bean (Pheseolus vulgaris L.)*, in J. Expt. Biosci.1(1):19-24, January 2010.

Pam Hazelton and Brian Murphy. 2007. Interpreting Soil Test Results; What Do All the Numbers Mean? University of Technology, Sydney (UTS), Department of Infrastructure, and Natural Resources & Planning: CSIRO PUBLISHING pages 66-83

Rashid, M.M. 1993. *Sabji Biggan* (In Bengali) 1st ed., Bangla Academy, Bangladesh.

S.A.S. (Statistical Analyis System). 2002. Guide for personal computers. 6th edition. S.A.S. Institute Inc., Cary, NC, USA;