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Full Length Research

Evaluation of different blended fertilizer types and rates for better yield of common bean (*Phaseolus vulgaris L.*) at Mirab Abaya, Southern Ethiopia

Tarekegn Keriso Menisho*, Metadel Minaye Getahun, Zeleke Eromo Ewunetu and Ewnet Zeleke Kayida

Arba Minch Agricultural Research Center, SARI, P.O. Box 2228, Arba Minch, Ethiopia.

*Corresponding author. Email: yedideya04@gmail.com; Tel: +251-926078692.

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ABSTRACT: In Ethiopia, the common bean has been cultivated in different parts of the country. However, average national and regional yield is low due to various biotic and abiotic stresses like diseases, insect pests, drought, and nutritional deficiencies. Hence, this experiment was conducted in 2018 and 2019 cropping season to determine the optimum rates and types of blended fertilizer for maximum yield of common bean in Mirab Abaya woreda, Southern Ethiopia. The experiment was comprised of eight treatments; control, 100 kg NPS +10 kg urea (23 , 36, 7), 142 kg NPS + 42 kg urea (46 , 54 ,10), 189 kg NPS + 72 kg urea (69 , 72 ,13) , 100 kg NPSB + 11 kg urea (23, 36 , 6.7, 0.71), 150 kg NPSB + 42 kg urea, 200 kg NPSB + 72 kg urea (69, 72, 13 1.4) and 150 kg NPSB + 141 kg urea (92, 54, 10, 1.07) ha^{-1} blended fertilizers; and was laid out in a randomized complete block design with three replications. Data on growth and yield related parameters were collected and analyzed using SAS software. The significant effect of blended fertilizers was observed on plant height, branches number per plant and grain yield and non-significant on pods number per plant and seeds number per pod of common bean. The highest grain yield (3858 kg) was obtained with 100 kg NPS + 10 kg ha^{-1} urea application, while the lowest (3025 kg) ha^{-1} was obtained from control. The highest net return of 33072 Eth-birr ha^{-1} with marginal rate of return of 354% and 26524 Eth-birr ha^{-1} with marginal rate of return of 1481% were obtained from the application of 100 kg ha^{-1} of NPS blended fertilizer with 10 kg urea ha^{-1} and 200 kg ha^{-1} of NPSB blended fertilizer combined with 72 kg urea ha^{-1} respectively. Therefore, based on the yield response and economic indicators, it is recommended to apply 100 kg ha^{-1} of NPS blended fertilizer along with 10 kg urea ha^{-1} for common bean at Mirab Abaya, Southern Ethiopia and areas with the same soil conditions and agro ecology.

Keywords: Common bean, economic feasibility, growth, nutrient, yield.

INTRODUCTION

In Ethiopia, the common bean has been cultivated in different parts, mainly at central, eastern, and southern parts of the country. The CSA (2016) states that, Ethiopia accounts 216,803.91 ha (13.5%) production area and 3,72766.48 ton (12.5%) dry bean production nationally and 97,694.18 (41.43%) production area and 1,529,62.702 tons (38.6%) dry bean production. It is highly preferred by Ethiopian farmers because of its fast maturing characteristics that enable households to get cash income required to purchase food and other household needs when other crops have not yet matured (Legese et al., 2006). Its production contributes both as food, fodder for livestock, export commodity and serves as a source of income and employment to a large supply chain and for risk aversion strategies to poor farmers' during drought due to early maturity and moderate degree of drought tolerance (Darkwa et al., 2016.). The crop provides vital nutrients such as high starch, protein and dietary fiber and is an excellent source of minerals and vitamins (Ferris and Kaganzi, 2008). As a legume, it provides nitrogen and other soil health benefits under cropping system to subsequently grown crops (Franke et al., 2018). It is used as food in different form; the green unripe pods are cooked or conserved as vegetable and the ripe seeds are cooked for "*nifro"* or boiled with mixed sorghum or maize and can be consumed as "*woti*" using powder form (MOARD, 2009).

Despite the multiple uses, the average national and regional yield of common bean was estimated as 982 kg ha^{-1} and 963 kg ha^{-1}, respectively in Ethiopia, while its production potential is 2500 to 4000 kg ha^{-1} in research fields (CSA, 2016). Lack of appropriate technology, utilization of low agricultural input and cropping in low fertility soils, especially with low N content are the main causes of low productivity at farmer level (Beebe et al., 2013). Soil factors such as nutrient deficiency like low soil nitrogen and phosphorus, and acidic soil conditions are important limitations for common bean production in most of the common bean growing areas. In common bean, symbiotic N fixation rates, seed protein level and tolerance to phosphorus deficiency are low in comparison to other legumes (Broughton et al., 2003).

In Ethiopia, fertilizer use trend has been focused mainly on the use and application of nitrogen and phosphorous fertilizers in the form of DAP (18-46-0) and urea (46-0-0) or blanket recommendation for the major food crops. The previous result indicated in Ethiopia fertilizer recommendations is based on very general crop specific guidelines or more often, a single recommendation for all crops (100 kg DAP (18-46-0) and 100 kg urea (46-0-0). Urea and DAP are the only fertilizer sources that have been in use for the past four decades in the country (IFDC, 2015). This blanket recommendation often fails to take into consideration differences in resource endowment (soil type, labour capacity, climate risk) or make allowances for dramatic changes in input/output price ratio, thereby discouraging farmers from fertilizer application. Moreover, the nutrients in the blanket recommendation are not well balanced agronomically and its continued use will gradually exhaust soil nutrient reserves. According to those sources, urea and DAP are the only fertilizers imported into the country since 1971. Urea is chemically composed of 46% of N, while DAP contains 18% of N and 46% of P.

Today, in addition to N and P, other essential nutrients like S, B and Zn deficiencies are widespread in Ethiopian soils, while some soils are also deficient in K, Cu, Mn and Fe (Laekemariam, 2016). To overcome this problem of nutrient deficiency balanced fertilizers containing N, P, S, B and Zn have been recommended for site specific nutrient deficiencies and thereby increase crop production and productivity. The major recently recommended blended fertilizers for the study areas are NPS and NPSB (ATA, 2016). Although the type of required blended fertilizers are identified for the region, optimum rates of the major recommended blended fertilizer types for different crops, agro ecologies and soil types is not yet determined for the study area. Besides, it is quite essential to verify the soil fertility map for major crops grown in different agro-ecologies and on different soil types to increase crop yield and also to improve quality of major crops grown in SNNP region. Therefore, study of crop nutrient sources beyond N and P, especially fertilizers containing S and B and other micro-nutrients quite important to increase common bean productivity. Thus, the aim of this study is to determine the optimum rates, types and economic analysis of blended fertilizers for maximum yield of common bean on Mirab Abaya woreda, Southern Ethiopia.

MATERIALS AND METHODS

Description of the study area

The field experiment was conducted in the Mirab Abaya district of the Southern Nations, Nationalities and Peoples Regional State (SNNPRS) for two consecutive main cropping seasons under rain-fed conditions during 2018 and 2019. Mirab Abaya district is geographically located at 06°15' 933" and 037°66' 262" latitude and longitude, respectively. The altitude of the area is 1186 m above sea level. Maximum and minimum annual temperature was 38 and 19°C, while maximum and minimum annual rainfall was recorded 1100 and 600 mm, respectively. The soil of the experimental area was found to be clay in texture (28% sand, 32% silt and 40% clay), moderately alkaline (pH of 7.41), moderate total N content (0.49%), low in available P (14.95 mg/kg), low in S (4.22 mg/kg) and low in organic carbon (1.6%).

Treatments and experimental design

The experiment was conducted following Randomized Complete Block Design with eight treatments, which were replicated three times. The experiment was designed based on the nutrient deficiency of the area which is indicated in the soil fertility map of Ethiopia (ATA, 2016). Accordingly, two types of fertilizers (Nitrogen, Posphrous, Sulphur and Nitrogen, Posphrous, Sulphur, Boron) were used at different rates. These treatments were control (no fertilizer), three rates of NPS with urea: 100 kg NPS + 10 kg urea in nutrient level NPS was (23, 38,7.0), 142 kg NPS + 42 kg urea (46, 54, 10.0), and four rates of NPSB with urea: 100 kg NPSB + 11 kg urea (23, 36, 6.7, 0.71), 150 kg NPSB + 42 kg urea (46, 54, 10, 1.07), 200 kg NPSB + 72 kg urea (69, 72, 13, 1.4), 150 kg NPSB + 141 kg urea (92, 54, 10, 1.07) (Table 1**)**. Each block and plot within the block was spaced 1 m and 0.5 m, respectively, with plot size of 2.8 m x 3 m. Each plot consisted of seven rows, spaced at 40 cm while plants in a row was spaced at 10 cm.

Experimental procedure and crop management

The experimental field was prepared three times by using

Table 1. Description of nutrients applied in each treatment during field experiment treatments.

Fertilizer	Nutrients applied			
	N	P_2O_5	S	B
No fertilizer	0	0	0	0
100 kg NPS + 10 kg urea ha^{-1}	23	36	7	-
142 kg NPS + 42 kg urea ha^{-1}	46	54	10	-
189 kg NPS + 72 kg urea ha^{-1}	69	72	13	-
100 kg NPSB+11 kg urea ha^{-1}	23	36	6.7	0.71
150 kg NPSB + 42 kg urea ha^{-1}	46	54	10	1.07
200 kg NPSB + 72 kg urea ha^{-1}	69	72	13	1.4
150 kg NPSB + 141 kg urea ha^{-1}	92	54	10	1.07

oxen-drawn implements (local plough *maresha*) according to farmers' conventional farming practices. The field was ploughed three times. The improved common bean variety Hawasa Dume (SARIAWRC 2008) was used as a seed source for the study. Besides this, NPS and NPSB with urea at different rates were used as a source of nitrogen (N), phosphorous (P), sulfur (S) and boron (B) for the experiment. The dried seeds were planted by hand at a specified spacing (40 cm × 10 cm) by placing two seeds per hill. After germination, the additional seedling was thinned out. All of the blended fertilizers were applied during planting, while urea was applied 35 days after sowing. Furthermore, all necessary agronomic practices were carried out uniformly for all plots as per the recommendation for the crop. The crop was harvested manually when 90% of the leaves and pods turned yellow. Threshing was done separately for each treatment manually.

Data collection and measurements

Soil data collection and analysis

Soil sampling was done by taking one representative composite sample at a depth of 20 cm from randomly selected spots diagonally across the experimental field using an auger before sowing. The sample was dried in air, thoroughly mixed and ground to pass through a 2 mm sieve in preparation for laboratory analysis and analyzed for soil texture, pH, organic carbon, total nitrogen, available phosphorus and sulfur.

Crop data collection

Plant height (cm): It was measured at physiological maturity from the base to the tip of a plant from randomly tagged plants using meter tape and averaged.

Number of branches per plant: It was determined by counting the total number of branches on randomly pre-tagged five plants in the net plot at physiological maturity and averaged on per plant basis.

Number of pods per plant: It was recorded on the basis of harvested pod from tagged plants and the average was taken as the number of pods per plant.

Seed number per pod: The total number of seeds in the pods of five plants was counted to find the number of seeds per pod.

Above ground dry biomass yield (kg /ha): At harvest, plants were taken from the plot, washed with water, dried, weighed using field balance, and recorded biomass yield.

Seed yield (kg/ha): Seeds from the plot were collected and weighed using field balance and adjust to 12.5% moisture, finally, it was converted into hectare basis.

Statistical data analysis

Growth parameters, yield components, and yield of common bean data were analyzed by using SAS software. Both years' data were analyzed separately and then F-test was done to test homogeneity according to Gomez and Gomez (1984). For significant treatment effects, mean separation was done using the least significance difference (LSD) test at 5% level of significance.

Partial budget analysis

The partial budget analysis was carried out by using the methodology described by CIMMYT (1988) in which prevailing market prices for inputs at sowing and outputs at harvesting were used. Accordingly, average seed yield was adjusted downward by 10% to close yields obtained under farmers' management. Partial budget analysis was done to investigate the economic feasibility of the treatments by using partial and marginal analysis. Marginal rate of return (MRR) was calculated as the change in net benefit (NB) divided by the change in total variable cost (TVC) of the successive net benefit and total variable cost levels (CIMMYT, 1988).

Table 2A. Physicochemical properties of the experimental site soil before planting (soil texture).

Character	Value
Sand (%)	28
Silt (%)	32
Clay (%)	40
Textural class	Clay

Table 2B. Physicochemical properties of the experimental site soil before planting (chemical analysis).

Parameter	Value	Rating	Reference
Soil pH (1:2.5 H2O)	7.41	Moderately alkaline	Tadesse et al. (1991)
Organic Carbon (%)	1.6	Medium	Tadesse et al. (1991)
Total N (%)	0.49 %	High	Berhanu (1980)
Available P (mg/kg)	14.95	Medium	Cottenie (1980)

Table 3. The effect of different blended fertilizers on the growth parameters of common bean.

Treatment	Plant height (cm/plant)	Branch (No/plant)
Control (no fertilizer)	69.20^{b}	4.20^{ab}
100 kg NPS + 10 kg urea (23, 38, 7.0)	73.40^{ab}	4.17^{ab}
142 kg NPS + 42 kg urea (46, 54, 10.0)	76.63^{ab}	3.93^{ab}
189 kg NPS + 72 kg urea (69, 72, 13)	82.50^{a}	4.67^{a}
100 kg NPSB + 11 kg urea (23,36, 6.7, 0.71)	79.67^{a}	4.17^{ab}
150 kg NPSB + 42 kg urea (46, 54, 10, 1.07)	78.03^{ab}	4.33^{ab}
200 kg NPSB + 72 kg urea (69, 72, 13, 1.4)	77.37^{ab}	3.57^{b}
150 kg NPSB + 141 kg urea (92, 54, 10, 1.07)	78.50^{ab}	4.37^{ab}
LSD (0.05)	10.06	0.82
CV (%)	11.19	16.83

Means in the column followed by the same letter (s) are not significantly different at 5% level of significance. LSD (0. 05): Least significant difference at 5% level and CV (%): Coefficient of variation (%).

RESULT AND DISCUSSION

Pre-sowing soil physical and chemical properties of the experimental site

Soil texture is an important soil physical characteristic as it determines water intake rate (infiltration), water holding capacity of the soil, the ease of tilling, the amount of aeration, and also influences soil fertility (Gupta, 2000). It is one of the inherent soil properties less affected by management and determines nutrient status, organic matter content, air circulation and water holding capacity of a given soil. According to the soil textural class determination triangle, soils of the experimental sites were found to be clay, i.e. sand (28%), silt (32%) and clay (40%) (Table 2A). According to the soil analysis test, the soil pH of the experimental site was 7.41 which is moderately alkaline, based on Tadesse et al. (1991) rating scale. The available P level was 14.95 mg/kg which is medium according to the rating scale of Olsen et al. (1954). The result of laboratory analysis showed that a soil organic carbon (OC) content of the study site was 1.6% which is medium OC according to Tadesse et al. (1991) rating scale. The total N content of the soil of the study sites was (0.49%) which is high according to Berhanu (1980) (Table 2B).

Growth, yield and yield parameters of common bean

Plant height

Data presented in Table 3 shows that the application of different blended fertilizer types and rates had a significant effect on plant height. The tallest plant (82.50 cm) was obtained from the application of 189 kg NPS + 72 kg urea top dressing/ha. The increase in plant height in response to the increased blended NPS application rate might be

Table 4. The effect of different blended fertilizers on pods and seeds number per plant and grain yield of common bean.

Treatment	Pod no/plant	Seed no/pod	Seed yield (kg/ha)
Control (no fertilizer)	21.23	5.9	3025[b]
100 kg NPS +10 kg urea (23, 38 ,7.0)	23.63	5.9	3858[a]
142 kg NPS+42 kg urea (46, 54, 10.0)	22.27	5.6	3523[ab]
189 kg NPS+72 kg urea (69, 72 ,13)	23.43	5.63	3130[b]
100 kg NPSB+11 kg urea (23, 36, 6.7, 0.71)	22.53	5.8	3558 [ab]
150 kg NPSB+42 kg urea (46, 54, 10, 1.07)	22.37	5.6	3303[ab]
200 kg NPSB+72 kg urea (69,72, 13, 1.4)	24.67	5.78	3395[ab]
150 kg NPSB + 141 kg urea (92, 54, 10, 1.07)	24.22	5.7	3415 [ab]
LSD (0.05)	NS	NS	698
CV (%)	13.40	10.38	17.53

Means in the column followed by the same letter(s) are not significantly different at 5% level of significance. LSD (0. 05): Least significant difference at 5% level and CV (%): Coefficient of variation (%).

Table 5. Economic analysis of blended fertilizer types and rates on growth and yield of common bean at Mirab Abaya, Southern Ethiopia (2018 - 2019).

Treatment	Adjusted yield (kg/ha)	Gross income	TVC	Net benefit	MRR (%)
Control (no fertilizer)	2723	27230	0.00	27230	0
100 kg NPS + 10 kg urea (23, 38, 7.0)	3472	34720	1648.4	33072	354
100 kg NPSB + 11 kg urea (23, 36, 6.7, 0.71)	3202	32020	1655.8	30364	D
142 kg NPS + 42 kg urea (46, 54, 10.0)	3170	31700	2743.8	28956	D
150 kg NPSB + 42 kg urea (46, 54, 10, 1.07)	2973	29730	2853.4	26877	D
189 kg NPS + 72 kg urea (69, 72, 13)	2817	28170	3885.3	24284.7	D
200 kg NPSB + 72 kg urea (69, 72, 13, 1.4)	3056	30560	4036.5	26524	1481
150 kg NPSB + 141 kg urea (92, 54, 10, 1.07)	3074	30740	4288.7	26451	D

NB: Price of Urea: 14.26 ETB/kg, NPS: 15.03 ETB/kg, NPSB: 14.96 ETB/kg, common bean grain: 10 ETB/kg.

due to the maximum vegetative growth of the plants under higher N, P and S availability. In conformity with the current result, Deresa (2018) found that maximum vegetative growth of the plant under higher N, S, and P. Plant height increased with an increase in nitrogen level (Deresa, 2018). Moreover, in blended NPS, the increase in P application increases plant height (Nigussie and Dereje, 2016).

Number of branches per plant

The application of different blended fertilizers types and rate had significant effect on the number of branches per plant (Table 3). The highest (4.67) number of branches obtained from the application of 189 kg NPS + 72 kg urea top dressing/ha, in contrary the less number of branches per plant given by 200 Kg NPSB +72 Kg urea. The increase in the number of branches per plant in response to the increased rate of blended NPS application rate indicates higher vegetative growth of the plants under higher N, P and S availability. This result in line with finding of Shubhashree (2007) who reported a significantly higher number of branches per plant of common bean due to higher N, P and S availability. The increment in the number of branches with the increased rate of P might also be due to the importance of P for cell division, leading to the increase in plant height and number of branches (Emishaw and Tesfaye, 2007).

In addition, Moniruzzaman et al. (2008) reported that the branch number of bean per plant increased significantly with the increase in N. The increased branches observed under blended NPS fertilizer might be attributed to the readily available form of S that enhanced uptake of other nutrients at the initial stage of crop growth. The result was also in agreement with the finding of Jawahar et al. (2017) who reported that application of the high amount of S recorded the highest number of branches per plant of common bean.

Seed yield

As in in Table 4, the application of different blended fertilizer types and rates had a significant effect on seed yield. Maximum seed (3858 kg/ha) yield obtained from the application of 100 kg NPS+10 kg urea top dressing/ha. With the increase in N, yield of the common bean decreased. Tadesse and Dechassa (2017) supported the current result by reporting maximum yield of common bean obtained with 23 kg/ha an N application beyond this level the yield was reduced. Abera and Tadela (2016) also reported the maximum yield of common bean from the application of lower N rate (23 kg ha^{-1}). The negative effect of a higher rate of nitrogen on yield may be attributed to decreasing nitrogen fixations or the tendency of higher rates of nitrogen to enhance vegetative growth that might have resulted in self-shading thereby reducing the overall yield.

Conclusions and Recommendations

The findings of the study indicated that the growth, yield and yield components of common bean responded significantly due to the application of different rates and types of blended fertilizer. Thus, the highest (3472 kg ha^{-1}) adjusted yield response was obtained from the application of 100 kg ha^{-1} of NPS blended fertilizer along with 10 kg ha^{-1} urea top dressing and was superior by 23.25% to control. In terms of economic feasibility, application of NPS blended fertilizer @100 kg ha^{-1} with 10 kg ha^{-1} urea top dressing and 200 kg NPSB blended fertilizer + 72 kg ha^{-1} urea top dressing gave the highest net return of 33072 Eth-birr ha^{-1} and 26524 Eth-birr ha^{-1}, respectively with MRR of 354% and 1481%. Therefore, based on the yield response and economic indicators, it is recommended to apply 100 kg ha^{-1} of NPS blended fertilizer and 10 kg ha^{-1} urea top dressing at Mirab Abaya and areas with the same soil conditions and agro-ecology.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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