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Yield Response of Common Beans (*Phaseolus vulgaris L.*) to the Rate of NPS and Bio-Fertilizer Inoculation at Boloso Bombe Woreda Wolaita Zone, South Ethiopia

Research Article

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Abstract

Common bean is one of the important pulse crops that play a vital role in human diet and consumed in sub Saharan Africa, including Ethiopia. Soil fertility is one of the factors limiting the production of common bean in Ethiopia. From these Bio-fertilizer and NPS fertilizers are the major yield limiting factors for common bean production in the study area. Thus, the experiment was conducted at Boloso Bombe Woreda in 2020/2021 cropping season to determine the rates of NPS and Bio-fertilizer on the yield components and yield of common bean at study area. The experiments were consisted of four levels of blended NPS (0, 50,100,150kg ha^{-1}) and Bio-Fertilizer (0, 250, 500 and 750g ha^{-1}). The RCB design in factorial arrangement with three replications was used. All data were collected and subjected to analysis of variance. The ANOVA result showed that Bio-Fertilizer had significanteffect on days to flowering and physiological maturity and plant height. The highest number of days to flowering (42.03) and days to physiological maturity (84.48) were recorded for Bio-Fertilizer (750 g). Significantly higher number of days to flowering (42.59) was recorded from 150 kg ha^{-1} NPS rate. The highest number of total nodules per plant (68.53) and seeds per pod (7.5) were recorded from the rate of 750 g ha 1 bio-fertilizer with NPS rate of 100 kg ha^{-1}. The highest (3033.7 kg ha^{-1}) and lowest (1174kg ha^{-1}) grain yield were obtained from the interaction effect of 150 kg ha^{-1} NPS and 750 g ha^{-1} bio-fertilizer at control level respectively. The economic analysis also indicated that the highest net return of (95915.6) ETB ha^{-1} was obtained from rate of NPS and Bio-Fertilizer application at 100 kg ha^{-1} with 750 g ha^{-1} respectively. Based on the economic analysis of the study, it can be recommended that the rate of bio-fertilizer inoculation with 750 g ha 1and NPS 100 kg ha^{-11} were appropriate for superior production in the study area.

Keywords: Biological Nitrogen Fixation; Effective Nodules; Economic Feasibility and Strain.

Introduction

Common bean (*Phaseolus Vulgaris L.*) is one of the important pulse crops that play a vital role in human diet and consumed in Sub Saharan Africa, including Ethiopia. It is lowland pulses and best adapted in areas with a warm temperature having mean air temperature between 18 and 24°C for its production. Common bean adds not only diversity to production systems on resource poor farmer's field; but also it contributes to the stability of farming systems in Ethiopia [6]. In the study area the average productivity is 1579 kg ha^{-1} which is lower than the national and attainable yield (2500 to 3000 kg ha^{1}) under good management conditions [9].

There are numbers of limiting factors contribute to low productivity of common bean such as lack of improved varieties, poor agronomic practices, low soil fertility management and inadequate fertilizer application rate and type [4]. The main causes of low productivity at farmer fields are a poor technology level, utilization of low agricultural input and cropping in low fertility soils [7]. The percentage of biological nitrogen fixation of the N assimilation in common bean is lower as compared to other legumes being 40 50% compared to 75% with fababeans (Vicia faba), 70% with peas (Pisumsativum) and up to 95% with lupines [3, 11]. Hence, it is characterized with poor capacity to fix atmospheric nitrogen.

In Wolaita zone low NPS fertilizer usage and lack of adequate information on the use of Bio-Fertilizer inoculants are the major yield limiting factors for common bean production. Bio-Fertilizer inoculation significantly improved nodule number perplant as compared with un inoculated treatment; this is because of inoculated bacteria strain had good nodulation inducing capac-

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ity over the native soil [17]. Inoculation of Bio-Fertilizer strain (B 129) significantly increased hundred seed weight (56.2 g) and grainyield (24161. Kg ha^{-1})[3]. To solve above problem, the research was conducted with objective of determining the optimum and economically feasible rate of bio-fertilizer and NPS fertilizer for grain yield and nodulation of common bean in study area.

Materials and Methods

Description of Study Area

The experiment was conducted in 2020/21, during the main rainy cropping season at Farawochakebele which is located in Southern Ethiopia about 325 km from the capital Addis Ababa. It is about 55 km away from Zonal town, Sodo towards west. Geographical it was located at 7°8'31" N latitude, 37°34' 85" E longitude and analtitude of 1542 meter above sea level. It receives mean annual rainfall of 500-800 mm with annual average temperature of 26.4°C. The monthly total rainfall and average maximum temperature at the experimental area was 491.2mm and 25.3°C respectively [18].

Experimental Materials

An improved variety of common bean (Nassir) was used as test crop for the study. It was released from Melkasa agricultural Research in 2003 adapted to low and mid altitude areas. It is semi climbing, seeding rate of 90 100 Kg ha^{-1}, days flowering 40 55, mostly used for domestic consumption, takes about 86–88 days to physiological maturity and has dark-red seed coat pigmentation (Walelign, 2015). Blended NPS (19% N, 38% P_2O_5 and 7% S) and Bio-Fertilizer (HB129) were used as source of fertilizer materials.

Treatments, Design and Experimental Procedures

The treatments were consisted of four rates of blended NPS fertilizer (0, 50, 100, and 150kg ha^{-1}) and four rates of Bio-fertilizer strains (0, 250, 500, and 750 gha^{-1}) arranged in a randomized complete block design (RCBD) with three replications. Planting materials and bio-fertilizer were prepared and the seed was soaked to 20-30c° on sun boiled water. After that 2 to 3 tea spoons of sugar was added to the water in order to sticking purpose. Seed inoculation was done under shade in the field to avoid bacterial cell death by sun. Inoculated seed was allowed weir-drying for a few minutes before sown, then added bio-fertilizer to the seed and thoroughly mixed with seed. After sowing, the seed was immediately covered with moist soil to avoid bio-fertilizer cell death from desiccation. The size of each plot was 2.40m by 1.60m (3.84m^2), and the spacing between plots and replication was 0.6m and 1m respectively. The plant spacing was 40cm between rows and10cm between plants.

Agronomic Practices

All cultural practices were applied in according to the recommendation of the area. Land was prepared on the onset of May. The experimental field was ploughed by oxen three times before planting. The number of rows marked in each plot according to the spacing proposed. Hand weeding were done 3 and 4 weeks after sowing. Harvesting was taken place when pods turn to grayish red.

Data Collection and Measurements

Phenological and Growth Parameters: Days to flowerings was measured by counting the number of days from the date of sowing to the date on which at least 50% of the plants have flower. Days to physiological maturity was taken as the number of days from planting to the period when 90% of the plants in a plot show change in the foliage and pod color and seed hardening. Plant height was measured from eight randomly selected plants at physiological maturity from the base of the plant to the top of the main shoot. Numbers of primary branches counted by branches emerge directly from the main shoot fromeight randomly selected plants at physiological maturity. Number of total nodules per plant and number of effective nodules per plant was measured after 50 days of sowing from five plants plot^{-1} by destructive sampling method.

Yield and Yield Components: Number of pods per plant was counted from eight randomly selected plants from the net plot area at harvest. Numbers of seeds per pod were taken by counting the number of seeds from five pods from each of eight plants at harvest. Hundred seed weight was determined by weighing 100 randomly selected dry seeds from the harvested net plot using a sensitive balance and the weight was adjusted to 10% seed moisture content. Total above ground biomass was determined by weighing above-ground shoot with pods, stem, and foliage from net plot area at physiological maturity. Grain yield was measured by weighing air-dried seeds of the net plot area and adjusted at 10% seed moisture content. Harvest index is the proportion of grain yield to biological yield.

Statistical Data Analysis

Data collected from experimental plots was summarized using Microsoft excel. The pooled data was subjected to analysis of variance (ANOVA) according to the Generalized Linear Model (GLM) of Genstat 18th software (GenStat, 2016) [15]. Significance differences between the treatment means were separated and compared using the least significance difference (LSD) test ata 5% level of significance.

Results and Discussions

Phenological Parameters of Common Bean

Days to Flowering: The analysis of variance showed that number of days to 50% flowering was significantly ($P< 0.05$) affected by the main effects of NPS and bio-fertilizer application. Increasing NPS rate from control (40.40) to 100 kg NPS ha^{-1}(42.03) increased the number of days required to reach 50% flowering (Table 1). The increased rates of NPS supply might be attributed to the prolonged vegetative growth due to combined application of N, P and S. Tewari and Singh (2000) reported that common bean crop supplied with nitrogen (160 kg N ha^{-1}) required significantly more number of days to reach the growth stage of 50% flowering. The result was also in accordance with that of Nebret and Nigussie (2017) [23] who reported when the nitrogen supply was increased from 0 to 46 kg N ha^1, the days to flowering was prolonged significantly in common bean. Likewise, Habtamu et al. (2017) [17] reported that, significantly longest days (45.86) to flowering due to application of 46 kg ha 1 of P2O5 and 41 kg ha-1of N.

Increasing bio-fertilizer rate from 0 kg ha1 to 750 kg ha 1 increased the number of days required to reach 50% flowering from 40.40 days to 42.20 days (Table 1). The possible reason for delayed flowering with the bio-fertilizer might be due to the fact that inoculation enhanced N fixation and thereby increasing N uptake by plants contributed to improved vegetative growth of common bean there by delayed flowering.

Days to Physiological Maturity: Days to physiological maturity was significantly ($P<0.05$) affected by the main effects of NPS andbio-fertilizerrate. Increasing NPS ratefrom 0 kg ha1 to 150 kg ha1 increased the number of days required to reach physiological maturity from 76.95 to 84.88 days (Table 1). Also increasing bio-fertilizer application rate from 0 to 750g ha1 increased the number of days required to reach physiological maturity from 77.93 to 84.38 days (Table1). This is in line with the result of Nebret and Nigussie (2017) [23] who reportedthat increase in N application rate from 0 to 46 kg N ha1 led to a significant increase in the number of days required to reach physiological maturity from 87.9 to 89.9 days.

Growth Parameters of Common Bean

Plant Height: Analysis of variance showed that interaction effect of NPS rate with bio-fertilizer were significantly ($P<0.05$) affected on plant height (Table 2). The highest plant height (79.89cm) and the lowest plant height (52.89cm) were observed at NPS rate of control and 150 kg ha^{-1} respectively. Also the highest plant height (77.75 cm) was observed at the rate of Bio-Fertilizer (750 g ha1) and the lowest plant height was observed on control (58.22cm) (Table 2). The response of common bean to combined application of NPS with bio-fertilizer might be contributed the increased availability of nitrogen in the soil for uptake by plant roots, which may have sufficiently enhanced vegetative growth through increasing cell division and elongation. This result was in line with Nebret and Nigussie (2017) [23] who reported that, increasing N level from 0 kg ha^{-1} to 23kg ha^{-1} increased plant height of common bean at both Hirna and Haramaya. The promotion effect of high phosphorus in NPS fertilizer level and balanced NPS supply on plant height may be due to better development of the root system and nutrient absorption [19].

Number of Branches per Plant: The main effects of bio-fertilize application and NPS rate were significant ($P<0.05$) effect on the number of primary branches per plant. The highest number of branches (4.213) was observed at 150 kg NPS ha1 while the lowest number (3.902) was at no application of NPS (Table 2). The possible reason for the highest number of primary branches per plant at 150 kg NPS ha^{-1} might be due to that legumes require

Table 1. The Main Effects of NPS and Bio-Fertilizer Rate to Days to Flowering and Days to Physiological Maturity.

NPS rates kg ha^{-1}	No of Days to 50% Flowering	No of Days to 90% physiological maturity
0	40.40 ^{b}	76.95^{b}
50	41.32^{ab}	79.80^{b}
100	42.03^{a}	83.83^{a}
150	41.33^{ab}	84.88^{a}
Bio-fertilizer g ha^{-1}		
0	40.40^{b}	77.93^{b}
250	40.87^{ab}	79.33^{b}
500	41.61^{ab}	83.83^{a}
750	42.20^{a}	84.38^{a}
LSD	1.103	3.293
CV%	3.2	4.9

Means followed by the same letters within a column are not significantly different at 5% probability level.CV: Coefficient of Variability, LSD: Least Significant Difference

Table 2. The Main Effect of NPS and Bio-Fertilizer on Plant Height, Number of Branches and Number of Total Nodule.

NPS rates kg ha^{-1}	Plant Height (m)	Number of branches	Number of Total nodule
0	52.89^{d}	3.902^{b}	36.07^{d}
50	62.15^{c}	4.050^{ab}	46.98^{c}
100	68.63^{b}	4.140^{a}	56.95^{b}
150	79.89^{as}	4.213^{a}	60.65^{a}
LSD	5.201	0.191	3.2
Bio-fertilizer g ha^{-1}			
0	58.22^{c}	3.992^{b}	58.22^{c}
250	60.78^{c}	3.973^{b}	60.78^{c}
500	66.80^{b}	4.062^{b}	66.80^{b}
750	77.75^{a}	4.277^{a}	77.75^{a}
LSD	5.201	0.191	3.2
CV%	9.5	6.1	7.6

Means followed by the same letters within a column are not significantly different at 5% probability level.CV: Coefficient of Variability, LSD: Least Significant Difference

P for optimal symbiotic performance and there was close relationship between P level and symbiotic mechanism in legumes. The highest number of branches(4.277) was observed at rate of 750 g ha^{-1} Bio-fertilizer while the lowest number of branch (3.992) was obtained from control.

The increment in number of primary branches per plant might be due to the importance of P in NPS fertilizer for cell division activity, leading to the increase of plant height and number of branches and consequently increased the plant dry weight. Sulfur in NPS is important for growth and physiological functioning, promoting nodule formation in legumes, chlorophyll formationand formation of nitrogenase enzymes. Meseret and Amin (2014) [21] reported the highest number of branches per plant (5.67) was obtained at application rate of 20 kg P_2O_5 ha^1. Likewise, Habtamuet, al. (2017) [17] reported the maximum number of primary branches per plant (6.6) was obtained due to application of recommended rate of NPS fertilizer (46 kg ha 1 P_2O_5 and 41 kg ha 1 N). Moreover,inoculation produced higher number of primary branches (4.22) than control. This might be due to higher vegetative growth of the plants under higher N by BNF availability. Mfilingeet al. (2014) [22] reported that inoculation of chickpea with Rhizobium in field and in the glass house significantly increased number of primary branches per plant. Similarly, Ahmed et al., (2010) obtained positive and significant effects of inoculation and phosphorus fertilization on number of branches of chickpea.

Number of Total Nodule: The main effect of bio-fertilizer and NPS rate was significant ($P<0.05$) effect on total and effective numbers of nodules per plant. The highest number of total nodules (60.65) was obtained at 150 kg ha^{-1} NPS rate while the lowest number (36.07) was at no application of NPS. The highest number of total nodules (77.75) was obtained at Bio-fertilizer application rate of 750 g ha^1 while, the lowest number of nodule (58.22) was obtained at control (table 2). Bio-Fertilizer application resulted in increasednumber of nodules per plant compared to unapplied treatment which could be due to the fact that fertilized bacteria strain had good application inducing capacity over the native soil bio fertilized population, low native Rhizobium population in the soil, less competitive native Rhizobium against the inoculated. In line with this result, Habtamu et al. (2017) [17] reported the highest number of nodules per plant (15.3) for Nasir.

Number of Effective Nodule: The interaction effects of bio-fertilizer and NPS rate were significant ($P<0.05$) on effective numbers of nodules per plant The highest number of effective nodules (17.17) were observed at 150 kg ha^1 NPS and 750 gr ha 1 bio fertilizer while, the lowest number (7.25) were observed at control (table 3). Bio-fertilizer application resulted in increased number of nodules per plant compared to un inoculated treatment whichcould be due to the fact that inoculated bacteria strain had good nodulation inducing capacity over the native soil rhizobium population, low native rhizobium population in the soil, less competitive native Rhizobium against the inoculated. Mehrpouyan (2011) [20] also reported that significant increase in nodule number in common beancultivars when inoculatedwith rhizobium leguminosarum strain Rb 117. Likewise, Fatima et al., (2007) [14] reported in soybean that nodule formation was more sensitive to phosphorus deficiency than plant growth and application of phosphorus improved nodulation parameters when compared with no phosphorous fertilizer.

Yield Components and Yield of Common Bean

Number of Pods per Plant: The analysis of variance showed that the interaction effect NPS and Bio-fertilizer rate were significant ($P<0.05$) on numbers of pods per plant. Highest number of number of pods (16.30) were observed at 150 kg ha^{-1} NPS and 750g ha^{-1} of Bio-fertilizer while, the lowest number (6.53) were observed at controlled (Table 3). Increased number of pods with NPS application might be due to optimum availability and utilization of N, P and S for reproductive development and pod formation in legumes. Application of nitrogen also increases panicles or heads in cereals and number of pods in legumes [13]. Zafalet al., (2003)[27] reported thatapplication of P stimulate the plants to

Table 3. The Interaction Effect of NPS and Bio-Fertilizeron the Number of Effective Nodule.

NPS-rate Kg ha^{-1}	Bio-rate gr ha^{-1}	number of effective nodule
0	0	7.25^{i}
	250	8.08^{hi}
	500	9.67^{fg}
	750	10.08^{ef}
50	0	8.70^{gh}
	250	9.42^{fg}
	500	11.25^{de}
	750	14.17^{bc}
100	0	9.92^{fg}
	250	11.50^{d}
	500	13.00^{c}
	750	16.42^{a}
150	0	11.50^{d}
	250	13.42^{c}
	500	15.08^{b}
	750	17.17^{a}
	LSD	1.25
	CV %	6.5

Means followed by the same letters within a column are not significantly different at 5% probability level.CV: Coefficient of Variability, LSD: Least Significant Difference

produce more pods per plant as P strongly encourages flowering and podding. Similarly, Meseret and Amin (2014) [21] obtained higher number of pods per plant (48.16) of common bean with application of P(20 kg P ha[1]). Amare et al. (2014)[4] also reported that, application of P at 40 kg P_2O_5 ha[1] produced the maximum significant number ofpods per plant (19.01). Pod number per plant was significantly higher in seed applied plants (13.68) compared to unapplied plants which might indicate the effectiveness of applicants over native soil Rhizobium.

Number of Seeds per Pod: The analysis of variance showed that common bean number of seeds per pod was significantly ($P<0.05$) affected by the interaction effect of NPS and Bio-fertilizer. The highest number of seed per pods at interaction effects were (7.475) observed at 150 kg ha^{-1} and 750gr ha^{-1} while, the lowest number (5.458) were observed at controlled (Table 4). The results showed that the increment of seeds per pod with increasing NPS fertilizer application up to optimum level might be due to adequate supply of nutrients in NPS fertilizer for nodule formation, protein synthesis, fruiting and seed formation. The result was similar with Meseret and Amin (2014) [21] who reported the highest number of seeds per pod (5.85) was obtained at 20 kg ha^{-1} phosphorus rate. Similarly, Habtamu et al., (2017) [17] reported relatively highest number of seeds per pod was obtained with the application of 46 kg ha^{-1} of P_2O_5 and 41 kg ha^{-1} of nitrogen.

Hundred Seed Weight: The analysis of variance showed that the interaction effect NPS and bio-fertilizer were significant ($P<0.05$) on numbers of hundred seed weight. The highest number of hundred seed weight were (32.17) observed at 150 kg ha^{-1} NPS and 750gr ha^{-1} bio-fertilizer rates while, the lowest number (23.58) were observed at controlled (Table 4). The possible reason for this might be that nitrogen improves grain or seed weights in crop plants and reduces grain sterility [13]. Similarly, Amare et al. (2014) [4] reported that the increasing doses of phosphorus from the control to 40 kg ha[1] P_2O_5 resulted in significant increment in 100 seedweight. Inaddition, Abdulkadir et al., (2014) [1]reported that phosphorous fertilized crop when compared with the control produced more pods per plant which were better filled with heavier seeds and this translated to higher grain yield. Nebret (2017) [23] reported that increasing sulphur ratefrom 0 kg ha[1] to 20 kg ha[1] increased 100 seed weight from 35.7 g to 36.8 g.

Rhizobiu minoculated treatments achieved significant increases in hundred seed weight (28.76 g) compared to un-inoculated (26.57g) treatments (Table 4) which could be due to the symbiotic relationship between Rhizobium and common bean plants, which results infixation of at mospheric nitrogen into the roots and translocation of amino acids to the shoots, thus leading to increased seed size. This result was in agreement with the study by Asad et.al.(2004) [5] where weight of100 seeds increased significantly in the common bean inoculated with carrier based as well as pure cultures of rhizobium than thatof non-inoculated treatment.

Above Ground Dry Biomass Yield: In this study the biomass yield of common beam was significantly ($P<0.05$) affected by the interaction effect of bio-fertilizer and NPS rate. The highest above ground dry biomass (7183kg ha^{-1}) obtained at 150 NPS kg ha-1and 750g ha^{-1} bio-fertilizer, while the lowest (3233 kg ha^{-1}) was observed at control (Table 5). This increment in dry matter yield with application of NPS fertilizer might be due to the adequate supply of N, P and S which increased the number of branches per plant, leaf area, photosynthetic area and number of pods per plant there by dry matter accumulation. Sulphur may enhance cell multiplication, elongation, expansion and chlorophyll bio synthesis and increased the assimilate production with grain yield in cereals and legumes [13]. In agreement with this result, Veeresh (2003) reported that the dry matter production of common bean increased significantly with the application of differ-

Table 4. The Number of Pods Per Plants, Hundred Seed Weight and Seeds Per Pod as Influenced by the Interaction Effect of NPS Rates and Bio-Fertilizer.

Bio- rate g ha^{-1}	NPS kg ha^{-1}	No of Pod per Plant	No of Seed per Pod	100 seed weight (g ha^{-1})
0	0	6.53^{j}	5.458^{i}	23.58^{g}
	250	8.75^{i}	5.650^{hi}	25.25^{efg}
	500	10.21^{h}	5.83^{gh}	24.83^{fg}
	750	12.17^{efg}	6.1^{defg}	25.00^{fg}
50	0	11.22^{gh}	5.77^{ghi}	25.67^{d-g}
	250	11.55^{g}	5.98^{e-h}	26.64^{c-f}
	500	11.98^{fg}	6.08^{d-g}	27.92^{bcd}
	750	13.42^{d}	6.55^{bc}	25.33^{efg}
100	0	11.83^{fg}	5.950^{fgh}	26.56^{c-f}
	250	11.87^{fg}	5.983^{e-h}	26.78^{c-f}
	500	13.92^{cd}	6.242^{c-f}	28.41^{bc}
	750	15.45^{ab}	7.475^{a}	31.00^{a}
150	0	12.80^{def}	6.383^{bcd}	27.75^{cde}
	250	13.26^{de}	6.333^{cde}	27.6^{cde}
	500	14.72^{bc}	6.708^{b}	30.4^{ab}
	750	16.30^{a}	7.467^{a}	32.17^{a}
	LSD	1.36	0.36	2.54
	CV%	5.6	3.5	5.6

Means followed by the same letters within a column are not significantly different at 5% probability level.CV: Coefficient of Variability, LSD: Least Significant Difference

Table 5. Above Ground Dry Biomass and Grain Yield of Common Bean as Influenced by the Interaction Effect of Bio-Fertilizer with NPS Rate.

NPS- rate Kg ha^{-1}	Bio-fertilizer rate g ha^{-1}	Total bio-mass Above ground (Kg ha^{-1})	Grain yield (Kg ha^{-1})
0	0	3233h	1174j
	250	3377gh	1233ij
	500	3713fgh	1464g-j
	750	4217e-h	1767efg
50	0	3433gh	1335hij
	250	366fgh	1406hij
	500	4463ef	1797efg
	750	5073de	2100de
100	0	4010fgh	1579ghi
	250	3947fgh	1619gh
	500	5503cd	2328cd
	750	715ab	3019ab
150	0	4310efg	1672fgh
	250	4263efg	2003def
	500	6167bc	2657bc
	750	7183a	3033.667a
	LSD	1007.1	352.3
	CV%	13.1	11.2

Means followed by the same letters within a column are not significantly different at 5% probability level.CV: Coefficient of Variability, LSD: Least Significant Difference

Table 6. Harvest index of common bean as influenced by the main effect on the application rates of Bio-fertilizer and NPS.

NPS-rates kg ha^{-1}	Harvesting Index (%)
0	39.02c
50	40.26bc
100	41.59ab
150	43.05a
Bio-fertilizer gha^{-1}	
0	38.45b
250	40.75ab
500	42.13a
750	42.59a
LSD	2.33
CV%	6.8

Means followed by the same letters within a column are not significantly different at 5% probability level.CV: Coefficient of Variability, LSD: Least Significant Difference

ent levels of N and P fertilizers.Likewise, Gifoleet al., (2011) [16] reported the highest total biomass (4597 kg ha 1) from the treatment with the application of 40 kg Pha1.

Grain Yield: In this study the grain yield of common beam was significantly ($P<0.05$) affected by the interaction effect of bio-fertilizer and NPS rate. The highest grain yield (3033.7 kg ha-1) obtained at 150 NPS kg ha-1and 750g ha^{-1} bio-fertilizer, while the lowest (1174kg ha^{-1}) was observed at control (Table 5). Abera and Buraka (2016) [3] also reported that the maximum seed yield (2160 kg ha^{-1}) of common bean was obtained from the application of the 23 kg ha^{-1} N rate. Amare et al., (2014) also reported the maximum seed yield (2326 kg ha^{-1}) of common bean was obtained with the applicationof P_2O_5 at rate of 20 kg ha^{-1}. Similarly, Gifoleet al. (2011) [16] reported that, the highest grain yield (2547 kg ha 1) of common bean was obtained from the application of 40 kg P ha 1. Nyokiand Ndakidemi (2014) reported that bio fertilizer inoculation significantly improved the yield and yield components of legumes such as number of pods per plant, number of seeds per pod, number of seeds per plant, 100 seed weight, and grain yield relative tocontrol. Similarly, Abebe and Tolera (2014) [2] reported that inoculation significantly increased grain yield in faba bean. Abera and Buraka (2016) [3] also reported the maximum seed yield (2416.3 kg ha^{-1}) was obtained from seed inoculation with bio-fertilizer strain.

Harvest Index (HI): The analysis of variance indicated that the main effect of bio-fertilizer and NPS rate was significant ($p<0.05$)

effect on harvest index of common bean. The highest HI (43.05 % and 42.59%) was observed from the application of 150 kg ha 1 NPS and 750 g ha1 bio fertilizer rate respectively (Table 6). The lowest HI (39.02%) and 38.45%) was observed from the control (Table 6). Birhanu (2006) reported that there was a significant increase of harvest index with the application of P on common bean. Daniel et al. (2012) [10] reported that the highest HI (43.69%) was observed from the application of NPS rate of 100 kg ha 1 and with Rhizobium inoculation (39.67%).

Summary, Conclusion And Recommendation

Summary and Conclusion: Low soil fertility status and reduced biological nitrogen fixation are some of the major constraints limiting common bean yield in the study area. Ensuring a well balanced supply of blended NPS fertilizer and Bio-Fertilizer application to the crop may result in higher grain yield. Limited research has been done on the effective rate of blended NPS and Bio-fertilizer on yield and yield components of common bean. Therefore, field experiment was conducted to evaluate the effective ratesof blended NPS and bio-fertilizer application on yield, yield components and economic feasibility of common bean production. Based on the results of study, it can be concluded that the rate of 750 g ha 1 of bio-fertilizer with 100 kg ha1 of NPS found appropriate to be used. Therefore, combined application of bio-fertilizer (750 g ha1) and NPS (150 kg ha1) rates, were significantly affected the number of total nodules, number of pods, number of seeds, hundred seed weight and grain yields of common bean. According to economic analysis the highest net return was obtained from 100 kg ha1 of NPS and 750 g ha1 of Bio-Fertilizer application. Also, the maximum marginal rate of returns was obtained from the rate of NPS and Bio-Fertilizer application at 100 kg ha1 with 750 g ha1.

Recommendation: Based on the economic analysis,statistical analysis and marginal rate of returns results, it can berecommended that, the combined application of 100 kg ha1 NPS and 750 g ha1 bio-fertilizer inoculations were appropriate recommendation for superior production of common bean in the study area. However, the result should be repeated under different agro ecologies in order to reach a conclusive recommendation.

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