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Response of common bean (*Phaseolus vulgaris* L.) varieties to rates of blended NPS fertilizer in Adola district, Southern Ethiopia

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Common bean is one of the most economically important pulse crops cultivated in Ethiopia. However, its average yield reported at national level remains far below the potential yield to be attained. This is partly due to low soil fertility management, inappropriate agronomic packages and diseases and pest problems. Hence, this experiment was conducted to investigate the effect of blended NPS rates on growth, yield and yield components of common bean varieties and to identify economically feasible rates of blended NPS at Guji Zone Southern Ethiopia. The experiment was conducted in Adola sub-site of Bore Agricultural Research Center during 2016 to 2017 main cropping seasons. The factors studied were six rates of blended NPS (0, 50, 100, 150, 200 and 250 kg ha^{-1}) and three varieties of common bean (Angar, Ibado and Nasir). These were laid out in a factorial arrangement in randomized complete block design with three replications. Data on phonological, growth yield and yield related parameters were collected and analyzed using SAS software. The result showed that significantly the highest number of primary branches per plant (2.77) and the highest number of total pods (18.52) were recorded at the highest rate of 250 kg NPS ha^{-1} whereas the highest number of total nodules (80.47) and effective nodules per plant (35.54) were obtained from the application of 200 kg NPS ha^{-1}. Among the varieties, Angar gave significantly the highest number of primary branches per plant (2.55) and number of pods per plant (15.3). The interaction of variety and blended NPS had significant effect on almost all parameters except on the number of total and effective nodules per plant, number of primary branches per plant and number of pods per plant. Variety Nasir gave the highest plant height (99.72 cm) with application of 150 kg NPS ha^{-1} while Ibado with application rate of 200 kg blended NPS ha^{-1} had the highest hundred seed weight (54.33 g). The highest grain yield (3260 kg ha^{-1}) was recorded for variety Angar at 250 kg NPS ha^{-1}. However, the highest net benefit (29,825 Birr ha^{-1}) was obtained from combination of variety Ibado with application 200 kg ha^{-1} of blended NPS. Thus, it can be concluded that combined application of 200 kg ha^{-1} of blended NPS with variety Ibado proved to be superior with respect to economic advantage.

Key words: Blended fertilizer, nitrogen, phosphorus, sulphur.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.*)*, is herbaceous annual plant domesticated independently in ancient Mesoamerica and in the Andes, and now is grown worldwide for both dry seeds or as a green bean. Thousands of legume species exist but common bean in any form is the most eaten by human beings compared to any other legumes (Broughton et al., 2003). When common bean is used for its unripe fruit, it is termed as green bean or snap bean. About 23.9 million tons of dry bean, 20.7 million tons of green bean, and 1.9 million tons of string or common bean were produced worldwide in 2012 (FAOSTAT, 2014). It is estimated that the crop meets more than 50% of dietary protein requirements of households in sub-Saharan Africa. The annual per capita consumption of common bean is higher among low-income people who cannot afford to buy nutritious food stuff, such as meats and fish (Broughton et al., 2003).

Common bean 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 (Legesse et al., 2006). It is also an important food and cash crop in Guji zone with an area of 15,850.82 ha and average productivity of 1.52 tons/ha. Similarly, it contributed 39.49% for household consumption, 13.33% for seed, 44.1% for sale, 0.58% animal for feed and 2.05 other uses in the study zone (CSA, 2016).

Improved common bean production encompasses proper use of different agronomic practices which include improved variety, seed rate, spacing, fertilizer rate, and pesticide application as per recommendations. However, the current national average yield of common bean (1.48 tons) is far less than the attainable yield (2500 to 3000 kg ha^{-1}) under good management conditions for most improved varieties. This low yield of common bean in Ethiopia is attributed to several production constraints, which include lack of improved varieties for the different agro-ecological zones, poor agronomic practices such as low soil fertility management, untimely and inappropriate field operations (Alemitu, 2011).

A range of environmental factors, such as low soil nitrogen and phosphorus levels, and acidic soil conditions are important constraints for bean production in most areas where the crop is grown (Girma, 2009). Wortmann (2006) also reported that low soil fertility status especially low level of N and P to be the major constraints of common bean production responsible for the loss of grain yield up to 1.2 million tons in Africa. In general, an increase in grain yield and other agronomic parameters of common bean were observed as the rate of nitrogen and phosphorus increased till 27 kg N ha^{-1} and 69 kg P_2O_5 ha^{-1} (150 kg DAP ha^{-1}) (Girma, 2009). This fertilizer rate also gave yield advantages of 39% over the control.

Among the nutrients, nitrogen is the critical limiting element for growth of most plants including common beans due to its unavailability and poor fixation (Vance, 2001). Deficiency in N causes reduced growth, leaf yellowing, reduced branching and small trifoliate leaves in beans (CIAT, 1986). Previous surveys estimated that over 60% of the bean production areas in Central, Southern, and Eastern Africa were affected by N deficiency. This caused yield losses of up to 40% as compared to the N-fertilized areas (Singh, 1999). Besides, common bean is considered to be a poor fixer of atmospheric N when compared with other crop legumes and generally responds poorly to inoculation of rhizobia in the field. As a result, common bean is being generally considered as more responsive than other legumes to N fertilization (Graham, 1981).

Bean N fertilizer requirement depends on soil fertility levels; for low soil nitrogen levels (below 34 kg N ha^{-1}) N fertilizer is generally recommended in order for deficiency symptoms not to manifest and for full development up to production. Moreover, up to 60 kg N ha^{-1} also promotes increased nodule number, mass and size, giving highest yields ((Dwivedi et al., 1994). However, nitrogenous activity declines with applied nitrogen (Davis and Brick, 2009), decreasing the sink strength, and hence, reduce the quantity of photo-assimilate partitioned to nodules and grain. Early application may also result in excessive vegetative growth leading to delayed flowering, reduced pod set, lower seed yield and a greater risk of disease infestation (Setegne and Leggese, 2003).

The application of inorganic phosphorus fertilizer has positive effect on the yield and yield components of common bean. Rana and Singh (1998) revealed that grain weight per plant exhibited a pronounced response to phosphorus application, mean values of grain weight per plant records of 13.0, 17.4 and 20.7 g due to phosphorus fertilization of 0, 50 and 100 kg P_2O_5 ha^{-1}, respectively. Veeresh (2003) observed significant increase in grain weight per plant (8.65 g) due to increased P application up to 75 kg P_2O_5 ha^{-1}. Dwivedi et al. (1994) also reported linear increase in the number of grains per pod of common bean due to increase in phosphorus fertilization from 50 to 150 kg P_2O_5 ha^{-1}, but the differences were not significant beyond 100 kg P_2O_5 ha^{-1}. Saxena and Verma (1994) reported that the mean number of grains per pod linearly increased from 5.53 to 7.50 due to increased phosphorus fertilization from 0 to 120 kg P_2O_5 ha^{-1}.

Sulfur (S) is one of the essential nutrients for plant growth and it accumulates 0.2 to 0.5% in plant tissue on dry matter basis. It is required in similar amount as that of phosphorus (Ali et al., 2008). Sulphur plays a vital role in improving vegetative structure for nutrient absorption, strong sink strength through development of reproductive structure and production of assimilates to fill economically important sink. Sulphur nutrition of bean and other plants

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Table 1. Description of common bean varieties used for the study.

Characteristics	Varieties		
	Angar	Ibado	Nasir
Altitude (masl)	1300-2000	1400-2250	1200-1900
Annual Rainfall (mm)	1000-1300	500-850	500-800
Planting date	Mid-Late June	Mid-June-Early July	Mid June-Early July
Days of 50 flowering	41-52	43-58	40-55
Days to 95% maturity	85-96	90-120	86-88
Growth habit	Bushy	Bushy	Bushy
Seed colour	Dark red	Red	Red
Yield in research site (t ha^{-1})	2.0 - 3.2	2-2.9	2-3.2
Year of release	2005	2003	2003

Source: MoARD (2003, 2005).

is important since its application not only increases growth rate but also improves the quality of the seed (Clarkson et al., 1989). Total number of nodules and active nodules significantly increased with application of S up to 20 kg S ha^{-1} (Ganeshamurthy and Readly, 2000). Formation of nodules was increased due to sulphur application in blackgram (*Phaseolus mungo*) and is involved in the formation of nitrogenase enzyme known to promote nitrogen fixation in legumes (Scherer et al., 2006).

Soil fertility mapping project in Ethiopia recently reported the deficiency of K, S, Zn, B and Cu in addition to N and P in major Ethiopian soils and thus recommend application of customized and balanced fertilizers (EthioSIS, 2013). To address these nutrient deficiencies, farmers in Guji zone have been using uniform blanket application of 100 kg DAP ha^{-1} (18 kg N and 46 kg P_2O_5 ha^{-1}) for all legumes including common bean to increase crop yields for about five decades and this did not consider soil fertility status and crop requirement. This emphasizes the importance of developing an alternative means to meet the demand of nutrient in plants by using blended NPS that contains S in addition to the commonly used N and P fertilizers. However, no study has been done on response of common bean (*P. vulgaris* L.) varieties to the rates of blended NPS fertilizer in Adola district, Southern Ethiopia.

Thus, the objectives of this study were to investigate the effect of blended NPS rates on growth, yield and yield components of common bean varieties and to identify economically feasible rates of blended NPS at Guji Zone, Southern Ethiopia.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Adola sub-site of Bore Agricultural Research Center (BOARC), Guji Zone, Oromia Regional State in Southern Ethiopia under rain-fed conditions during the 2016 cropping season (September-December). The site is located in Adola town in Dufa '*Kebele'* just on the west side of the main road to Negelle town. It is located at about 463 km south from Addis Ababa, capital city of the country. Geographically, the experimental site is situated at latitude of 55°36'31" North and longitude of 38°58'91"East at an altitude of 1721 masl.

The climatic condition of the area is a humid moisture condition, with a relatively shorter growing season. The area receives annual rainfall of 1084 mm with a bimodal pattern extending from April to November. The mean annual minimum and maximum temperature is 15.93 and 9.89°C, respectively. The type of the soil is red basaltic soil (Nitisols) and Orthic Aerosols ((Yazachew and Kasahun, 2011). The soil is clay in texture and moderately acidic with pH of around 5.88 (Table 3).

Experimental materials

Three common bean varieties, namely: Angar (medium-seeded); Ibado (large-seeded); and Nasir (medium seeded) were used (Table 1).

Variety Angar was released by Bako Agricultural Research Center in 2005. Ibado was released by Areka Agricultural Research Center in 2003 and Nasir by Melkasa Agricultural Research Center in 2003. Blended NPS (19% N, 38% P_2O_5, and 7% S) was used as sources of N, P and S, respectively, for the study.

Soil sampling and analysis

Pre-planting soil samples was taken randomly in a zigzag fashion from the experimental plots at the depth of 0 to 30 cm before planting. Twenty soil core samples were taken by an auger from the whole experimental field and combined to form a composited sample in a bucket. Then, the collected samples were air-dried at room temperature under shade and ground to pass through a 2 mm sieve for laboratory analysis of soil pH, and available phosphorus. Small quantity of this 2 mm sieved soil material allowed to passed through 0.2 mm sieve for soil organic carbon (OC) and total nitrogen. The composite soil samples were analyzed for selected physicochemical properties mainly textural analysis (sand silt and clay), soil pH, total nitrogen (N), available sulphur (S), organic carbon (OC), available phosphorus (P), cation exchange capacity (CEC) (c mol kg^{-1}), exchangeable potassium, magnesium and calcium using the appropriate laboratory procedures at Horticoop Ethiopia (Horticultural) PLC Soil and Water Analysis Laboratory.

Soil textural class was determined by Boycous Hydrometer

Table 2. Rate of fertilizer and their nutrient content (kg ha^{-1}) treatments for the experiment.

No.	Blended NPS Fertilizer rate (kg ha^{-1})	N	P_2O_5	S
1	0 kg NPS	0	0	0
2	50 kg NPS	9.5	19	3.5
3	100 kg NPS	19	38	7
4	150 kg NPS	28.5	57	10.5
5	200 kg NPS	38	76	14
6	250 kg NPS	47.5	95	17.5

Table 3. Physico-chemical properties of the experimental site soil before planting.

Character	Value	Rating
A. Soil texture		-
Sand (%)	30	-
Silt (%)	12	-
Clay (%)	58	-
Textural class	-	Clay
B. Chemical analysis		
Soil pH	5.88	Moderately acidic
Organic carbon (%)	2.3	High
Total N (%)	0.19	Low
Available P (mg kg^{-1})	5.61	Very low
Available S (mg kg^{-1})	14.50	Low
CEC [meq/100 g soil)	14.9	Low

Method (Aderson and Ingram, 1993). Organic carbon (OC) was estimated by wet digestion method (Walkey and Black, 1934) and organic matter was calculated by multiplying the OC% by a factor of 1.724. Total nitrogen was analyzed by Kjeldhal method (Jackson, 1962). The soil pH was measured potentiometrically in 1:2.5 soil-water suspensions with standard glass electrode pH meter (Van Reeuwijk, 1992). Cation exchangeable capacity (CEC) was determined by leaching the soil with neutral 1N ammonium acetate (FAO, 2008). Available phosphorus was determined by the Olsen's method using a spectrophotometer (Olsen, 1954). Available sulfur (S) was measured using turbidimetric method (EthioSIS, 2014). Exchangeable potassium, magnesium, and calcium were determined by Melich-3 methods (Mehlich, 1984).

Treatments and experimental design

The treatments were factorial combinations of six blended NPS fertilizer rates (0, 50, 100,150, 200 and 250 kg ha^{-1}) (Table 2) and three varieties (Angar, Ibado and Nasir). The experiment was laid out as Randomized Complete Block Design (RCBD) and replicated three times per treatment in factorial combination. The gross plot size was 3.0 m × 2.8 m = 8.4 m^2. The spacing between blocks and plots was 1.0 and 0.6 m, respectively. Each plot had 7 rows spaced 40 cm apart. One outer most row on each side of a plot and three plants (30 cm) on each end of rows were considered as border. One row next to the border rows on any side was used for destructive sampling. Thus, the net pot size was (1.6 m × 2.4 m = 3.84 m^2) having four rows each row with 24 plants.

Experimental procedure and crop management

The experimental field was prepared by using oxen-drawn implements (local plough maresha) according to farmers' conventional farming practices. The field was ploughed three times. The first plough was at the end of May 2016, the second in mid-July and the third during the middle of August before planting the crop to fine tilth. The plots were leveled manually. All the varieties were sown on 1 October. The dried seeds were planted by hand at a specified spacing (40 × 10 cm^2) by placing two seeds per hill and later thinned to one plant per hill after emergence. All the required amount of blended NPS was applied in band during planting. Furthermore, all necessary cultural and agronomic practices were carried out uniformly for all plots as per the recommendation for the crop at all stages of growth and development. The crop was harvested manually using a sickle when 90% of the leaves and pods turned yellow on 12 December, and dried under the sun for 4 days before threshing. Threshing was done separately for each treatment manually.

Data collected

An effect of blended NPS rate was investigated by measuring data on phonology, growth, yield and yield component parameters. Data on phonological parameters were measured through visual observation as the number of days from sowing to when 50% of plants in a net plot had reached flowering and 90% physiological maturity. Data on growth and yield component parameters were taken in each plot from ten randomly selected plants at physiological maturity and at harvest time, respectively. For hundred seed weight and grain yield the whole plant from the net plot area was harvested and the yield per hectare was determined by converting the yield per plot (kg per plot) into kg per hectare

Statistical data analysis

All the measured parameters were subjected to analysis of variance (ANOVA) appropriate to factorial experiment in RCBD according to SAS software 9.1 versions. Significance difference (LSD) test at 5% probability level was used for mean comparison.

Economic analysis

Economic analysis was performed using partial budget analysis following the procedure described by CIMMYT (1988) in which prevailing market prices for inputs at planting and for outputs at harvesting were used. All costs and benefits were calculated on ha basis in Birr. The concepts used in the partial budget analysis were the mean grain yield of each treatment, the field price of common bean grain, and the gross field benefit (GFB) ha^{-1} (the product of field price and the mean yield for each treatment).

The net benefit (NB) was calculated as the difference between the gross benefit and the total cost. The average yield obtained from experimental plot was reduced by 10% to adjust with the expected farmers' yield by the same treatment. Prices of grain (Birr kg^{-1}) were obtained from local market for each variety: Ibado was 12 Birr kg^{-1} and Angar and Nasir were 8 Birr kg^{-1}, and total sale from 1 ha was computed using adjusted yield. Other costs such as cost of fertilizer (1400 Birr 100 kg^{-1} blended NPS) and its application cost (350 Birr ha^{-1}) were considered as the costs that vary for treatment to treatment.

RESULTS AND DISCUSSION

Physico-chemical properties of the experimental site soil

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, soil of the experimental site was found to be clay (Table 3). High clay content might indicate the better water and nutrient holding capacity of the soil of the experimental site.

According to the soil analysis test, the soil pH of the experimental site was 5.88 (Table 3). Thus, according to Landon's (1991) rating, the chemical reaction of the experimental site is moderately acidic. The available P level in the experimental site which is 5.61 mg kg^{-1} (Table 3) is very low according to the rating of EthioSIS (2014). This low available phosphorus could be due to fixation in such acidic soils.

The result of laboratory analysis showed that the total nitrogen percentage (0.19%) was low as per the rating of EthioSIS (2014). Cation exchange capacity is the capacity of the soil to hold and exchange cations. It provides buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. The result showed the CEC of the experimental soil to be 14.9 meq/100 g soils rated as moderate according to rating of Landon (1991). The total carbon content in the soil was 2.3% which was rated as high as per the classification of Hazelton and Murphy (2007). Thus, the OM content of the soil was optimum as rated by EthioSIS (2014). On the other hand, the available sulphur content in the soils has values of 14.50 mg kg^{-1} which was rated as low as per the classification of EthioSIS (2014).

Phenological and growth parameters of common bean

Days to flowering

Days to 50% flowering had significantly ($P<0.05$) influenced by interaction of blended NPS rate and varieties P rate, but the main effects of variety and blended NPS rate were found to be highly significant ($P <0.01$) on days to reach 50% flowering (Table 1). Significantly, the highest number of days (46.67 days) to reach flowering was recorded due to application of 200 kg ha^{-1} of blended NPS for variety Nasir and for variety Angar at NPS rate of 250 kg ha^{-1} while the earliest days to flowering (38.33 days) was recorded due to application of 50 kg ha^{-1} of blended NPS for variety Ibado (Table 4). Variety Ibado was found to be early maturing as compared to the other varieties across all NPS rates.

The result obtained from the current study revealed that the days to flowering were delayed with increment of application rate of blended NPS fertilizer which could be due to the delaying effect of nitrogen obtained from blended NPS fertilizer. This result was in line with the findings of Reta (2015) who reported that increasing the nitrogen rate from nil to 69 kg N ha^{-1} significantly prolonged the days to 50% flowering of linseed (*Linum usitatissimum* L). This might be due to the fact that excessive supply of N promotes luxuriant and succulent vegetative growth, dominating the reproductive phase. This result is corroborated by that of Ali and Raouf (2011) who reported that number of days from sowing to flowering increased significantly with increasing nitrogen application amount from 23 to 46 kg N ha^{-1} in chickpea.

However, Tesemma and Alemayehu (2015) reported that interaction of P with variety to be non-significant on common bean. This result is also in contrast to the finding of Nebret (2012) who reported non-significant interaction effects of nitrogen and sulphur on days to flowering of common bean.

Days to physiological maturity

Days to physiological maturity was highly significantly

Table 4. Mean number of days to flowering of common bean as affected by the interaction of variety and blended NPS fertilizer rates at Adola during 2016-2017 main season.

Variety	NPS rate (kg ha^{-1})						Mean
	0	50	100	150	200	250	
Angar	45.33^{abc}	45.33^{abc}	45.33^{abc}	45.33^{abc}	46.33^{ab}	46.67^{a}	45.72
Nasir	45.67^{abc}	45.00^{bc}	45.33^{abc}	45.67^{abc}	46.67^{a}	44.67^{c}	40.50
Ibado	41.67^{d}	38.33^{e}	39.67^{e}	39.67^{e}	42.00^{d}	42.00^{d}	45.50
Mean	44.22	42.89	43.44	43.56	45.00	44.33	-
LSD (0.05)	-	-	1.58	-	-	-	-
CV (%)	-	-	2.20	-	-	-	-

Means followed by the same letters are not significantly different as judged by LSD test at 5%. CV: Coefficient of variation.

Table 5. Mean number of days to physiological maturity of common bean as affected by the interaction of variety and blended NPS fertilizer rates at Adola during 2016-2017 main season.

Variety	NPS rate (kg ha^{-1})						Mean
	0	50	100	150	200	250	
Angar	96.00^{a-d}	93.33^{de}	98.00^{abc}	98.67^{ab}	94.00^{cde}	99.33^{a}	96.56
Nasir	96.33^{a-d}	95.67^{a-d}	94.00^{cde}	95.33^{a-d}	98.00^{abc}	93.33^{de}	95.44
Ibado	91.33^{e}	95.67^{a-d}	95.00^{b-e}	97.33^{a-d}	98.67^{ab}	98.00^{abc}	96.00
Mean	94.56	94.89	95.67	97.11	96.89	96.89	-
LSD (0.05)	-	-	3.48	-	-	-	-
CV (%)	-	-	2.2	-	-	-	-

Means followed by the same letters are not significantly different as judged by LSD test at 5%. CV: Coefficient of variation.

(p<0.01) influenced by interaction of varieties with blended NPS application rate but not significantly influenced by main effect of variety (Table 5). Physiological maturity of common bean was delayed with increase in blended NPS rate. The highest number of days required to physiological maturity (99.33 days) was recorded for the highest rate of blended NPS application rate (250 kg ha^{-1}) for variety Angar while the shortest days to physiological maturity (91.33 days) was recorded without the NPS application for variety Ibado (Table 5).

The results indicated that days to maturity in most cases were prolonged in response to the increased levels of blended NPS which can be attributed to the role of nitrogen in the NPS that promoted vegetative growth. This is in line with the results of Gupta and Sharma (2000) who reported that nitrogen promoted vegetative and lush growth thereby delaying plant maturity of onion. This indicates that the nutrients taken up by plant roots from the soil were used for increased cell division and synthesis of carbohydrate, which will predominantly be partitioned to the vegetative sink of the plants, resulting in plants with a luxurious foliage growth (Marschner, 2012).

This result is further corroborated with the finding of Huerta et al. (1997) who reported delayed physiological maturity due to nitrogen fertilization of up to 80 kg ha^{-1} in common bean. In contrast, Nebret (2012) reported that the application of sulphur (0 to 60 kg ha^{-1}) had no significant effect on days to maturity on common bean.

Plant height

The analysis of variance showed highly significant (P<0.01) effect of varieties, blended NPS rates and their interaction on plant height at physiological maturity (Table 6). Variety Nasir showed the highest plant height (99.72 cm) with application of 150 kg NPS ha^{-1} whereas the shortest plants (31.08 cm) were seen for Ibado without NPS fertilizer (Table 6).

Plant height was significantly increased from 31.08 cm for variety Ibado with 0 kg NPS ha^{-1} to 99.72 cm for variety Nasir at 150 kg NPS ha^{-1}. The increase in plant height in response to the increased blended NPS application rate might be due to the maximum vegetative growth of the plants under higher N, P and S availability. Nitrogen helps in chlorophyll formation, phosphorus establishes strong root system and sulphur enhanced the formation of chlorophyll and encouraged vegetative growth (Halvin et al., 2003). In conformity with the current result, Moniruzzaman et al. (2008) found that plant height was significantly increased up to 160 kg N ha^{-1}. Also application of phosphorus at the highest level (120 kg

Table 6. Means of plant height (cm) of common bean as affected by the interaction of variety and blended NPS fertilizer rates at Adola during 2016-2017 main season.

Variety	NPS rate (kg ha^{-1})						Mean
	0	50	100	150	200	250	
Angar	56.30^{ef}	83.44^{bc}	75.12^{cd}	85.58^{abc}	89.71^{abc}	91.97^{ab}	80.35
Nasir	63.13^{de}	57.17^{efg}	88.94^{abc}	99.72^{a}	90.69^{abc}	90.52^{abc}	81.69
Ibado	31.08^{i}	38.57^{hi}	43.33^{ghi}	45.6f^{gh}	48.96^{fgh}	48.55^{fgh}	42.83
Mean	50.17	59.73	69.13	77.27	76.45	77.01	-
LSD (0.05)	-	-	13.69	-	-	-	-
CV (%)	-	-	12.00	-	-	-	-

Means followed by the same letters are not significantly different as judged by LSD test at 5%. CV: Coefficient of variation.

Table 7. Mean numbers of primary branches, total and effective nodules per plant of common bean as influenced by the main effects of variety and blended NPS fertilizer rates at Adola during 2016-2017 main cropping season.

Treatment	Number of primary branches per plant	Number of total nodules per plant	Number of effective nodule per plant
Variety			
Angar	2.55^{a}	63.01	32.88
Ibado	2.28^{ab}	68.09	32.56
Nasir	2.05^{b}	61.83	30.38
LSD (0.05)	0.28	NS	NS
NSP rate (kg ha^{-1})			
0	1.56^{d}	40.94^{c}	27.43^{c}
50	2.05^{c}	61.16^{b}	30.87^{bc}
100	2.25^{ab}	58.52^{b}	31.87^{b}
150	2.55^{a}	60.36^{b}	32.51^{ab}
200	2.58^{a}	80.47^{a}	35.54^{ab}
250	2.77^{a}	64.41^{b}	33.41^{ab}
LSD (0.05)	0.38	12.0	4.07
CV (%)	17.7	20.5	14.2

Means in the same column and treatment category followed by the same letters are not significantly different as judged by LSD at 5% level of significance. NS: Non-significant.

P_2O_5 ha^{-1}) increased plant height. The promotion effect of high P level on plant height of maize may be due to better development of the root system and nutrient absorption (Hussain et al., 2006). The increase in plant height might also be ascribed to better root formation due to sulphur, which in turn activated higher absorption of N, P, K and sulphur from soil and improved metabolic activity inside the plant. Similar results were r reported by Jawahar et al. (2017) where sulphur level of 40 kg ha^{-1} was found to increase the plant height, LAI, chlorophyll content and number of branches per plant of blackgram (*Vigna mungo).* In contrast to this result, Fisseha and Yayis (2015) reported no significant main and interaction effect of N and P levels on plant height of common bean. Similarly, Meseret and Amin (2014) also reported that P rate at 0 to 40 kg ha^{-1} had no significant effect on plant height in common bean.

Number of primary branches

The analysis of variance showed highly significant (P<0.01) main effect of variety and blended NPS fertilizer application rates on number of primary branches, while their interaction did not significantly influence the number of primary branches (Table 7). Variety Angar recorded the highest number of primary branches per plant (2.55) while the lowest number of primary branches (2.05) was recorded for variety Ibado. This difference might be due to genetic differences in production of number of primary branches among the varieties. This difference might be due to genetic differences in production of number of primary branches among the varieties. The result was consistent with the finding of Addisu (2013) who reported that number of primary and secondary branches was highly significantly different among the chickpea varieties at Debre-Zeit with the Desi variety Natoli had significantly higher number of primary (3.21) and secondary branches (6.73) than the Kabuli variety Acos Dubie with 2.26 and 3.49, respectively.

The blended NPS rate had highly significant ($P<0.01$) effect on number of primary branches per plant. Increasing rates of blended NPS fertilizer from 0 to 250 kg ha^{-1} showed progressive increase in the number of primary branches per plant (Table 7). Thus, the highest number of primary branches per plant (2.77) was recorded at the highest rate of application of (250 kg NPS ha^{-1}) and it was statistically at par with NPS rates of 200, 150, and 100 kg NPS ha^{-1}, while the lowest number of primary branches per plant (1.56) was recorded for the control. The increase in number of primary 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. In line with this result, Shubhashree (2007) reported significantly higher number of branches per plant of common bean with 75 kg P_2O_5 ha^{-1} over the control.

The increment in number of branches with 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 (Tesfaye et al., 2007). In line with this result, Moniruzzaman et al. (2008) reported that the number of branches per plant increased significantly with the increase of N up to 120 kg ha^{-1} on common bean. The increased primary branches observed under blended fertilizer might be attributed to readily available form of S that enhanced uptake of nutrients even 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 40 kg S ha^{-1} recorded highest number of branches per plant (7.75) in blackgram (*V. mungo*).

Total number of nodules

The main effect of variety and interaction of variety with blended NPS rate had no significant effect on total number of nodules, but the main effect of blended NPS rate had highly significant ($P<0.01$) effect on total number of nodules (Table 7). Thus, the highest number of total nodules per plant (80.47) was obtained from the application of blended NPS rate of 200 kg NPS ha^{-1} while the lowest number of total nodules (40.94) was recorded from nil application of blended NPS fertilizer.

Application of blended NPS fertilizers significantly increased the number of nodules up to 200 kg ha^{-1} which might be due to better root development with increasing levels of these nutrients. But the total nodule number decreased at 250 kg NPS ha^{-1}. The decrease in number of nodules per plant at highest rates of blended NPS might be due to increasing nitrogen application rates and thereby attributed to the negative effect of fertilizer-N on nodule formation and growth at the high rates. This result is in line with that of Chen et al. (1992) and Starling et al. (1998) who reported that high rate of nitrogen (56.58 kg N ha^{-1}), resulted in reduction of nodule number and nodule weight in soya bean.

The increase in number of total nodules at 200 kg NPS ha^{-1} might also be due to phosphorus which is needed in relatively large amounts by legumes for growth and to promote leaf area, biomass, yield, nodule number and nodule mass in different legumes. Consistent with this result, Amare et al. (2014) who reported that nodule number was significantly increased with increasing levels of phosphorus with the lowest (12.89) and the highest (31.85) numbers in common bean obtained from the control treatment and application of 20 kg P_2O_5 ha^{-1}, respectively. Yadav (2011) reported the synergistic effect of phosphorus and sulphur on number and weight of nodules per plant with the maximum number of nodules plant per plant was recorded at the highest level of phosphorus (40 kg P_2O_5 ha^{-1}) along with sulphur (20 kg S ha^{-1}) on clusterbean (*Cyamopsis tetrogonoloba*).

Number of effective nodules

Blended NPS fertilizer application had significant ($P<0.05$) effect on number of effective nodules per plant, but main effect of variety and interaction of variety with blended NPS had no significant effect (Table 7).

Number of effective nodules per plant increased with the increasing rate of blended NPS application rate. Increasing of blended NPS fertilizer from 0 to 200 kg ha^{-1} enhanced the number of effective nodules per plant (Table 7). The highest number of effective nodules per plant (35.54) was recorded at the rate of 200 kg NPS ha^{-1} while the lowest number of effective nodules per plant (27.43) was recorded at the rate of 0 kg NPS ha^{-1}. The increased number of effective nodules with the increase in NPS application up to 200 kg NPS ha^{-1} might be due to the vital role of phosphorus in increasing the number and size of nodule and the amount of nitrogen assimilated per unit of nodules. In agreement with this result, Bashir et al. (2011) reported that phosphorus plays a vital role in increasing plant tip and root growth, decreasing the time needed for developing nodules to become active (effective) for the benefit to the host legume. Similarly, Tsai et al. (1993) reported that application of nitrogen in the range of 22 to 33 kg ha^{-1} enhanced both nodulation and seed yield of French bean (*P. vulgaris*).

The increased number of effective nodules with the application of NPS over the control might also be from increased sulphur application which might be due to the high dose of sulphur and increasing its availability along with other major nutrients. This result is in line with the

Table 8. Mean stand count per plot at harvest of common bean as influenced by interaction of variety and blended NPS fertilizer rates at Adola during 2016-2017 main cropping season.

Variety	NPS rate (kg ha^{-1})						Mean
	0	50	100	150	200	250	
Angar	88^{ab}	92.67^{a}	79.33^{cdef}	79.00^{c-f}	84.00^{bc}	72.33^{g}	82.56
Ibado	77.33^{efg}	89.33^{ab}	84.00^{bc}	73.33^{fg}	83.67^{bcd}	76.67^{efg}	80.72
Nasir	81.33^{cde}	88.67^{ab}	83.00^{bcde}	83.67^{bcd}	80.67^{cde}	83.67^{bcd}	83.50
Mean	82.22	90.22	82.11	78.67	80.67	83.67	-
LSD (0.05)	-	-	5.62	-	-	-	-
CV (%)	-	-	4.10	-	-	-	-

Means in rows and columns followed by the same letter are not significantly different judged by LSD test at 5% level of significance. CV: Coefficient of variation.

reported significant increase in the number of active nodules of soybean with the application of sulphur up to 20 kg ha^{-1}, at which point nodule production reached a plateau and did not increase further. Scherer et al. (2006) also reported that formation of nodule in blackgram was increased in response to sulphur application which is involved in the formation of nitrogenous enzyme known to promote nitrogen fixation in legumes.

Yield and yield components

Stand count at harvest

The main effect of NPS and the interaction of varieties and blended NPS rate had highly significant (P<0.01) effect on stand count at harvest. But varieties had no significant effect on stand count at harvest (Table 8). The highest stand count per plot at harvest (92.67) was obtained at applied blended NPS rate of 50 kg ha^{-1} for variety Angar, whereas the lowest stand count at harvest (72.33) was recorded for variety Angar at the highest rate of fertilizer application (250 kg NPS ha^{-1}). The reduction in final crop stand count at the highest NPS rate could be due to sufficient supply of nutrients which in turn favored vigorous vegetative growth, thereby resulting in higher intra-plant competition and crowding out of weaker plants by the vigorous ones.

Number of pods per plant

Highly significant (P<0.01) effects of blended NPS fertilizer application rate and varieties were observed on the number of total pods per plant while the interaction effect did not significantly influence the number of total pods (Table 9). The highest number of total pods per plant (18.52) was recorded at application rate of 250 kg NPS ha^{-1} whereas the lowest number of total pods (8.7) was obtained from the unfertilized plot (Table 9).

The increase in number of pods per plant with the increased NPS rates might possibly be due to adequate availability of N, P and S which might have facilitated the production of primary branches and plant height which might in turn have contributed for the production of higher number of total pods. In conformity with this result, Moniruzzaman et al. (2008) reported significant effect of N fertilizers on pod production per plant of French bean with the maximum number of pods per plant (25.49) obtained at 120-120-60-20-4-1 kg of N-P_2O_5-K_2O-S-Zn-B. The increment of number of pods per plant due to application of P fertilizer confirms the fact that P fertilizer promotes the formation of nodes and pods in legumes (Buttery, 1969). In agreement with this result, Dereje et al. (2015) also found that the number of pods per plant of common bean significantly increased in response to increasing rate of phosphorus up-to the highest rate (92 kg P_2O_5 ha^{-1}). On the other hand, Jawahar et al. (2017) reported that application of 40 kg S ha^{-1} recorded the highest number of seeds per pod of blackgram. This could be due to the increasing levels of sulphur application enhanced its availability to the crop and increase photosynthetic activity of crop

In this study, varieties also exhibited highly significant (P<0.01) difference in the number of pods per plant. Variety Angar produced the highest number of pods per plant (15.3) while the lowest number of pods per plant (10.24) was recorded for variety Ibado (Table 9). The variation in the number of pods per plant among the varieties might be related to the genotypic variation of the cultivars in producing pods. In line with the results of the present study, different authors reported significant variations in the number of pods per plant for common bean varieties (Fageria et al., 2010; Mourice and Tryphone, 2012).

Number of seeds per pod

The interaction effect of variety and blended NPS application rates and main effects of blended NPS application rates were not significant, but the main effects of varieties had highly significant (P<0.01) effect on the number of seeds per pod (Table 9). The highest number

Table 9. Mean number of pods per plant and seeds per pod of common bean as influenced by varieties and blended NPS fertilizer rates at Adola during 2016-2017 main season.

Treatment	Number of pods per plant	Number of seeds per pod
Variety		
Angar	15.30[a]	5.35[a]
Ibado	10.24[c]	5.33[a]
Nasir	12.63[ab]	3.18[b]
LSD (0.05)	2.21	0.22
NSP rate (kg ha^{-1})		
0	8.70[c]	4.40
50	11.82[bc]	4.54
100	12.6[ab]	4.73
150	12.51[ab]	4.54
200	14.91[ab]	4.76
250	18.52[a]	4.75
LSD (0.05)	3.14	NS
CV (%)	25.1	6.2

Means in columns and rows followed by the same letter are not significantly different judged by LSD test at 5% level of significance. ns: Non-significant, CV: coefficient of variation.

Table 10. Means of hundred seed weight (g) of common bean as influenced by interaction of variety and blended NPS fertilizer rates at Adola during 2016-2017 main season.

Variety	NPS rate (kg ha^{-1})						Mean
	0	50	100	150	200	250	
Angar	23.33[e]	23.33[e]	38.33[c]	20.00[e]	21.67[e]	42.33[bc]	28.17
Ibado	38.33[c]	40.00[c]	38.33[c]	38.33[c]	54.33[a]	46.67[b]	42.67
Nasir	21.67[e]	20.00[e]	20.00[e]	20.00[e]	31.67[d]	30.00[d]	23.89
Mean	27.78	27.78	32.22	26.11	35.89	39.67	-
LSD (0.05)	-	-	5.58	-	-	-	-
CV (%)	-	-	10.6	-	-	-	-

Means in columns and rows followed by the same letters are not significantly different as judged by LSD test at 5% level of significance. CV: Coefficient of variation.

of seeds per pod (5.35) was recorded for variety Nasir followed by Angar (5.33) whereas the least number of seeds per pod (3.18) was recorded for variety Ibado (Table 9). This indicates that the trait is mainly controlled by genetic factors than the management. Consistent with the results of this study, Mourice and Tryphonne (2012) observed significant variations in number of seeds per pod among common bean genotypes. The variation in number of seeds per pod could be attributed to the variation in the size of seeds of the cultivars where variety Ibado with the highest seed size produced lower number of seeds per pod. In agreement with this result, Fageria and Santos (2008) also reported that the number of seeds per pod of different common bean genotypes varied in the range of 3.1 to 6 and attributed the difference due to the genetic variation of cultivars. However, the result of the present study was in contrast with the findings of Shubhashree (2007) who reported that the number of seeds per pod of French bean increased significantly with the levels of phosphorus added.

Hundred seed weight

Hundred seed weight was highly significantly ($p<0.01$) influenced by varieties, blended NPS rate and their interactions interaction (Table 10). Variety Ibado with application of 200 kg blended NPS ha^{-1} fertilizer scored significantly the highest hundred seed weight (54.33 g) while the lowest hundred seed weight (20 g) was for variety Nasir with 100 kg blended NPS ha^{-1} application rate (Table 10). This might be because nutrient use efficiency by crop was enhanced at optimum level of N, P and S since grain weight indicates the amount of

Table 11. Means of above-ground dry biomass yield (kg ha^{-1}) of common bean as influenced by interaction of variety and blended NPS fertilizer rates at Adola during 2016-2017 main season.

Variety	NPS rate (kg ha^{-1})						Mean
	0	50	100	150	200	250	
Angar	5794^{def}	5178e^{f}	9135^{ab}	5798^{def}	6191^{c-f}	10278^{a}	7062.33
Ibado	4129^{f}	4936e^{f}	5724^{def}	6527^{b-f}	8802^{abc}	7329^{b-e}	6241.17
Nasir	4045^{f}	6443^{b-f}	6640^{b-f}	5782^{def}	8073^{a-d}	9073^{ab}	6676
Mean	4656	5519	7166.33	6035.67	7688.67	8893.33	-
LSD (0.05)	-	-	2421.3	-	-	-	-
CV (%)	-	-	21.9	-	-	-	-

Means in columns and rows followed by the same letters are not significantly different as judged by LSD test at 5% level of significance. CV: Coefficient of variation.

resource utilized during critical growth periods. The increase in 100 seed weight with fertilizer application is in agreement with the finding of Shamim and Naimat (1987) who related the increment in 100-seed weight to the influence of cell division, phosphorus content in the seeds as well as the formation of fat and albumin. The increase in hundred seed weight as a result of increased P application might be attributed to important roles the nutrient plays in regenerative growth of the crop (Zafar et al., 2013), leading to increased seed size (Fageria*,* 2009), which in turn may improve hundred seed weight. Similarly, Amare et al. (2014) observed significant increase in thousand seed weights of common bean as a result of phosphorus application up to 40 kg ha^{-1}. In contrast to the results of this study, Fisseha and Yayis (2015) reported that the different levels of phosphorus (46, 69 and 92 kg P_2O_5 ha^{-1}) fertilizer used had not resulted in significant difference in 100 seed weight of common bean. Variation in hundred seed weight might have occurred due to the presence of difference in seed size among the common bean varieties as hundred seed weight increases with increase in the seed size. In line with this result, Tanaka and Fujita (1979) stated that the number of seeds per pod and weights of hundred seeds were strongly controlled genetically in field bean (*Pisum sativim*). The higher 100 seed weight for variety Ibado is associated with the size of the seed in accordance with Hawtin et al. (1980) who explained that the larger the seed, the higher its seed weight.

Above-ground dry biomass yield

The above-ground dry biomass yield was significantly (P<0.01) affected by the NPS fertilizer application and the interactions of fertilizer application with variety, however, the main effect of varieties had no significant effect on biomass yield (Table 11). The result generally showed an increase in biomass production with increase in the rate of blended NPS among the bean varieties. The highest recorded due to the application of highest rate of NPS fertilizer (250 kg NPS ha^{-1}) for variety Angar followed by variety Angar at 100 kg NPS ha^{-1}, whereas the lowest (4045 kg ha^{-1}) biomass yield was obtained for variety Nasir under the control NPS rate (Table 11). The increase in biomass yield of cultivars across blended NPS rates could be attributed to the fact that the enhanced availability of N significantly increased plant height, number of pods per plant and to the overall vegetative growth of the plants that contributed to higher aboveground dry biomass yield. This result was in line with that of Veeresh (2003) who reported that total dry matter production per plant increased significantly from 12.0 to 16.03 g due to increased nitrogen application from 40 to 120 kg N ha^{-1} on French bean (*P. vulgaris*).

The increment in dry matter yield with application of blended NPS fertilizer might also be due to the adequate supply of P from the NPS that could be attributed to an increase in number of branches per plant, which increased photosynthetic area and the number of pods per plant. The significant increase in the aboveground dry biomass yield in response to increasing rate of phosphorus application proves that the soil of the study area is in fact deficient in available soil P and requires external P fertilizer application for enhancing the yield of the crop. This result was in conformity with the findings of Getachew and Angaw (2006) who reported a significant linear response of above-ground dry biomass yield to phosphorus application in faba bean on acidic Nitisols. In contrast with this result, Nebret (2012) reported that application of sulphur up to 60 kg S ha^{-1} and interaction of nitrogen with sulphur did not result in significant effect on above-ground dry biomass of common bean.

Seed yield

Seed yield was significantly (P<0.05) affected by the above-ground dry biomass yield (10278 kg ha $^{-1}$) was main effect of variety and highly significantly (P<0.01) affected due to main effects of blended NPS fertilizer rate and the interaction of varieties with fertilizer combination (Table 12). The highest grain yield was recorded for variety Angar (3260 kg ha^{-1}) at 250 kg NPS ha^{-1} which

Table 12. Means of seed yield (kg ha^{-1}) of common bean as influenced by interaction of variety and blended NPS fertilizer rates at Adola during 2016-2017 main season.

Variety	NPS rate (kg ha^{-1})						Mean
	0	50	100	150	200	250	
Angar	2485[cde]	2360[e]	2582[b-e]	3044a[bc]	2558[b-e]	3260[a]	2715
Ibado	1700[g]	2249[ef]	2389[de]	2521[b-e]	3053[abc]	3079[ab]	2499
Nasir	1763[fg]	2500[b-e]	2747[a-e]	2250[ef]	2956[a-d]	2505[b-e]	2453
Mean	1983	2370	2573	2605	2856	2948	-
LSD (0.05)	-	-	-	497.4	-	-	-
CV (%)	-	-	-	11.7	-	-	-

Means within columns and rows followed by the same letter are not significantly different as judged by LSD test at 5% level of significance. CV: Coefficient of Variation.

was followed by Nasir (3079 kg ha^{-1}) at similar rate of blended NPS level while the lowest yield (1700 kg ha^{-1}) was observed for variety Ibado at control fertilizer treatment (Table 12).

Differences in seed yield among the common bean varieties might be related to the genotypic variations in P use efficiency. Hence, the cultivars which produced higher grain yield might have either better ability to absorb the applied P from the soil solution or translocate and use the absorbed P for grain formation than the low yielding cultivar. In agreement with the results of this study, Gobeze and Legese (2015) and Mource and Tryphone (2012) observed significant variations in grain yield for common bean due to genotypic variations for P use efficiency which may arise from variation in P acquisition and translocation and use of absorbed P for grain formation in common bean. The result might be attributed to the fact that applying NPS fertilizer increases crop growth and yield on soils which are naturally low in NPS and in soils that have been depleted (Mullins, 2001). Similar results were reported by Gebre-Egziabher et al. (2014) that P application at the rate of 46 kg P_2O_5 ha^{-1} gave higher number of pods per plant and yield as compared to unfertilized plots in common bean. In line with this result, application of S with or without P recorded significantly higher seed yield up to 40 kg S ha^{-1} on chickpea (Shivakumar, 2001) and on blackgram (Jawahar et al., 2017). It might also be due to increased levels of S, its availability along with major nutrients and higher uptake of crop and influencing growth and yield components of the crop, which ultimately lead to effective, assimilate partitioning of photosynthates from source to sink in post-flowering stage and resulted in highest seed yield.

Differences in seed yield among the common bean cultivars might also be related to their response to applied N. In conformity to this result, Dwivedi et al. (1994) found increased yield of common bean due to increasing levels of nitrogen up to 100 kg ha^{-1} with the difference between 80 and 100 kg N ha^{-1} being not significant. Boroomanndan et al. (2009) also reported that seed yield of soybean increased significantly at 40 kg N ha^{-1} as compared to the control treatment. However, application of 80 kg N ha^{-1} decreased seed yield, indicating that there is a limit to the maximum level of nitrogen to be supplied to avoid its detrimental effect on the plant.

Harvest index

Harvest index was highly significantly ($P < 0.01$) affected by the interaction of variety with blended NPS rate (Table 13). The highest harvest index (0.53) and lowest harvest index (0.28) were recorded for variety Angar with application of blended NPS at 150 kg ha^{-1} and for Nasir at 250 kg ha^{-1}, respectively (Table 13). This might be that the higher NPS fertilizers rate had high influence on vegetative growth than nutrient translocation from plant biomass to seed. In line with this result, Singh and Kumar (1996) reported the highest harvest index of lentil was obtained when 45 kg P ha^{-1} and 30 kg S ha^{-1} were applied. The increment in harvest index with rates of fertilizer is in agreement with the findings of Dhanjal et al. (2001) who also reported improvement in harvest index values of 31.60, 31.99 and 33.86% due to increasing N level zero to 60 and 120 kg N ha^{-1}, respectively. However, Gifole et al. (2011) reported no significant response of harvest index of common bean to P application.

Economic analysis

The agronomic data upon which the recommendations are based must be relevant to the farmers' own agro-ecological conditions and the evaluation of those data must be consistent with the farmers' goals and socio-economic circumstances (CIMMYT, 1988).

The net benefit was computed due to common bean varieties, application of blended NPS fertilizer and interaction of varieties with application of blended NPS fertilizer. The economic analysis revealed that the highest net benefit (29825 Birr ha^{-1}) was obtained from combina-

Table 13. Means harvest index of common bean as influenced by interaction of variety and blended NPS fertilizer rates at Adola during 2016-2017 main season.

Variety	NPS rate (g ha^{-1})						Mean
	0	50	100	150	200	250	
Angar	0.43^{ab}	0.46^{ab}	0.28^{d}	0.53^{a}	0.41^{ab}	0.32^{d}	0.41
Ibado	0.41^{ab}	0.46^{ab}	0.42^{ab}	0.39^{abc}	0.35^{cd}	0.41^{ab}	0.41
Nasir	0.42^{ab}	0.39^{abc}	0.41^{ab}	0.39^{abc}	0.37^{cd}	0.28^{d}	0.38
Mean	0.42	0.44	0.37	0.44	0.38	0.34	-
LSD (0.05)	-	-	0.05	-	-	-	-
CV (%)	-	-	7.30	-	-	-	-

Means within columns and rows followed by the same letter are not significantly different as judged by LSD at 5% level of significance. CV: Coefficient of variation

Table 14. Result of economic analysis for response of common bean varieties to rates of blended NPS fertilizer rates at Adola 2016-2017 main season.

Treatment	Adjusted yield (kg ha^{-1})	NPS cost (Birr ha^{-1})	NPS application cost (Birr ha^{-1})	Total cost (Birr ha^{-1})	Total revenue (Birr ha^{-1})	Net benefit (Birr ha^{-1})
Angar+0	2235.4	0	0	0	17883	17883
Ibado+0	1529.8	0	0	0	18358	18358
Nasir+0	1586.5	0	0	0	12692	12692
Angar+50	2123.6	700	350	1050	16989	15939
Ibado+50	2024.4	700	350	1050	24293	23243
Nasir+50	2250.1	700	350	1050	18001	16951
Angar+100	2324.0	1400	350	1750	18592	16842
Ibado+100	2150.3	1400	350	1750	25804	24054
Nasir+100	2471.9	1400	350	1750	19775	18025
Angar+150	2739.8	2100	350	2450	21918	19468
Ibado+150	2268.8	2100	350	2450	27226	24776
Nasir+150	2024.8	2100	350	2450	16198	13748
Angar+200	2301.9	2800	350	3150	18415	15265
Ibado+200	2747.9	2800	350	3150	32975	29825
Nasir+200	2660.3	2800	350	3150	21282	18132
Angar+250	2934.2	3500	350	3850	23474	19624
Ibado+250	2771.5	3500	350	3850	33258	29408
Nasir+250	2254.9	3500	350	3850	18039	14189

NPS cost=1400 Birr/100 kg, NPS application cost=350 Birr ha^{-1}, common bean grain price of Angar and Nasir = 8, Ibado=12 Birr kg^{-1}.

tion of variety Ibado with application of 200 kg NPS ha^{-1} while the lowest net benefit (12692 Birr ha^{-1}) was obtained from variety Nasir with no fertilizer application (Table 14).

Therefore, production of Ibado variety with the application of 200 kg NPS ha^{-1} was the most productive variety for economical production as compared to Angar and Nasir varieties and can be recommended for the study area. Dereje et al. (2015) reported that planting of the cultivar Nasir produced the highest net benefit (15903.1 Birr ha^{-1}) with acceptable marginal rate of return (3040%) compared to other cultivars at Areka. Fisseha and Yayis (2015) also reported net benefit of 21,070 ETB ha^{-1} with marginal rate of return of 80% by the application of 69 kg P_2O_5 ha^{-1} at Areka.

Conclusion

Response of common bean (*P. vulgaris* L.) varieties to rates of blended NPS fertilizer were investigated on Nitisols and Orthic Aerosols soils of Guji Zone, Southern Ethiopia. It was conducted during the main 2016 to 2017 cropping season with the objective to investigate the effect of blended NPS rates on growth, yield and yield components of common bean varieties and to identify economically feasible rates of blended NPS at Guji Zone, Southern Ethiopia.

The result showed the main effects of NPS rate variety and their interaction had a significant effect on some growth and yield component parameters. The highest level of NPS rate (200 to 250 kg ha^{-1}) resulted in higher values of number of primary branches per plant, number of total nodules, number of effective nodules and total number of pods, number of total pods per plant, highest number of total nodules and effective nodules. Varieties exhibited variation on number of pods per plant, number of primary branches and number of seeds per pod. Variety Angar gave the highest number of primary branches per plant and number of pods per plant, whereas the highest number of seeds per pod was recorded for variety Nasir.

However, the interaction of variety and blended NPS had significant effect on almost all parameters except on the number of total and effective nodules per plant, number of primary branches per plant and number of pods per plant. The highest number of days to flowering and days to physiological maturity were recorded due to application of 200 and 250 kg ha^{-1} of blended NPS, respectively for variety Nasir. Variety Nasir gave the highest plant height with application of 150 kg NPS ha^{-1} whereas variety Ibado with application of rate of 200 kg blended NPS ha^{-1} had the highest hundred seed weight. The highest above-ground dry biomass yield was recorded due to the application of highest rate of fertilizer for variety Angar. The highest grain yieldwas recorded for variety Angar at 250 kg NPS ha^{-1} whereas the highest harvest index was recorded by variety Angar with application of blended NPS of 150 kg ha^{-1}.

Based on the partial budget analysis, the highest net benefit (29825 Birr ha^{-1}) was obtained from combination of variety Ibado with application of 200 kg NPS ha^{-1}, whereas the lowest was from variety Nasir (12692 Birr ha^{-1}) with no fertilizer application.

Thus, it can be concluded that application of 200 kg ha^{-1} with variety Ibado was found to be superior and can be used for common bean production in mid-land of Adola district, Southern Oromia.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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