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Determination of Optimum Rate of Blended Fertilizer for Pod Yield of Snap Bean (*Pharsalus vulgaris L.)* at Teda, North Gondar, Ethiopia

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Abstract

Snap bean is one of the important legume vegetable crops. Snap bean production in Ethiopia has both challenge and opportunity. But there is limited research regarding the response of snap bean to different sources of fertilizer. There is no site and crop specific rate determination of blended fertilizer was not done yet. Seven blended fertilizer with the recommended NP_2O_5 rates were evaluated during 2016 offseason by irrigation at Teda experimental site of University of Gondar, northwest part of Ethiopia. The objective of this study was to evaluate the response of “Idom’ variety of snap bean to different levels of blended fertilizer in the study area. The trail was laid out in the randomized complete block design with three replications. The analysis of variance showed significant variation among varieties for all the parameters studied such as number of pods/plant, pod length, pod diameters, plant height, pod yield and biomass. The blended fertilizer rate the recommended NP_2O_5 and 300kg/ha blended fertilizer gave high pod yield 8.6 ton/ha and 4.3 ton/ha respectively. The partial analysis result showed that the recommended NP_2O_5 and 300kg/ha blended fertilizer have a net benefit of 139,645.5and 66,726.8 birr and 36,459.4 and 3396.66% marginal rate of return per one birr of investment respectively.

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Therefore based on the governments direction to use blended fertilizer instead of di-ammonium phosphate, use of 300 kg/ha blended fertilizer can be used as an option to maximize snap bean productivity and higher return.

Keyword: snap bean; pod yield ; blended fertilizer.

1. Introduction

Snap bean(*Pharsalus vulgaris L.*) are a vegetable crop in the legume family ,well suited to small-scale and part –time farming operations. Snap bean is one of the important legume vegetable crops [16]. Snap bean comprises a group of common bean that has been selected for succulent pods with reduced fiber which primarily grown for its young, edible fleshly pods. The immature pods and seeds are produced and marketed fresh, canned or frozen products [1]. According to [6] In Ethiopia, different plant types (bush/pole) of diverse pod characters (bobby/fine bean) of the crop are produced for export purposes. In the last five years its production has been steadily increasing due to the involvement of state horticultural enterprises, there has local and foreign private investors and farmers and thus occupies the highest share (94%) of export potential [5]. The crop is widely cultivated due to its good source of fiber. Cultivated in the arid regions for both green pods and dry seeds, considered as a good source of protein. The total annual production of green beans in the world reaches 6,814,403 tons from the area of 960,272 ha [7]. About 50 and 30% of world production comes from Asia and Europe. Of these, China and Turkey produce 17% and 13% of the world production, respectively [16]. In Ethiopia, there is no exact information as to when green bean was first introduced; however, the crop is cultivated in different major growing areas of the country. Currently, the total area coverage of green bean in Ethiopia is more than 15,379 ha with an average total production of 6,803 tonnes [7]. It has been among the most important and highly prioritized crops as a means of foreign currency earning in Ethiopia [8]. Nowadays, it is becoming a high value commodity which has the potential for improving the incomes and livelihoods of thousands of smallholder farmers in Ethiopia and diversifying and increasing Ethiopia's agricultural export exchange earnings [1]. Previously, Ethiopian small holder farmers were limited to DAP and UREA, fertilizers that only delivered N and P nutrients. Farmers and farmer corporative union (FCUs) have already requested that the government make the new blended fertilizers more available [13]. The use of fertilizer previously has been limited to only DAP and UREA. According to [11], Ethiopia's crop yields have been constrained by very limited set of imported fertilizer, and ultimately affect the main crop production and productivity of the country. However, the same report indicated that, soil tests show that crop lands lack other essential nutrients such as sulfur, boron, potassium, zinc, and copper. Based on agricultural transformation agency of Ethiopia [3], blended fertilizer from a 100kg has a macro and micro nutrient content of (23%N,10%P,5%K,3%S,2%Mg and 0.3%Zn). A research conducted by Gondar Agriculture Research Center fertilizer recommendation indicated that, for Snap bean higher pod yield 92kg/ha of N and 69kg/ha P_2O_5 was recommended [9]. Research works to improve the yield potential of snap bean research programmers have not received desired attention. Gondar Agricultural Research Center (GARC) tries to conduct verity adaptation and NP fertilizer rate determination experiment. But no information is available on the response of snap bean to blended fertilizer for both rain feed as well as irrigation system. There is dearth information on the response of snap bean to blended fertilizer with respect to pod yield. This investigation was conducted to find out the influence of blended fertilizer on production of snap bean in vertisol under irrigation condition. Therefore, this experiment was conducted to determine optimum rate of blended fertilizer for snap bean pod yield and to evaluate the impact of blended fertilizer on yield and yield component of snap bean pod yield for teda area.

2. Material and Method

2.1. Description of the experimental site

The experiment was conducted at Educational site of Collage of Agricultural &Rural Transformation at Teda during 2016 off season by irrigation. Teda is located near to the main road and under the administration of university of Gondar in Melse Zenawi campus. It has an altitude range from 2000m a.s.l, and longitude of 37.479682 ^{0}E and 12.4776 ^{0}N. Annual rain fall is1200mm and the average temperature of 25 ^{0}C and the soil is black vertisol.

2.2. Experimental Material

The experiment had seven laves of blended fertilizer (0, 50,100,150, 200, 250 and 300kg/ha) with the recommended rate of NP fertilizer (92Kg/ha of N and 69kg/ha $P_2O_{5)}$ were used as a treatment. The blended fertilizer has a nutrient composition of (23%N, 10%P, 5%K,3%S,2%Mg,and0.3%Zn) with a 100 kg amount.

2.3. Experimental Design and management

Eight fertilizer rates were arranged in Randomized Complete Block Design (RCBD) with three replications. Seeds of the improved variety "Idom" were sow on a plot having 4m length and 5 rows with spacing of 1.5m and 0.5m between blocks and plots respectively. Seeds were drilled in rows of 40 cm spacing and have been thinned to 10 cm spacing between plants 15 days after sowing. All amount of phosphorus in the form of DAP and 1/3 N and blended fertilizer was applied at planting time and the remaining fertilizer also applied at vegetative and flowering stage of the crop at equal amount. The split application of fertilizer was done in to three growth stage (1/3 at planting, 1/3 at vegetative, and 1/3 at flowering stage). All other management agronomic managements were applied equally for each plot.

2.4. Data Collection and Measurements

Phonological data

Days to 50% flowering: This parameter of the plant was determined by counting the number of days from sowing to the time when 50% of the plants started to emerge the tip of panicles through visual observation.

Days to maturity: Days to maturity was determined as the number of days from sowing to the time when the plants reached maturity based on visual observation. It was indicated by physiological maturity of fresh edible pods from the plant before seeds were matured and fibers were developed.

Growth, yield and yield component

Plant height: Plant height was measured at physiological maturity from the ground level to the tip of plant from ten randomly selected plants in each plot.

Pod length: It was the length of the pod from the node where the pods were emerged to the tip of the pod which was determined from an average of ten selected plants per plot.

Number of edible pods: The numbers of pods were determined by counting the pods from the central two harvestable rows with an area of 0.8 m x 4 m plants and converted to hectare.

Pod diameter: It is the diameter of the pod from central part of the pod and which was determined from an average of ten pods from randomly selected ten plants per plot.

Fresh pod yield: Fresh pod yield was measured by harvesting the picking the fresh marketable pod from the net middle plot area of 0.8m x 4 m to avoid border effects.

Biomass yield: At maturity, the whole plant parts, including leaves, stems, roots and pods from the net plot area were harvested and, the biomass was measured.

Harvest index: Harvest index was calculated by dividing fresh pod yield by the total fresh biomass yield and multiplied by 100.

Cost of input, price of output: was recorded based on the actual market information to determine the profit margin of the recommended fertilizer rate

2.5. Data analysis

The analysis of variance (ANOVA) was done to evaluate the performance of agronomic and yield related parameters among different fertilizer rates following the standard procedure given by Gomez and Gomez using SAS soft ware [18]. Mean separation was done using LSD at 5% probability level if there is statically significant difference among the levels of fertilizer rates.

2.6. Partial Budget Analysis

Partial budget analysis was made following CIMMYT methodology [4]. The cost of and pod were used for the benefit analysis. Marginal rate of return was calculated as change of benefit divided by change of cost. To assess the costs and benefits associated with different treatments the partial budget technique as described by [4] was applied on the yield results. Economic analysis was done using the prevailing market prices for inputs at planting (100 kg urea (1250 birr), 100 kg of DAP (1400 birr), 100 kg of blended fertilizer (1400 birr) and for outputs at the time the crop was harvested (market price of 2000 birr per quintal). All costs and benefits were calculated on hectare basis in Ethiopia birr (Birr ha-1).

Marginal rate of return (MRR), was calculated by the following formula:

$$\text{MRR (between treatments, a \& b)} = \frac{\text{Change in NB (NBb- NBa}}{\text{Change in TCV(TCVb -TCVa)}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Thus, a MRR of 100% implies a return of one birr on every birr of expenditure in the given variable input.

3. Results and discussion

The analysis of variance or plant height, number of pod per plant, pod length, pod diameter, pod yield and biomass are presented here below.

3.1. Plant height

Highly significant variation ($P>0.01$) was observed among the studied fertilizer rates for plant height. The longer plant height was recorded (48.067cm) for fertilizer level (*92/69* NP_2O_5) whiles the shortest plant height (17.233cm) at level (control) (Table 1).

The result showed that snap bean crop respond well to fertilizer application. Blended fertilizer has 23%N from 100 kg total mass, which contributes for tissue development and interned elongation. Similar results were reported by [14] studies have shown increases in vegetative growth of snap beans and dry beans on addition of N-fertilizer.

Table 1: mean plant height of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	Plant Height
0	17.233^{E}
50	20.00^{E}
100	27.467^{D}
150	32.733^{C}
200	37.067^{B}
250	38.233^{B}
300	40.367^{B}
92/69 NP2O5	48.067^{A}
Mean	32.64583
LSD (0.05%)	4.0475
CV (%)	7.079750

3.2. Leaf per plant

Highly significant variation ($P>0.01$) was observed among the studied fertilizer rates for number of leafs per plant. The more number of leafs was observed by the application of 92/69 NP_2O_5 kg/ha (31.33) and the lowest by the control treatment (9.33) (Table 2).

The result indicated that as fertilizer application rate increases the number of leaf per plant increases, which is directly associated with the formation of more assimilate and convert to economical yield (pod).

Table 2: Mean number of leaf per plant of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	No. of leaf per plant
0	9.33^{E}
50	$12D^{E}$
100	14.67^{CD}
150	15.67^{CD}
200	19.33^{BC}
250	15.67^{CD}
300	21^{B}
92/69 NP2O5	31.33^{A}
Mean	17.375
LSD (0.05%)	5.046
CV (%)	16.58

N.B. = Means with the same letter are not statically significant, LSD = least significant difference, CV = coefficient of variation

3.3. Number of branch per plant

Number of fruiting branches is one of the yield contributing parameters directly related to yield. There is a highly significant variation (P>0.001) was observed among the studied fertilizer rates for number of branches per plant.

The more number of branches was observed by the application of 92/69 NP_2O_5 kg/ha (6.67) and the lowest by the control treatment (1.33) (Table 3). The other treatments showed almost similar results to branch formation.

3.4. Days to 50% Flowering

Days to flower emergence was highly significantly ($P < 0.001$) affected by the fertilizer application and significantly (Table 4). The early flower formation was observed by fertilizer receiving plots as compared to the control. The unfertilized crop develop flowering with in average days of (46.667) while the early flower formation by the blended fertilizer rate of (35.333) average day’s (Table 4).

Table 3: Mean number of branch per plant of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	No. of branches per plant
0 NPK	1.33^{D}
50 NPK	1.67^{D}
100 NPK	2.33^{CD}
150 NPK	3.67^{BC}
200 NPK	3.33^{BC}
250 NPK	3.67^{BC}
300 NPK	4.67^{B}
92/69 NP2O5	6.67^{A}
Mean	3.41
LSD (0.05%)	1.404
CV (%)	23.46

N.B. = Means with the same letter are not statically significant, LSD = least significant difference, CV = coefficient of variation

Table 4: Mean 50% flowering date of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	Days to 50% flowering
0	46.667^{A}
50	42.00^{B}
100	39.667^{BC}
150	38.333^{CD}
200	36.667^{CD}
250	35.333^{D}
300	36.333^{D}
92/69 NP2O5	37.667^{CD}
Mean	39.08
LSD (0.05%)	3.054
CV (%)	4.462356

3.5. Number of pod per plant

Snap bean as a vegetable crop grown for its fresh pod production, which is the economical yield of snap bean. The result indicated that number of pod per plant was highly significantly ($P< 0.001$) influenced by the application of different levels of blended fertilizer as well as by the previous recommendation (92/69 NP_2O_5) (Table 5). The highest pod length was observed by application of 92/69 NP_2O_5kg/ha (13.667) and the lowest by the control and 50 kg/ha (2.335) 9Table 5).

Table 5: Mean number of pod per plant of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	No. of Pod per plant
0	2.335^{D}
50	2.333^{D}
100	3.00^{CD}
150	4.333^{BCD}
200	6.00^{BC}
250	7.00^{B}
300	7.333^{B}
92/69 NP2O5	13.667^{A}
Mean	5.75
LSD (0.05%)	3.26
CV (%)	32.39752

3.6. Pod length

Pod length is one of the yield attributes of snap bean that contribute to total yield. Crops with higher pod length could have higher grain yield. Pod length was highly significantly (P< 0.001) influenced by the application of different levels of blended fertilizer as well as by the previous recommendation (92/69 NP_2O_5) (Table 6). The highest pod length was observed by application of 92/69 NP_2O_5kg/ha and the lowest by the control.

Table 6: Mean pod length of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	Pod Length
0	6.633^{D}
50	8.633^{CD}
100	8.8^{C}
150	10.633^{BC}
200	10.567^{BC}
250	10.467^{BC}
300	10.933^{B}
92/69 NP2O5	13.367^{A}
Mean	10.00417
LSD (0.05%)	2.1016
CV (%)	11.99599

3.7. Pod diameter

Pod diameter is the circumference of the pod measured before fiber formation. The result indicated that there is no variation among different fertilizer rates except with the control treatment which showed the lowest pod diameter (4.8mm) (Table 7).

Table 7: Mean pod diameter of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	Pod Diameter
0	4.8^{B}
50	6.533^{A}
100	6.967^{A}
150	7.2^{A}
200	6.633^{A}
250	7.4^{A}
300	7.433^{A}
92/69 NP2O5	8.133^{A}
Mean	6.88750
LSD (0.05%)	1.643
CV (%)	13.6219

3.8. Pod yield

The analysis of variance showed that pod yield of snap bean was very highly significantly ($P < 0.001$) influenced by the applied fertilizer rate. Snap bean yield generally increased with the increase in the rate of blended fertilizer and higher response by application of 92/69 NP_2O_5 kg/ha (Table 8). The result is supported by [12] indicated that total pod yield as well as pod quality of snap beans were significantly enhanced with increased levels of nitrogen. This is in agreement with studies done on snap bean which indicated that increasing NPK rates or increasing N: P fertilizer levels increased yield of green beans [2]. Similar results were obtained by [10] in which application of N-fertilizer at 100kg/ha to the vegetable green beans led to high marketable yield. This report indicated that snap bean is poor in N-fixation and require high amount of applied fertilizer for better yield and quality. Similar result was reported by [17], indicate that snap bean plants will not grow well or produce the best yield with low soil N availability. Likewise, [15] reported that the N fertilizer requirement of snap bean plant is high, due to its weak fixation capacity of atmospheric N compared to other legumes.

3.9. Biomass yield

Significant differences ($p<0.001$) was observed on snap bean due to the applied levels of fertilizer for total biomass. The highest total biomass was recorded by the application of (*92/69* NP_2O_5) of followed by (300 kg/ha blended) with a value of and ton/ha respectively. The least biomass was recorded by control treatment with a value of (8982.6 and 4871.5 ton/ha) respectively (Table 9). Biomass yield generally increased significantly with the increase in the rate of blended fertilizer application.

Table 8: Mean pod yield of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	Pod Yield/kg/ha
0	543.8^{F}
50	1256.9^{EF}
100	1653.5^{DE}
150	2084^{CD}
200	2284.7^{CD}
250	2820.6^{C}
300	4260.4^{B}
92/69 NP2O5	8561.5^{A}
Mean	2933.175
LSD (0.05%)	786.19
CV (%)	15.30564

Table 9: Mean biomass yield of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	Fresh BM (ton/ha)
0	569.5^{F}
50	1079.9^{EF}
100	1972.2^{DEF}
150	2479.2^{CDE}
200	3691^{BC}
250	3621.5^{BCD}
300	4871.5^{B}
92/69 NP2O5	8982.6^{A}
Mean	3408.425
LSD (0.05%)	1654.7
CV (%)	27.72163

3.10. Harvest index

Harvest index, the ration of pod yield to total biomass yield, is a measure of the degree to which a crop partitions photo assimilate into economical yield pod. Significant variation (p<0.) was observed in response to the application of different level of fertilizer. The fertilizer level *50* kg/ha (117.13) and *92/69* NP_2O_5*kg/ha* (100.53) recorded highest harvest index while the level 200 kg/ha recorded the lowest (64.33) (Table 10). The higher harvest index refers that, the pod yield proportionally increased due to n increment of total biomass due to application of fertilizer or plants convert more assimilate to pod formation.

Table 10: Harvest index of snap bean as affected by different rates of fertilizer application

Fertilizer Rate (kg/ha)	Harvest Index
0	96.5^{AB}
50	117.13^{A}
100	86.2^{ABC}
150	87.9^{ABC}
200	64.33^{C}
250	82.87^{BC}
300	87.47^{ABC}
92/69 NP2O5	100.53^{AB}
Mean	90.36667
LSD (0.05%)	31.977
CV (%)	20.20657

3.11. Partial Budget Analysis

As indicated in (Appendix 2), marginal rate of return (MRR) analysis were done for the eight treatment combinations under varying costs and prices (Appendix 2) for each fertilizer levels. In economic analysis, it is assumed that farmers require a minimal rate of return of 100%, representing an increase in net return of at least 1 Birr for every 1Birr invested, to be sufficiently motivated to adopt a new agricultural technology. In the response of snap bean to the applied fertilizer level, higher net margins were shown at 92/69 NP_2O_5 and 300 kg/ha blended fertilizer with net benefit of 139,645.5and 66,726.8 birr respectively. This gave marginal rate of return of MRR=36459.4 and 3396.7 % per birr invested for 92/69 NP_2O_5 and 300 kg/ha blended fertilizer respectively. According to the manual for economic analysis of [4] the recommendation is not necessarily based on the treatment with the highest marginal rate of return compared to that of neither next lowest cost, the treatment with the highest net benefit, and nor the treatment with the highest yield.

The identification of a recommendation is based on a change from one treatment to another if the marginal rate of return of that change is greater than the minimum rate of return. Since the assumption was that minimum level of return (100%), indicated that application of fertilizer at any level can benefit the producer even if the return amount varies.

4. Conclusion

Snap bean (*Pharsalus vulgaris L.*) is a vegetable crop in the legume family, well suited to small-scale and part –time farming operations. Snap bean is one of the important legume vegetable crops The crop is widely cultivated due to its good source of fiber. Cultivated in the arid regions for both green pods and dry seeds, considered as a good source of protein. It has been among the most important and highly prioritized crops as a means of foreign currency earning in Ethiopia. Now a days, it is becoming a high value commodity which has the potential for improving the incomes and livelihoods of thousands of smallholder farmers in Ethiopia and diversifying and increasing Ethiopia's agricultural export exchange earnings. Besides the promotion of snap bean in the area, developing economical optimum fertilizer rate based on the current and future government policy scenario is very important. There is dearth information on the response of snap bean to blended fertilizer with respect to pod yield. The results from the study suggest that application of 92/69 kg of N/P_20_5 ha-1 and 300 kg/ha blended fertilizer respectively, reached better economical return with maximum pod yield production for *Idom* variety of snap bean in the study areas. Snap bean unlike the other pulses it is poor in fixing atmospheric nitrogen, the response to the external application of fertilizer is promising. The result also assure that, all fertilizer levels showed better pod and related yield parameters as compared to the control. The partial budget analysis showed that, applied fertilizer level, higher net margins were shown at 92/69 NP_2O_5 and 300 kg/ha blended fertilizer with net benefit of 139,645.5and 66,726.8 birr respectively. This gave marginal rate of return of MRR=36459.4 and 3396.7 % per birr invested for 92/69 NP_2O_5 and 300 kg/ha blended fertilizer respectively. However, definite recommendation may not be drawn from this research result since the maximum yield response of blended fertilizer was not obtained with the current levels of fertilizer and conducted only for one season. Therefore, the experiment has to be conducted by increasing the blended fertilizer level combined with additional urea as source of nitrogen for maximum pod yield.

5. Recommendation

This experiment was conducted by using seven blended fertilizer rates. But the result indicated that, with the application of fertilizer both pod yield and economic benefit was goes parallel unable to get the maximum yield level. So additional fertilizer rate beyond 300 kg blended fertilizer and/or the use of blended fertilizer rate should be combined with application of additional nitrogen at different growth stages of the crop.

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