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Performance of Common Bean (*Phaseolus vulgaris L.*) Varieties to variable Rates of NPS Fertilizer at Rifent, East Wollega Zone, Western Ethiopia

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Abstract

Common beans are one of the most important economic crops grown in Ethiopia. However, its yield is still very low. Improper use of NPS fertilizer level and the use of low-yielding local varieties are among the low production barriers for common beans. Therefore, a field experiment was conducted at Rifent kebele in Haro Limu District, East Wellega Zone of Oromia National Regional State during the 2020 rainy season to evaluate influence of variable rates of NPS fertilizer on performance of common bean varieties. The trial consisted of 15 treatments as a factorial combination of three haricot bean varieties (Dandessu, SER-119 and SER-125) and five levels of combined NPS fertilizers (0, 50, 100, 150, and 200 kg ha^{-1}) arranged with RCBD using three replication. The research result indicate that up to 50% of flowering days, up to 90% days of ripening, plant length, base branch number, total nodules, number of active nodules, seed per pod, and seed yield of bean varieties were strongly influenced by varieties, NPS fertilizer levels and their interactions. The highest values for days to 50% flowering, plant height, total nodules on each plant, total pods per plant was recorded from interaction of variety SER-119 and 200 kg ha-1NPS application while the lowest values noted from combination of variety Dandessu with nil application of NPS fertilizer rates. Similarly, the maximum primary branch per plant (2.86), seeds per pod (7.40) and seed yield (2712 kg ha^{-1}) was achieved from interaction of variety SER-119 with 150 kg ha^{-1} whereas the lowest values for primary branch per plant (1.63), seeds per pod (74.83) and seed yield (1183.63 kg ha^{-1} were recorded from combination of Dandessu variety and zero NPS application rates. Therefore, based on the yield performance, variety SER-119 with the combination of 150 kg ha^{-1} of NPS fertilizer application rates could be advised for the farmers in Rifent kebele and other areas having similar agro ecology with the study area. But the research is conducted at the same time of planting in the same area; hence the repetition of the study at different times of the year should be needed for conclusive recommendation.

Keywords: NPS rates; Seed yield; Common bean; Variety and growth traits

Introduction

The common bean (*Phaseolus vulgaris* L.) is an annual herbaceous plant grown independently in ancient Mesoamerica and the Andes, and is now grown as any other pulses. It is one of the most important legume crops grown on all continents of the world with over 23 million tons of Metric Tons (MT) production of which 7 million MT were produced in Latin America and Africa. Crops were grown in various parts of Ethiopia, especially in central, eastern, and southern parts of the country. In Ethiopia the common bean is ranked second next to the faba bean in terms of the area coverage among pulse crops and the whole grain area 0.74% (approximately 94,789.94 hectares) and 1.45% (approximately 186,293.55 hectares) was under the white haricot bean and the red haricot bean respectively [1].

Common beans are very popular with Ethiopian farmers because of their fast ripening properties that enable families to earn the necessary income to buy food and other household necessities when other crops are immature. Common beans are one of the largest food and financial crops in Ethiopia and have significant national economic value and also traditionally ensure food security in Ethiopia. Listed in third place as an exporter to Ethiopia, accounting for about 9.5% of total agricultural exports. It is often grown as a cash crop by small holder farmers [2].

Most Ethiopian bean producers are small holder farmers, and it is used as a staple food in many parts of the country when eaten in a variety of traditional foods. More than this; it is also important in providing fodder for livestock and contributes to improving soil fertility through nitrogen fixation in the atmosphere during planting.

Beans not only add variety to production systems in the fields of poor farmers but also contribute to the stability of farming systems in Ethiopia. It is a large grain legume used worldwide for its edible seeds and pods. In Ethiopia, it is one of the most important cash crops and a source of protein in many low and central regions. It contains starch, dietary fibers and is an excellent source of potassium, selenium, molybdenum, thiamine, vitamin B6 and folic acid. It is used as a variety of raw pods cooked or preserved as a vegetable and ripe seed cooked in "nifro" or boiled in a mixture of sorghum or maize and can be eaten "like" using a powder (MoARD) [3-7].

According to Wortmann et al. N and P deficiency is a major barrier to common bean production, resulting in a loss of 1.2 million tons of grain yield in Africa. Crop production using sulphur containing

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fertilizers increases the concentration of proteins rich in sulphur, cysteine and methionine. The total number of nodules and active nodules increased with an increase in Sulphur infusion up to 20 kg ha^{-1}. Increasing sulphur assimilation and nitrogen fixation are dependent on one another. Pod weights of beans can increase from the incorporation of sulphur-containing fertilizers. Girma also found that low levels of nitrogen and phosphorus in the soil, as well as acidic soil conditions, are important restraints in the production of common beans in many cropping areas of Ethiopia [8-12].

Fertilizer application at a recommended rate is important for high yields and grain quality. Fertilizer application is considered one of the most important factors in increasing crop yields in each area, however, the response to fertilizer type and application rate varies greatly by location, climate and soil type. Nitrogen deficiency occurs almost everywhere unless nitrogen is used as a fertilizer or compost. It has been reported that there has been an increase yield in responses to nitrogen fertilizer [13-17].

Phosphorus is the second most limiting nutrient after nitrogen in plant growth. Phosphorus deficiency is also a major barrier to legume growth in many soils. Haricot beans respond to phosphorus consumption and increase production in proportion to the increase in phosphorus fertilizers. Numerous studies on legume have shown that the presence of phosphorus in the soil is a major limitation of normal tropical bean production. Fertilizer application in haricot bean production may vary depending on the production area and soil fertility. According to the regional manual for Agricultural Bureau expansion program, Alemitu, Setegne and Legesse, recommended fertilizer level, 100 kg NPS ha^{-1} and 50 kg ha^{-1} UREA [18-25].

Statement of problem

Haricot beans are one of the most economically important pulse crops grown in Ethiopia. However, the production of haricot beans in Ethiopia is still far below its potential. This low yield of beans in Ethiopia is due to a number of production problems including lack of improved varieties, poor agricultural and soil practices such as poor soil fertility control including unsuitable fertilizer levels, improper use of crop space, diseases and pests, timely and inappropriate field service activities. Enhanced bean production and productivity can be enhanced by making better use of different agricultural practices including improved variety, seed quality, space, fertilizer level, and pesticide application according to recommendations. However, the current average yield of haricot beans (1.48 ton) is much smaller than the yield that can be obtained (2.5 to 3 ha^{-1}) under good management conditions of many improved varieties [26].

Growth and yield of common beans are affected due to improper use of NPS mixed fertilizers and reduced soil fertility leading to reduced growth and yield. Due to the improper use of NPS fertilizer levels, most farmers in the study area lose the best growth, production and expected prices for common beans each year. In addition, the majority of farmers in the study area did not use the ideal NPS fertilizer rates to improve the production of haricot bean crops. Also, there is a practice among farmers to use above or below the recommended NPS fertilizer levels in the study area. Excessive use of mixed NPS fertilizer leads to reduced crop nodules, reduced seedling emergence due to poisoning in haricot bean seeds and also created weak (high plant length and small stem width) that are easy to lodging, resulting in lower yields and seed yield. On the other hand, less use of NPS during the growing season reduces fresh weight and dry yield, nodule weight, seed yield, seed number and size. Research based recommendations on NPS integrated fertilizer level can increase crop production and increase the benefits of local farmers. Hence, it is important to determine the ideal levels of NPS mixed fertilizer for released bean varieties in order to increase the yield of common beans in the study area. Therefore, this investigation was done for the following purpose [27-31].

- Evaluate the effect of different levels of NPS fertilizer on the performance of Haricot bean varieties in Rifent kebele, East Wellega Zone.
- Identify optimum NPS fertilizer rates for common bean production in the study area.
- Identify the most effective common bean varieties in the study area.

Materials and Methods

Description of the study area

Site investigation was conducted at Rifent kebele located in the Haro Limu District, East Wellega Zone of the Oromia National Regional State during the 2020 rainy season. Rifent kebele is located at 509 kilometer west of Addis Ababa. The study area is approximately contain, Latitude 9.87 north; Longitude 36.19 East, 650 to 2320 meters above sea level; it receives an average annual rainfall of 850 to 1200 mm mm. The local temperature is approximately 16-25°C. The soil of the test site is characterized by a pH of 5.5 and the texture of the reddish brown to sandy loam. The main crops grown in this area are cereal (tef, maize and sorghum), pulse (beans, haricot beans, field peas, groundnut, and etc.

Description of test items

Three varieties of Haricot beans were used in the study, obtained from the Melkasa Agricultural Research Institute. Urea (46% N) and NPS (19% N, 38% P_2O_5, 7. % S,) were used as the source for N, P, and S, respectively (Table 1 and 2).

Name of varieties	Year of release	Altitude(m)	Productivity (kg ha^{-1})		Seed color
			Research	Farmers field	
Dandessu	2013	1300-1650	2200-3000	1900-2500	Red
SER-119	2014	1450-2000	3300	2500	Red
SER-125	2014	1450-2000	3500	2200	Red

Table 1: Description of improved types of haricot beans used in the study.

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

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

Treatment and design

The trial consisted of 15 treatments as a factorial combination of three haricot bean varieties (Dandessu, SER-119 and SER-125) and five levels of combined NPS fertilizers (0, 50, 100, 150, and 200 kg ha^{-1}) arranged with RCBD using three replication. The total size of the plot was 2 m × 3.2 m=6.4 m^2. The space between the blocks and the plots was 1.0 and 0.5 m, respectively. Each plots had 8 rows separated by 40 cm and 10 cm between plants. One outer row on each side of the plots and four plants (30 cm) at the end of the rows were considered boundary. The size of the net pot (1.2 m × 2.4 m=2.88 m^2) consists of six rows each with 12 plants. Total test area was 37 m x 11.6 m (429.2 m^2).

Trial and management procedures

The test field was plowed with oxen three times for good plowing. The field was repeatedly cultivated as a crop recommendation for weed control and the soil was exposed to sunlight. Unnecessary items remained and any water accumulation on site was removed to prevent disease. As the design specification, the field lay out was adjusted; the land was leveled and made fit for plant development. Sowing was done in mid-June, 2020. The seeds were sown by hand (40 × 10 cm) by placing two seeds on each hill at a depth of 2.5-7 cm depending on soil moisture conditions at sowing and later by one crop after emergence. 100 kg ha^{-1} of seed rate was applied with a different amount of NPS fertilizer applied at sowing. The first weeding is done within 3-4 weeks after germination and the second weeding is done 3-4 weeks after the first weeding. All other agronomic processes are performed at all test sites as a plant recommendation. Beans in the net area were harvested and threshed by hand when 90% of the leaves and pods turned yellow and dried under the sun for four days before threshing. Harvesting is done by hand using sickle to mature the body of the plant.

Data collected

Phenological parameter data are measured by the number of days from sowing to when 50% of the plants in the whole plot have reached flowering and maturity of 90%. Growth data and crop component parameters were taken from each component from 12 randomly selected plants in maturity.

Phenological variables

Days up to 50% flowering: is registered by counting the number of days taken from the day of sowing until, 50% of the plants in the net produce flowers and are determined by sight.

Days to 90% maturity: recorded by counting the number of days from the day of sowing to, 90% of plant leaves and pods that turn green to yellow lose their water and reach maturity in each net area.

Growth variables

Number of primary branches per plant: Taken by counting the number of basic branches in the main stem in 12 randomly picked plants at maturity.

Plant height: Measured in centimetres from 12 randomly selected plant samples in each area as the height from the bottom of the plant to the top of crop using meter tape. An average of 12 sample plants was taken as plant length.

Yield and yield components

Total number of nodules: Counted from 12 randomly selected plants per plots at maturity. The root mass of 12 plants taken randomly from the middle rows in each section was carefully exposed to 50% flowering and uprooted to study nodules. The roots were carefully washed using tap water and the nodules were separated and numbered.

Effective nodule number: Counted from 12 randomly selected plants per net plots at maturity throughout the treatment level. To determine the effective number of nodules, the inner color of the nodules was considered by cutting each nodule with the help of a sharp razor blade and the pink color were considered effective nodules, while the green nodules were considered ineffective.

Number of pods per plant: Was recorded by counting the number of pods from 12 randomly selected plants at harvest time and their average was taken as the number of pods per plant in the ripening stages of the plants.

Number of seeds per pod: 12 pods were randomly extracted from the net plot and seeds were counted to determine their number per pod.

Seed yield (t ha^{-1}): Sun dried biomass is ground in a sack using a stick. The yield of the seed is measured in kilograms after cleaning by taking the weight of the grain in the net area and converting it to a ton per hectare.

Statistical data analysis

All data collected were subject to Variance Analysis (ANOVA) using the SAS Software System (SAS, 2008). Significant differences between treatment modalities were compared with the LSD (Least Significance Difference) test at 5% significance level.

Results and Discussions

Days up to 50% flowering

Variation analysis showed that the main effect of NPS fertilizer levels and their interactions was very significant ($p<0.01$) effect in days up to 50% of common bean flower while the main effect of variety was ($p<0.05$) most affected days up to 50% flowering (Table 3).

Varieties	NPS rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Dandessu	42.32^{gh}	42.36^{h}	44.20^{efg}	45.60^{bcdef}	46.73^{abc}	44.48^{b}
SER-119	44.93d^{efg}	43.96^{fgh}	44.70^{efg}	45.96^{abcde}	47.46^{a}	45.40^{a}
SER-125	44.20^{efg}	44.33^{efg}	45.30^{cdefg}	46.56^{abcd}	47.13^{ab}	45.50^{a}
Mean	44.22^{cd}	43.55^{d}	44.22^{c}	46.04^{b}	47.11^{a}	
LSD (5%)	1.78					
CV (%)	2.35					
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.						

Table 3: Interaction effect of varieties and blended NPS fertilizer rates on days to flowering of common bean.

The longest days (47.46 days) to bloom had been registered from the SER-119 types with the best NPS utility value of two hundred kg ha^{-1} and the shortest 50% flowering days (42.32 days) have been recorded due to the usage of zero kg ha^{-1} of NPS combined with Dandessu variety (Table 1). As NPS fertilizer levels increase from zero to 200 kg per hectare, days to 50% flowering of common bean varieties become not on time because of increased nitrogen content material in NPS fertilizers contributing to immoderate vegetative growth and delayed flowering. This result become similar to finding of Deresa who mentioned that rising NPS fertilizer levels from zero to 250 kg ha^{-1} had been considerably delayed in days to bloom of haricot beans.

Days to 90% physiological maturity

Days up to 90% of the ripening of the common bean crop was significantly affected by the major influence of the variety, the fertilization rate of the NPS and their interactions (Table 2). Very long days (92.3 days) up to 90% maturity registered from SER-125 with the highest NPS application rate of 200 kg ha^{-1} and shorter days up to 90% maturity (69.40 days) were recorded from the Dandessu variety with a combined zero kg ha^{-1} of NPS (Table 4). It was a delayed period of up to 90% maturity of the common bean plant. This may be due to an increase in the amount of nitrogen fertilizer in the NPS fertilizer which contributes to the overgrown crop growth of the common bean which has led to a delay in the number of days required for ripening. Consistent with these findings, Abebe and Mekonnen reported that most of the days required for days to maturity were obtained from the highest use of NPSB. Similarly, Asefa et al. found that the delay in the effect of ripening effect on common beans was due to the combined use of N and P fertilizer levels.

Varieties	NPS rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Dandessu	69.40^{g}	72.70^{f}	76.80^{f}	82.06^{d}	84.80^{c}	77.15^{b}
SER-119	73.30^{f}	77.40^{e}	83.70^{cd}	85.90^{c}	87.66^{b}	81.59^{a}
SER-125	73.63^{f}	73.90^{f}	84.80^{c}	90.86^{a}	92.3^{a}	83.10^{a}72
Mean	72.11^{e}	74.66^{d}	81.76^{c}	86.27^{b}	88.25^{a}	80.61
LSD (5%)	2.36					
CV (%)	2.56					
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.						

Table 4: Interaction effect of varieties and blended NPS fertilizer rates on days to physiological maturity of common bean.

Plant height

Variation analysis showed that the major effect of variety, NPS fertilizer levels and the interaction effect of variety and NPS fertilizer levels had a significant impact (P<0.01) on the haricot bean crop height (Table 5). The maximum plant height (79.63 cm) was recorded from the highest NPS application levels of 200 kg ha^{-1} for the SER-119 and SER-125 varieties and the shortest plant lengths (54.86 cm) were achieved from zero fertilizer application rates for zero fertilizers NPS and a combination of Dandessu varieties. The increase in plant height due to the increased application rate of the mixed NPS may be due to higher crop growth under higher N, P and S levels. Consistent with this result, Deresa reported that crop height was significantly increased as the NPS fertilizer level increased from 0 to 150 kg ha^{-1} in a common bean crop. Similar results were reported by Jawahar, et al. when a sulfur level of 40 kg ha^{-1} was found to increase plant height.

Varieties	NPS rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Dandessu	54.86^{f}	59.26^{e}	61.93^{de}	69.66^{c}	75.80^{b}	64.30^{b}
SER-119	55.10^{f}	61.83^{de}	71.70^{c}	76.86^{ab}	79.63^{a}	69.30^{a}
SER-125	60.26^{e}	64.86^{d}	70.73^{c}	78.43^{ab}	79.63^{a}	70.78^{a}
Mean	56.74^{e}	61.98^{d}	68.12^{c}	74.98^{b}	78.35^{a}	68.04
LSD (5%)	3.72					
CV (%)	3.27					
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.						

Table 5: Interaction effect of varieties and blended NPS fertilizer rates on plant height of common bean.

Number of primary branch on each plant

Variation analysis showed that the major impact of varieties, fertilization rates of NPS and the interaction effect of variety and fertilizer levels of NPS had a significant impact (P<0.01) on the primary branch on each plant of common beans (Table 6). The maximum number of basic bean branch (2.86) was observed in SER-119 varieties with 150kg ha^{-1} NPS fertilizer application rate which was statistically at par with NPS at 200 kg ha^{-1} while a small number of common bean branch(1.63) were collected from nil NPS fertilizer application rate for the Dandessu and SER-125 varieties. The increase in the primary branch on each plant due to an increase in NPS fertilizer levels from 0 to 150 kg ha^{-1} may be due to N, P and high S which has a significant impact on vegetable growth in haricot beans. Consistent with this result, Shubhashree stated that the highest number of branches per plant bean crop with 75 kg of P_2O_5 ha^{-1} over control.

Varieties	NPS rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Dandessu	1.63^{g}	2.20^{f}	2.53^{e}	2.66^{cde}	2.83^{ab}	2.37^{b}
SER-119	1.76^{g}	2.30^{f}	2.76^{abcd}	2.86^{a}	2.80^{abc}	2.50^{a}
SER-125	1.63^{g}	2.1^{f}	2.63^{de}	2.80^{abc}	2.70^{bcd}	2.38^{b}
Mean	1.67^{d}	2.22^{c}	2.64^{b}	2.77^{a}	2.77^{a}	2.42
LSD (5%)	0.14					
CV (%)	3.57					
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.						

Table 6: Interaction effect of varieties and blended NPS fertilizer rates on number of primary branch common bean.

Number of nodules on each plant

Variation analysis showed that the major influence of varieties, NPS fertilizer levels and the interaction of varieties and NPS fertilizer levels had a significant impact (P<0.01) on the total number of nodules on each common bean plant (Table 7). The highest number of nodules on each plant (62.66) was recorded in the SER-119 variety with the highest NPS application rate of 200 kg ha-^{1} and the lowest number of nodules per plant (31.83) was obtained from the control for Dandessu variety. This has shown that the total nodules on the plant have been greatly increased with the increase in NPS fertilizer from non-applied to 200 kg ha^{-1}.

Varieties	NPS rates (kg ha-^{1})					
	0	50	100	150	200	Mean
Dandessu	31.83^{j}	38.96^{i}	47.26^{fg}	52.33^{d}	56.80^{c}	45.44^{b}
SER-119	43.36^{h}	46.83^{fg}	51.13^{de}	59.70^{b}	62.66^{a}	52.74^{a}
SER-125	43.26^{h}	45.03^{gh}	49.00^{ef}	59.60^{b}	61.70^{ab}	51.72^{a}
Mean	39.48^{e}	43.61^{d}	49.13^{c}	57.21^{b}	60.38^{a}	49.96
LSD (5%)	2.56					
CV (%)	3.07					
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.						

Table 7: Interaction effect of varieties and blended NPS fertilizer rates on number of total nodules per plant common bean.

This may be due to the increased phosphorus content in NPS fertilizers required in large quantities by legumes in order to grow and improve leaf area, biomass, yield, number of nodules and nodule weight in different pulses. Consistent with this result, Amare, et al. who reported that the number of nodules increased significantly with increased phosphorus levels. In addition, Deresa reported that the total nodules per plant were significantly increased with increasing NPS fertilizer from zero to 200 kg ha^{-1}.

Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.

Number of effective nodules on each plant

Variation analysis showed that the major influence of varieties, NPS fertilizer levels and the interaction of varieties and NPS fertilizer levels had a significant impact (P<0.01) on the total number of effective nodules on each common bean plant (Table 8). The number of effective nodules on each plant (32.46) was recorded in Dandessu varieties with a very high NPS application rate of 200 kg ha^{-1} and a low number of effective nodules per plant (21.46) were obtained from the control for Dandessu variety. This has shown that the total number of active nodules on the plant has grown significantly with the increase in NPS fertilizer from non-applied to 200 kg ha^{-1}. This may be due to the increase in phosphorus content in the NPS fertilizer required by the mass of legumes to grow and improve leaf area, biomass, yield, number of nodules and nodule weight at different pulses. And the combined use of mixed NPS fertilizer has significantly increased the total number of nodules and the number of active nodules in haricot beans. Consistent with this outcome, Abebe et al. reports the combined effect of nutrient uptake on NPKSB fertilizers mainly N-induced nodulation and P in NPKSB fertilizers combined to improve root growth and nitrogen fixation in haricot beans.

The growing number of active nodules detected by the use of the highest NPS over control may also result from increased use of N and S and other major nutrients. Phosphorus uptake may be major factors in N-fixation among genotypes by a number of active nodules. In addition, Deresa reported that the amount of active nodules per plant was significantly increased by increasing NPS fertilizer from zero to 200 kg ha^{-1}.

Varieties	NPS rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Dandessu	21.46^{h}	24.73^{g}	28.76^{de}	32.46^{a}	32.46^{a}	27.98^{a}
SER-119	24.76^{g}	27.56^{e}f	28.66^{de}	30.30^{abc}	31.73^{ab}	28.72^{a}
SER-125	22.46^{h}	24.66^{g}	26.30^{fg}	29.53^{cd}	30.30^{bcd}	26.65^{b}
Mean	22.90^{d}	25.65^{c}	27.91^{b}	30.96^{a}	31.50^{a}	27.78
LSD (5%)	1.82					
CV (%)	3.92					
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.						

Table 8: Interaction effect of varieties and blended NPS fertilizer rates on number of effective nodule per plant of common bean.

Number of pod per plant

The variation analysis showed that the significant effect of NPS fertilizer levels and the interaction of variety with NPS fertilizer levels had a significant effect (P<0.01) on the total number of nodules on each common bean plant (Table 9). However, the main effect of the variety showed a non-significant (p>0.05) difference in pod number per plant.

Varieties	NPS rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Dandessu	7.80^{g}	10.73^{f}	12.90^{cd}	14.66^{ab}	14.66^{ab}	12.15^{b}
SER-119	8.73^{g}	11.66^{def}	13.80^{bc}	14.46^{ab}	15.40^{a}	12.81^{a}
SER-125	8.90^{g}	11.30^{ef}	12.20^{de}	14.16^{abc}	13.86^{bc}	12.08^{b}
Mean	8.47^{d}	11.23^{c}	12.96^{b}	14.43^{a}	14.64^{a}	12.35
LSD (5%)	1.42					
CV (%)	6.91					
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.						

Table 9: Interaction effect of varieties and blended NPS fertilizer rates on number of pod per plant of common bean.

The highest number of pods per plant (15.40) was recorded in SER-119 varieties with the highest NPS value of 200 kg ha^{-1} and the lowest number of pods per plant (7.80) was obtained from the control with Dandessu (Table 9).

This has shown that the amount of pods per plant has increased significantly with an increase in NPS fertilizer from unused fertilizer to 200 kg ha^{-1}. The increase in the number of pods in each plant by the increase in NPS levels may be due to sufficient supply of N, P and S which may facilitate the production of base branches and plant lengths which may contribute to higher yields of pods. Consistent with this result, Moniruzzaman et al. who reported that the number of pods increased significantly with increasing NPS levels. In addition, Deresa reported that the number of pods per plant increased significantly with an increase in NPS fertilizer from zero to 200 kg ha^{-1}.

Number of seeds per pod

The variation analysis showed that the main effect of the variety, NPS fertilizer levels and the interaction of the varieties and NPS fertilizer levels had a significant effect (P<0.01) on the total number of seeds in each common bean crop (Table 10).

Varieties	NPS rates (kg ha^{-1})				
	0	50	100	150	200
Dandessu	4.83^{g}	5.56^{fg}	6.10^{cdef}	6.63^{abcd}	6.23^{bcdef}
SER-119	5.83^{def}	6.50^{abcde}	7.00^{abc}	7.40^{a}	7.00^{abc}
SER-125	5.66^{efg}	6.26^{bcdef}	6.60^{abcd}	7.10^{ab}	7.06^{ab}
LSD (5%)	0.92				
CV (%)	8.62				
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.					

Table 10: Interaction effect of Varieties and Blended NPS fertilizer rates on Number of seed of common bean.

The highest number of seeds on each pod (7.40) was recorded in SER-119 varieties with a maximum NPS value of 150 kg ha^{-1} and a minimum number of seeds per pod (4.83) obtained from Dandessu with control (Table 8). The increase in NPS fertilizer rate from unused to 150 kg ha^{-1} greatly increased the number of seeds per pod but above this level seeds per pod common beans decreased. This may be due to the increased nitrogen content in NPS fertilizers which contributes significantly to plant growth without being transformed into a dry matter for seed development in each pod. Similarly, differences in the number of seeds in each pod between haricot bean varieties may be due to genetic factors more than management practices. Consistent with the results of this study, Mourice and Tryphonne observed significant differences in seed per pod within the genotype of normal beans.

The variation in the number of seeds per pod may be due to the difference in the size of the seed pods of varieties.

Seed yield

Variation analysis showed that the major effect of the variety, NPS fertilizer and the interaction effect of varieties and NPS fertilizer levels had a significant effect (P<0.01) on the common bean seed yield (Table 9). The highest seed yield (2712 kg ha^{-1}) was recorded in SER-119 varieties with a very high NPS value of 150 kg ha^{-1} and a very low seed yield (1883.67 kg ha^{-1}) was obtained from Dandessu variety in combination with nil NPS (Table 11). The increase in NPS fertilizer from unused fertilizer to 150 kg ha^{-1} has greatly increased the yield of seed but above this level the yield of common bean seeds has decreased. This may be due to an increase in the nitrogen content in the NPS fertilizer which contributes significantly to plant growth without being converted into a dry seed development in each pod. Consistent with this, Deresa reported that increased grain yield through NPS fertilization may be due to increased nutritional use efficiency at higher N, P and S levels.

In addition, it has been reported that the growing NPSBZn level of more than 150 kg ha^{-1} significantly reduced the normal yield of beans. Differences in seed yield between common bean varieties may be related to genotypic variation in the optimal use of P. Therefore, cultivars that produce high yields of grain may have better absorption P incorporated into the soil mass or transfer and use the absorbed P to form grains than the less yielding variety. Consistent with the results of this study, Gobeze and Legese observed significant differences in grain yield in common beans due to genotypic variation of P-utilization that may result from differences in P acquisition and transmission and utilization of P-absorbed to make grain in beans.

Varieties	NPS rates (kg ha-^{1})				
	0	50	100	150	200
Dandessu	1883.67^{f}	1976.67^{ef}	2183.00^{cd}	2319.33^{c}	2327.67^{bc}
SER-119	2064.0^{def}	2172.00^{cde}	2368.00b^{c}	2712.00^{a}	2604.00^{a}
SER-125	1977.33^{e}f	2096.33^{de}	2246.00cd	2618.33^{a}	2527.67^{ab}
LSD (5%)	200				
CV (%)	8.62				
Means with the same letter(s) in the same columns and rows of each variable are not significantly affected at 5% probability level.					

Table 11: Interaction effect of varieties and blended NPS fertilizer rates on seed yield of common bean.

Conclusion

The results of the study indicate that up to 50% of flowering days, up to 90% days of ripening, plant length, base branch number, total nodules, number of active nodules, seed per pod, and seed yield of bean varieties were strongly influenced by varieties, NPS fertilizer levels and their interactions. The highest performance of days to 50% flowering, days to 90% maturity, plant height, total nodules on each plant, effective nodules and total pods per plant were numbered from the highest NPS rates of 200 kg ha^{-1} whereas the lowest performance was registered from the nil application rates of blended NPS fertilizer rates. The highest values for base branch number, seed per pod and seed yield were obtained from 150 kg ha^{-1} whereas the minimum values from zero NPS application. The highest values for days to 50% flowering, plant height, total nodules on each plant, total pods per plant was recorded from interaction of variety SER-119 and 200 kg ha^{-1} NPS application while the lowest values noted from combination of variety Dandessu with nil application of NPS fertilizer rates. Similarly, the maximum primary branch per plant (2.86), seeds per pod (7.40) and seed yield (2712 kg ha^{-1}) was achieved from interaction variety SER-119 with 150 kg ha^{-1} whereas the lowest values for primary branch per plant (1.63), seeds per pod (74.83) and seed yield (1183.63 kg ha^{-1} were recorded from combination of Dandessu variety and zero NPS application rates. Therefore, based on the yield performance, variety SER-119 with the combination of 150 kg ha^{-1} of NPS fertilizer application rates could be advised for the farmers in Rifent kebele and other areas having similar agro ecology with the study area. However, the trial was done for one cropping season at one site, so repetition of the study at different season and sites should be needed for conclusive recommendation.

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