Hindawi
Applied and Environmental Soil Science
Volume 2023, Article ID 9102273, 9 pages
https://doi.org/10.1155/2023/9102273

Research Article

Soil Test Based Fertilizer Calibration for Common Bean (*Phaseolus vulgaris L.*) Varieties of the Southern Ethiopia

Mesfin Kassa [1] and Tadesse Kifle [2]

[1] *Department of Plant Science, College of Agricultural, Wolaita Sodo University, P.O. Box. 138, Sodo, Ethiopia*
[2] *Department of Natural Resource Management, College of Agriculture, Wolkite University, Welkite, Ethiopia*

Correspondence should be addressed to Mesfin Kassa; mesfine2004@gmail.com

Received 13 May 2022; Revised 13 January 2023; Accepted 8 February 2023; Published 23 February 2023

Academic Editor: Claudio Cocozza

Blended Nitrogen, Phosphorus, Sulfur, and Boron fertilizer calibration foxr optimum common bean (*Phaseolus vulgaris L.*) varieties yield was used to assess the effect of different rates of blended fertilizer on growth, yield and yield components, and nutrient use efficiency of common bean varieties and to identify economically feasible rates of blended fertilizer at Meskan District, Southern Ethiopia during 2020 crop season. The experiment had six treatment levels of blended fertilizer (0, 50, 100, 150, 200, and 250 $kg{\cdot}ha^{-1}$), and two common bean varieties were arranged in a randomized complete block design with three replications. Soil samples of the experimental plots were analyzed and used as blended fertilizer calibration to estimate soil nutrient supplies and recommend fertilizer. The results revealed that growth, yield, and yield components were highly significantly ($p \leq 0.05$) affected by the main effect of varieties and application of blended NPSB rates. The interaction of varieties and blended fertilizer shown a significant ($p \leq 0.05$) effect on all parameters. The partial budget analysis indicated that the highest net benefit of 67665 ETB ha^{-1} was obtained from the Nasir variety with the application of 100 $kg{\cdot}ha^{-1}$. Therefore, growing the Nasir variety with blended fertilizer rates of 100 $kg{\cdot}ha^{-1}$ is economically feasible for the studied soil type and different locations.

1. Introduction

Low crop production is inappropriate soil fertility management [1]. The relatively low yield of common beans in Ethiopia including the study area is as a result of the low use of enhanced variety and low soil fertility status and poor management practice which are the major production constraints [2]; ATA [3]. Wossen [4] reported NPKSB nutrient ratios for common bean growth and yield. However, soil fertility mapping projects 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 the application of customized and balanced fertilizers [5]. Common bean N fertilizer requirement depends on soil fertility levels; for low soil nitrogen levels (below 34 kg $N{\cdot}ha^{-1}$) N fertilizer is generally recommended in order for deficiency symptoms not to manifest and for full development up to production, inorganic phosphorus fertilizer has a positive effect on the yield and yield components of common bean and sulfur is required in similar amount as that of phosphorus [6]. In Ethiopian soils, the deficiency of K, S, Zn, B, and Cu in addition to N and P have common bean recently reported by soil fertility mapping project, and thus recommend the application of customized and balanced fertilizers [11]. The fertilizer recommendation did not consider the existing soil nutrient supply and resulted in low crop yield response in the region [2]. To correct these nutrient deficiencies, farmers in the Gurage zone of the Southern Ethiopia have been using a uniform blanket application of 100 kg NPSB ha^{-1} for all legumes including common bean to increase crop yields and this did not consider soil fertility status and crop requirement. Therefore, this study was initiated with the following objectives to determine the effect of blended fertilizer on growth, yield, and yield components and on nutrient uptake and nutrient use efficiency of common bean varieties and to identify and

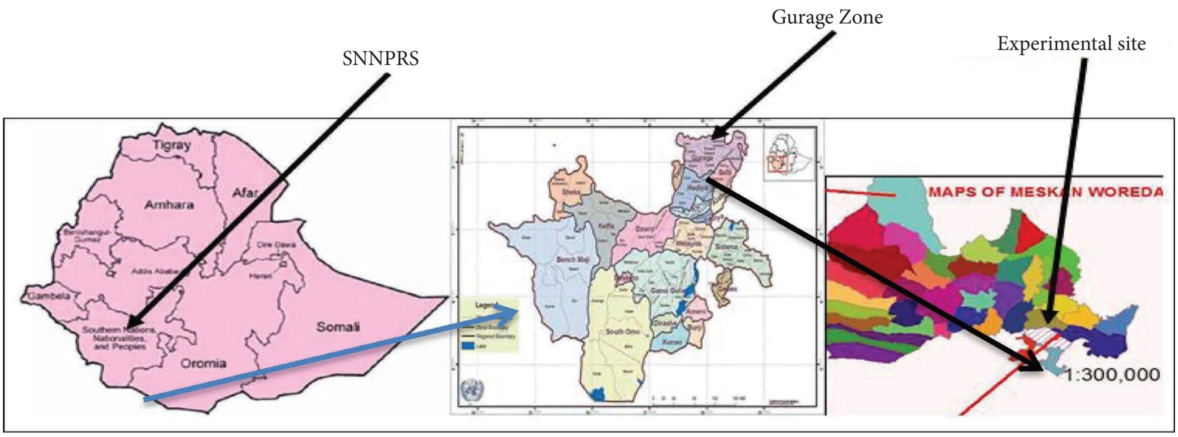

Figure 1: Map of the experimental site in Meskan District, Gurage Zone, Southern Ethiopia.

suggest the economically feasible rates of NPSB fertilizer for common bean varieties production in the study area.

2. Materials and Methods

2.1. Description of the Study Site. The experiment was conducted at Dobo Tuto Kebele, Meskan District, Gurage Zone, Southern Ethiopia, during the 2020 rain season. It is located 135 km south of Addis Ababa at a latitude and longitude range of 7°.99′35″–8°.02′781″N and 38°.26′31′–38°.57′86″E, respectively (Figure 1). The area has an elevation range of 1823–2000 meters above sea level. The mean annual rainfall is 1000–1200 mm with a bimodal pattern, which extends from February to April and June to September. The mean annual minimum and maximum temperatures are 10.3°C and 26°C, respectively (Figure 2).

2.2. Experiment Design and Treatments. The treatments were consisted of a factorial combination of six blended NPSB fertilizer rates (0, 50, 100, 150, 200, and 250 NPSB kg ha^{-1}), and two varieties (awassa dume and Nasir) were evaluated in a factorial arrangement laid in a randomized complete block design with three replications. Each plot size was $2.4 \times 3\ m^2$, which contained six rows per plot and the four central rows were used for data collection, the spacing between rows and plants were 40 cm and 10 cm, respectively. Blended NPSB (19% N, 38% P_2O_5, 7% S, and 0.1% B) was used as sources of N, P, S, and B, respectively, for the study.

2.3. Soil-Plant Samples and Analysis. Before planting, soil samples were taken randomly in a zigzag manner to a depth of 0–30 cm from 20 spots of the experimental field (Table 1). The soil samples were composited to one sample and air-dried ground and sieved using 2 mm and 0.5 mm (for organic carbon). Then, the composite soil sample was analyzed for soil pH in water and was determined potentiometrically in a supernatant suspension of 1 : 2.5 soils: water ratio using a combined glass electrode pH meter [14]. Soil texture was determined by the Bouyoucos hydrometer method [15]. Soil organic carbon (SOC) was using the Walkley and Black method [16], total nitrogen (TN) was using the Kjeldahl method [17] available phosphorous (AP) was using the Olsen method [13], cation exchange capacity (CEC) was extracted by 1M ammonium acetate (pH 7) method [18], available sulfur (AS) was determined using the turbid metric method, and available boron (AB) was determined using the hot water method [19]. After harvesting the plant samples was collected, dried, processed, and analyzed for total N, P, S, and B contents were determined by wet acid digestion procedure as suggested [20].

3. Data Collection

An effect of blended NPSB rate was examined by measuring data on phenology, growth, yield, and yield component parameters.

3.1. Efficiency Parameters. The actual uptakes of N, P, S, and B based on the potential supplies of N, P, S, and B were calculated using equations (1)–(4) as described in [21] as follows:

$$\mathrm{PE, kg\,kg^{-1}} = \frac{\mathrm{BY}_{f-\mathrm{BY}_u}}{N_{f-N_u}}, \quad (1)$$

where PE is thephysiological efficiency, BY_f is the biological yield (grain plus straw) of the fertilized pot (kg), BY_u is the biological yield of the unfertilized plot (kg), N_f is the nutrient uptake (grain plus straw) of the fertilized plot, and N_u is the N uptake of the unfertilized plot (kg).

$$\mathrm{RE} = \frac{\left(\mathrm{TU}_{a-}\mathrm{TU}_{a0}\right)}{F_{ra}}, \quad (2)$$

where RE is the recovery fraction, TU_a-average total nutrient uptake, kg ha^{-1} from treatments receiving a dose Fr (a) TU_{a0}-average total nutrient uptake, kg ha^{-1}, from the control treatments, F_{ra} is the rate of fertilizer application (kg ha^{-1}), and (a)-nutrient under consideration, namely, N, P, or K.

$$\mathrm{AE, kg\,kg^{-1}} = \frac{G_{f-}G_u}{N_f}, \quad (3)$$

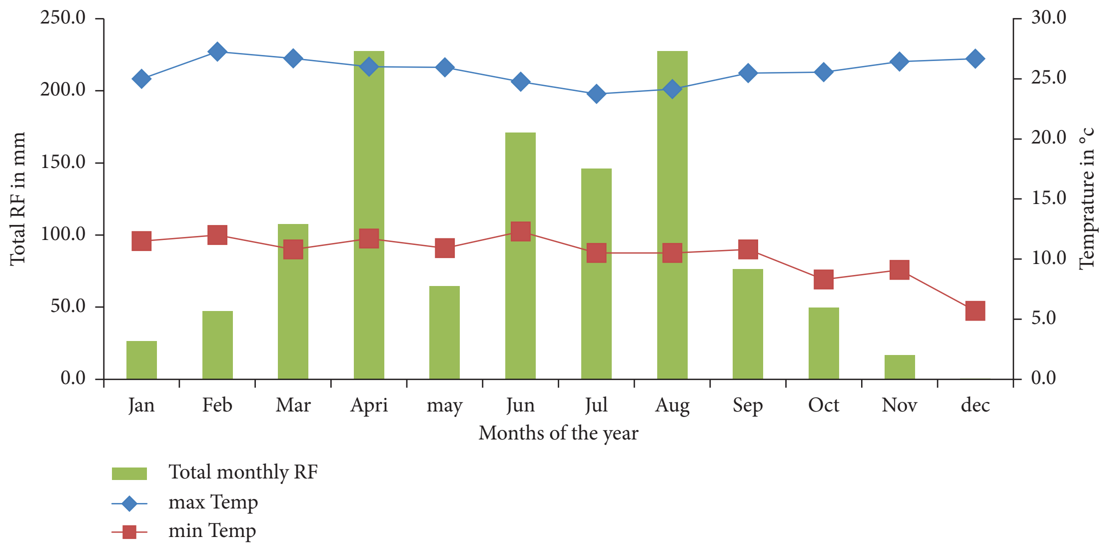

FIGURE 2: Monthly mean annual rainfall and monthly minimum and maximum temperature of Meskan District.

TABLE 1: Physicochemical properties of the study site's soil before planting.

No	Parameter	Unit	Values	Classification	References
1.1	Sand	%	40		
1.2	Silt	%	30		
1.3	Clay	%	30		
	Textural class			Clay loam	Bouyoucas hydrometer method
3	pH		6.8	Slightly acidic	Havlin et al. [11]
4	OC	%	2.70	Low	London [12]
5	TN	%	0.23	Moderate	Havlin et al. [11]
6	AP	mg kg^{-1}	2.15	Very low	Olsen et al. [13]
7	CEC	Cmock^{-1}	34.4	High	London [12]
8	AS	mg kg^{-1}	6.0	Very low	London [12]
9	AB	mg kg^{-1}	0.63	Very low	London [12]

where AE is the agronomic recovery, kg kg^{-1}; G_f is the grain yield of the fertilized plot, kg; G_u is the grain yield of the control plot, kg; and N_f is the quantity of N, P, and K fertilizer applied, kg.

Where EU: Utilization efficiency, Nutrient utilization efficiency is the product of physiological and apparent recovery efficiency. It can be calculated as follows:

$$\mathrm{EU}\left(\mathrm{kg}\, ha^{-1}\right) = \mathrm{PE\ X\ RE}. \tag{4}$$

3.2. Efficiency of Soil Nutrient Was Calculated from Soil Test Value. Calculation of the important parameters (NR, Cs, and Cf) was computed following the formula as defined by [22] as follows:

$$\textbf{Nutrient requirement}\ (\mathbf{NR})\left(\mathbf{kg\ q}^{-1}\right) = \frac{\text{Total uptake of nutrient}\left(\text{Kg}\, ha^{-1}\right)}{\text{Grain yields}\left(\text{Kg}\, ha^{-1}\right)},$$

$$\textbf{Percent contribution of available Nutrient from soil}\ (\%\mathbf{Cs}) = \frac{\text{Total uptake of nutrient in control plot}}{\text{Soil test value of that nutrient in control plot}} \text{ x } 100, \tag{5}$$

$$(\%\mathbf{Cf}) = \frac{(\text{Total uptake of nutrients}) - (\text{Soil test values of nutrients})\text{x}\,(\%\ \text{Cs})/100}{\text{Fertilizer do se (NPSB)applied}\left(\text{kg}\, ha^{-1}\right)} \text{X } 100.$$

3.3. Fertilizer Requirement Equations

$$\begin{aligned} FN &= \left(\frac{NR}{Cf}\right) \times 100T - \left(\frac{Cs}{Cf}\right) \times SN, \\ FP_2O_5 &= \left(\frac{NR}{Cf}\right) \times 100T - \left(\frac{Cs}{Cf}\right) \times 2.29 \text{ x } SP, \\ FS &= \left(\frac{NR}{Cf}\right) \times 100T - \left(\frac{Cs}{Cf}\right) \times SS, \\ FB &= \left(\frac{NR}{Cf}\right) \times 100T - \left(\frac{Cs}{Cf}\right) \times SB, \end{aligned} \tag{6}$$

where (% Cf) is the percent contribution of nutrient from fertilizer, FN is the fertilizer nitrogen (kg N ha^{-1}), FP_2O_5 is the fertilizer phosphorus (kg $P_2O_5 \cdot ha^{-1}$), FS is the fertilizer sulfur, and FB is the fertilizer boron.

T is the targeted yield (q ha^{-1}), SN is the soil test value for available nitrogen (kg ha^{-1}), SP is the soil test value for available phosphorus (kg ha^{-1}), SS is the soil test value for available sulfur (kg ha^{-1}), and SB is the soil test value for available boron (kg ha^{-1}).

3.4. Economic Analysis. Economic analysis was performed using partial budget analysis following the procedure of CIMMYT [28].

3.5. Statistical Analysis. Agronomic data were subjected to analysis of variance (ANOVA) using SAS 9.0 version software [29]. Least significant differences (LSDs) were used for mean separation comparison at a probability 5%.

4. Results and Discussions

4.1. Effect of Blended Fertilizer on Yield and Yield Components of Common Bean. The analysis of variance indicated that the main effect of varieties and NPSB rates had a highly significant effect ($p < 0.05$) on plant height (Table 2). The tallest plant height (97.96 cm) with the application of 100 kg·ha^{-1} NPSB rate, whereas the shortest plant height (79.6 cm) was recorded from 0 kg·ha^{-1} NPSB rate for the same variety (Table 2). The highest number of nodules per plant (39.2) and nodule dry weight (0.76 g) were recorded from variety awassa dume with application of 100 kg·ha^{-1} NPSB blended fertilizer, whereas the lowest nodules number (21) and nodule dry weight (0.20) were recorded from 0 kg·ha^{-1} by variety Nasir (Table 2). The highest number of primary branch per plant (4.6) was recorded for the Nasir variety with a blended fertilizer treatment (NPSB) of 100 kg·ha^{-1}, while the minimum number of primary branch per plant (2.8) was from the awassa variety Dume (Table 2). The highest number of pods per plant (52.04) was obtained from the application of 100 kg·ha^{-1} blended NPSB fertilizer rate from Nasir, whereas the minimum number of pods per plant (39.65) was recorded from 0 kg ha·$^{-1}$ NPSB fertilizer rates gave from awassa dume (Table 2). These results were consistent with the finding of Haleh et al. [30], Lake and Jemaludin [31] and, Turuko and Mohammed [28] reported yield and yield components statistically influenced by the application of NPSB application. The analysis of variance showed that the main effect of varieties and blended NPSB fertilizer rate had shown a highly significant ($p \leq 0.01$) effect at the same time the interaction of fertilizer application and varieties also had showed significant ($p < 0.01$) effect on the above ground dry biomass. The highest above ground dry biomass yield (5358 kg·ha^{-1}) gave at a fertilizer rate of 100 kg·ha^{-1} NPSB with variety awassa dume, whereas the lowest dry biomass yield (3918 kg·ha^{-1}) was obtained from control with variety Nasir (Figures 3(a)–3(c)). The highest hundred seed weight (28) was recorded from the variety awassa dume, while the minimum seed weight (21) gave with control from the Nasir variety (Figures 4(a)–4(c)). The highest harvest index (36.2) with an application rate of 100 kg·ha^{-1} blended fertilizer, whereas the lowest record (24.06) was registered from 0 kg·ha^{-1} NPSB rate for the same variety (Tables 3–5). According to Girma [29] who found a significant increment in the biological yield of common bean with an increased rate of NP fertilizers from 0 kg $P_20_5 \cdot ha^{-1}$ and 69 kg $P_20_5 \cdot ha^{-1}$ (150 kg DAP) and Tesfaye [30] reported that 100 seed weight in common bean increased with increase in phosphorus fertilizer application (69 kg·ha^{-1}).

4.2. Nutrient Use Efficiency. Variation in agronomic use efficiency appeared to result from differences between varieties and levels of NPSB fertilizer. Among NPSB application, the Nasir variety interacted with 100 kg·ha^{-1} NPSB level being observed with the greatest agronomic efficiency which reached 7.43 kg·kg^{-1} whereas, the awassa dume variety interacted with 250 kg·ha^{-1} NPSB level was low agronomic efficiency which reached 1.84 kg·kg^{-1}. As results indicated in (Table 6), the highest nutrient recovery efficiency (38.2%) was revealed with Nasir variety by fertilizer rate 100 kg·ha^{-1}, and the lowest nutrient recovery efficiency (3.67%) and (4.15%) was found from a fertilizer rate 250 kg·ha^{-1} with awassa dume and Nasir varieties, respectively (Figures 3(a)–3(d) and 4(a)–4(d)). The highest physiological nutrient use efficiency (6.74 kg·kg^{-1}) was recorded from the Nasir variety by a fertilizer rate of 100 kg·ha^{-1}. Since overhead findings, it was manifested that higher application of nutrient has resulted in more nutrient uptake (Figures 4(a)–4(d)). In line with this result, Malakouti [31] reported that the NPK fertilizer can increase fertilizer use efficiency and grain yield for different crops. Likewise, Jones et al. [32] stated that macronutrients and micronutrients of the grain yields of common bean were also increased [31].

4.3. Validation of the Fertilizer Requirement Equation. A confirmation study was leaded on the farmers' field for one year to verify the routine of the equation. In the confirmation study, six treatments including the soil-test based of NPSB rates, 98% of the soil test-based P rate, 93% of the soil test-based S rate, 61% of the soil test-based B, and NPSB

Table 2: Interaction effects of varieties and blended NPSB fertilizer rates on growth parameters of common bean at Meskan District in 2020 cropping season.

NSPB kg ha^{-1}	Number of primary branch per plant		Plant height (cm)		Number of nodules per plant		Nodule dry weight per plant		Number of pods per plant	
	Awassa dume	Nasir	Awassa dume	Nasir	Awassa dume	Nasir	Awassa dume	Nasir	Awassa dume	Nasir
0	2.8^{fgh}	4.13^{bcd}	79.6^{ghi}	85.26^{efg}	26^{hij}	21^{klm}	0.24^{efg}	0.20^{ghi}	39.65^{fgh}	42.6^{ef}
50	3.2^{efg}	4.2^{bc}	81.9^{fgh}	90.26^{cde}	30^{def}	24.5^{ijk}	0.38^{cd}	0.22^{fgh}	41.73^{efg}	44.69^{d}
100	3.6^{cde}	4.6^{a}	97.96^{a}	95.66^{bc}	39.2^{a}	27.46^{ghi}	0.76^{a}	0.28^{de}	43de	52.04^{a}
150	3.55^{cde}	4.6^{a}	97.66^{ab}	95.06^{bc}	38.5^{ab}	28.15^{fgh}	0.69^{b}	0.26^{def}	43.75^{de}	48.88^{c}
200	3.51^{bdef}	. 4.46^{b}	89.84^{cde}	92.8^{cd}	36.7^{abc}	28.73^{efg}	0.62^{bc}	0.26^{def}	44.81^{d}	49.70^{b}
250	3.48^{def}	4.13^{bcd}	86.6^{def}	92.66^{cd}	34.9^{cde}	28.25^{fgh}	0.59^{bc}	0.24^{efg}	44.92^{d}	49.10^{b}
LSD (0.05)	0.7	0.9	7.82	6.7	0.79	0.34	0.24	0.21	2.68	3.1
CV	7.68	5.65	7.37	5.1	4.11	5.1	6.26	6.2	2.30	2.7

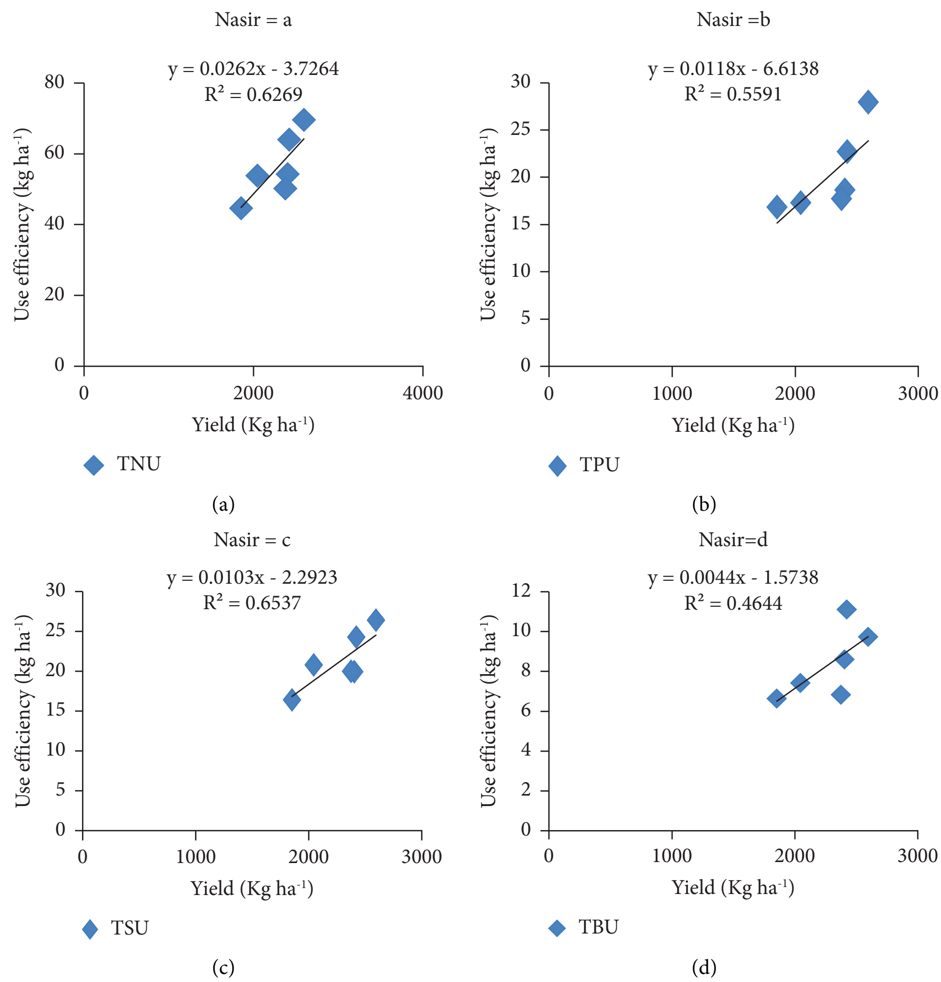

Figure 3: (a–d) Yield relation with uptakes of Nasir common bean variety.

recommendations (100 kg NPSB kg ha^{-1}) were evaluated on the grain yield of common bean verities. The data for calculating the fertilizer dose for the target yields of the awassa dume and Nasir varieties are shown in Tables 4 and 5. The application of NPSB blend fertilizer has a beneficial result of improving soil fertility and higher fertilizer use efficiency at 250 kg·ha^{-1} in both cases. For soil fertility management, it is necessary to select appropriate yield targets and apply fertilizers that produce the highest yields of awassa dume (2312 kg·ha^{-1}) and Nasir (2995 kg·ha^{-1}) at 100 kg NPSB ha^{-1}. Consistent with Tedesse and Dechassa [33] reported that the nutrient requirements of the common bean are high yielding.

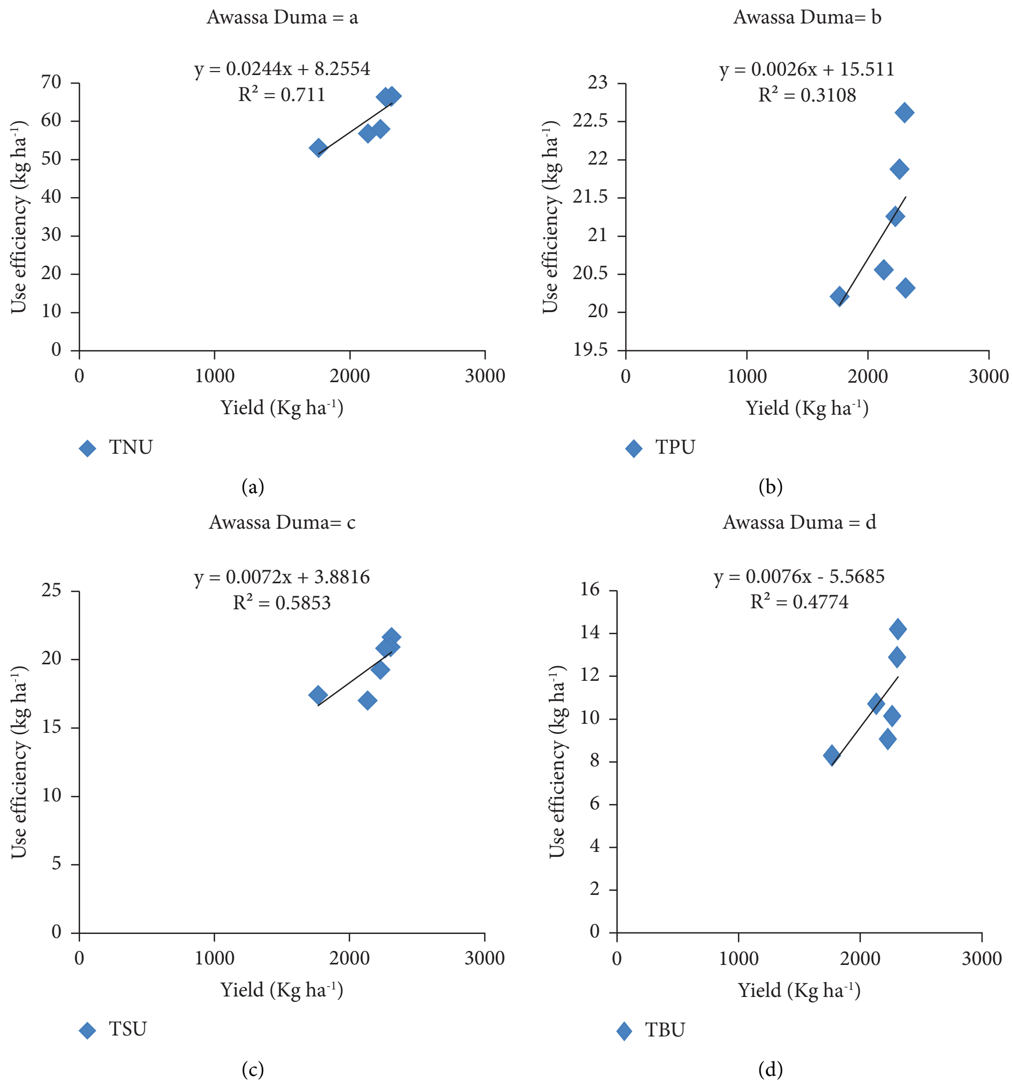

Figure 4: (a–d) Yield relation with uptakes of awassa dume common bean variety.

Table 3: Interaction effects of varieties and blended NPSB fertilizer rates on biomass yield and grain yield of common bean at Meskan in 2020 cropping season.

NSPB (kg ha^{-1})	Biomass yield (kg ha^{-1})		Grain yield (kg ha^{-1})		Harvest index (%)	
	Awassa dume	Nasir	Awassa dume	Nasir	Awassa dume	Nasir
0	4458^{def}	4268^{efg}	1768^{ghi}	1852^{fgh}	27.13^{ghi}	24.06^{hij}
50	5111^{b}	4576^{cde}	2133^{def}	2045^{efg}	27.23^{g}hi	29.6^{fgh}
100	5358^{a}	4988^{bc}	2312^{c}	2595^{a}	34.4^{b}	36.2^{a}
150	5266^{b}	4957^{bc}	2304^{cd}	2422^{b}	33.66^{bc}	34.10^{b}
200	5043^{bc}	4855^{c}	2264^{d}	2403^{b}	32.6^{cd}	31.6^{def}
250	4952^{bc}	4837^{c}	2227de	2375^{bc}	32.2^{cde}	31.2^{efg}
LSD (0.05)	19.87	20.9	26.9	27.82	11.9	5.6
CV	4.84	6.1	6.9	7.21	3.23	2.7

4.4. Partial Budget Analysis. The result of the data showed that the maximum and minimum gross benefit was obtained 70065 and 47736 ETB (Ethiopia Birr ha^{-1}) from a fertilizer rates 100 kg·ha^{-1} and 0 kg·ha^{-1} from Nassir and Hawssa Dume varieties, respectively. The highest net benefit 67665 ETB was recorded from a treatment treated by a fertilizer rate of 100 kg·ha^{-1} with the Nasir variety and the lowest net benefit 47736 ETB was received with a rate of 0 kg·ha^{-1} from the awassa dume variety. At the same time, the maximum rate of return (8.66%) was obtained with a fertilizer rate of 50 kg·ha^{-1} in the awassa dume variety (Table 7) and (13.65%) with a fertilizer rate of 100 kg·ha^{-1} with Nasir variety (Table 8).

Table 4: Basic data for computing fertilizer dose for targeted yields of awassa dume common bean variety at Meskan District, Gurage zone, Southern Ethiopia.

S.No	Treatments NPSB (Kg ha^{-1})	Nutrient requirement (Kg q^{-1})				Contribution of available nutrient from soil (%)				Contribution from applied fertilizer (%)			
		N	P	S	B	N	P	S	B	N	P	S	B
	0	3.00	1.14	0.90	0.46	7.69	3.13	0.96	4.38	—	—	—	—
	50	2.66	0.96	0.79	0.50	1.17	0.02	0.33	0.21	48.28	74.12	48.60	50.39
	100	2.88	0.87	0.93	0.61	0.66	0.17	0.21	0.14	100.88	121.03	101.59	100.14
	150	2.88	0.98	0.90	0.55	0.44	0.22	0.13	0.08	150.80	104.73	158.17	103.46
	200	2.93	0.96	0.91	0.44	0.32	0.10	0.10	0.05	207.29	76.08	204.29	197.57
	250	2.60	0.95	0.86	0.40	0.23	0.10	0.07	0.03	251.74	69.93	271.13	294.17

Table 5: Basic data for computing fertilizer dose for targeted yields of Nasir common bean variety at Meskan District, Gurage zone, Southern Ethiopia.

S.No	Treatments NPSB (Kg ha^{-1})	Nutrient requirement (Kg q^{-1})				Contribution of available nutrient from soil (%)				Contribution from applied fertilizer (%)			
		N	P	S	B	N	P	S	B	N	P	S	B
	0	2.6	0.90	0.88	0.35	74.31	2.92	0.91	3.51	—	—	—	—
	50	2.67	0.84	1.01	0.36	0.88	0.01	0.34	0.14	59.41	290.17	59.79	50.0
	100	2.64	1.07	1.01	0.37	0.50	0.11	0.19	0.09	131.89	251.06	135.45	99,63
	150	2.25	0.93	1.00	0.45	0.23	0.12	0.09	0.07	230.78	101.02	265.83	149.39
	200	2.11	0.77	0.82	0.35	0.08	0.12	0.02	0.04	620.54	65.14	676.14	149.55
	250	2.11	0.74	0.84	0.28	001	0.13	0.01	0.02	407.38	60.98	704.90	156.01

Table 6: Effect of blended fertilizer rates on nutrient use efficiency of common bean varieties.

Treatment kg ha^{-1}	Nutrient use efficiency					
	Awassa duma			Nasir		
	AE (kg kg^{-1})	RE (%)	PE (kg kg^{-1})	AE (kg kg^{-1})	RE (%)	PE (kg kg^{-1})
0	0.0	0.0	0.0	0.0	0.0	0.0
50	5.3^{b}	12.32^{f}	3.47^{efg}	3.86^{c}	29.98^{c}	1.95^{fgh}
100	5.44^{b}	34.35^{b}	4.36^{cd}	7.43^{a}	38.32^{a}	5.57^{b}
150	3.57^{cd}	15.87^{e}	4.37^{cd}	3.8^{c}	20.88^{d}	5.68^{b}
200	2.48^{ef}	10.4^{g}	4.14^{def}	2.76^{de}	8.49^{h}	5.43^{bc}
250	1.84^{fgh}	3.67^{ij}	4.24^{cde}	2.09^{efg}	4.15^{i}	6.4^{a}
Mean	3.11	12.77	3.43	3.32	16.97	4.17
LSD (0.05)	0.43	5.6	0.12	0.46	0.42	0.58
CV	5.09	6.08	5.04	0.92	5.07	0.18

Table 7: Marginal analysis of common bean variety as influenced by blended fertilizer rates.

Treatments (kg ha^{-1})	Varieties	Unadjusted yield (kg ha^{-1})	Adjusted yield (kg ha^{-1})	GB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	MRR (%)
0	Awassa dume	1768	1591.20	47736	0	47736	0
50	Awassa dume	2133	1919.7	57591	1200	56391	8.66
100	Awassa dume	2312	2080.8	62424	2400	60024	3.633
150	Awassa dume	2304	2073.6	62208	3600	58608	−1.42
200	Awassa dume	2264	2037.6	61128	4800	56328	−2.28
250	Awassa dume	2227	2004.3	60129	6000	54129	−2.20

Table 8: Marginal analysis of common bean variety as influenced by blended fertilizer rates.

Treatments kg	Varieties	Unadjusted yield (kg ha^{-1})	Adjusted yield (kg ha^{-1})	GB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	MRR (%)
0	Nassir	1852	1666.8	50004	0	50004	0
50	Nassir	2045	1840.5	55215	1200	54015	4.01
100	Nassir	2595	2335.5	70065	2400	67665	13.65
150	Nassir	2422	2179.8	65394	3600	61794	−5.871
200	Nassir	2403	2162.7	64881	4800	60081	−1.713
250	Nassir	2375	2137.5	64125	6000	58125	−1.96

GB: gross benefit, TVC: total variable cost, NB: net benefit, and MRR: marginal rate of return.

5. Conclusion

Low use of fertilizer and crop nutrient imbalance are the major constraint in realizing the high productivity of all cultivated crops in the study area. Thus, the study was conducted to assess the effect of different levels of blended NPSB fertilizer on growth, yield, and yield components, and use efficiency of common bean varieties. Treatments consisted of two common bean varieties with six blended NPSB fertilizer rates (0, 50, 100, 150, 200, and 250 kg·ha^{-1}) applied in RCBD with three replicates.

The result of the experiment revealed that the interaction of varieties and NPSB fertilization had showed a significant ($p \leq 0.01$) effect on plant height, nodule number, nodule dry weight, number of primary branches, number of pods per plant, biomass yield, grain yield, and harvest index. The partial budget analysis indicated that the highest net benefit (67665 ETB ha^{-1}) was obtained from variety Nasir with the application of 100 kg·ha^{-1} NPSB, whereas the lowest was from variety awassa dume (47736 ETB ha^{-1}) with no fertilizer application. Thus, it can be inferred that the application of 100 kg·ha^{-1} NPSB with variety Nasir was found to be higher and can be used for common bean production in the study area. However, the result of the study must be validated and approved in different agroecologies to give a comprehensive recommendation for a wide range of common bean production.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Tadesse Kifle and Mesfin Kassa contributed equally to this study.

Acknowledgments

The authors acknowledge the staff members of the Department of Plant Science, Wolaita Sodo University, and Wolkite University for providing them with the necessary support to conduct this study. This work was supported by Wolaita Sodo University and Wolkite University.

References

[1] M. M. Rahman, M. M. H. Bhuiyan, G. N. C. Satradhar, and A. K. Paul, "Effect of phosphorus, molybdenum and Rhizobium inoculation on yield and yield attributes of mungbean," *International Journal of Sustainable Crop Production*, vol. 3, no. 6, pp. 26–33, 2008.

[2] A. Mulugeta, "Factors affecting adoption of improved haricot bean varieties and associated agronomic practices in Dale woreda. SNNPRS," M.Sc. Thesis in Plant Sciences (Agronomy), awassa University, Awasa, Ethiopia, 2011.

[3] Agricultural Transformation Agency (Ata), "Transforming Agriculture in Ethiopia," Annual Report, Agricultural Transformation Agency (ATA), Addis Ababa, Ethiopia, 2014.

[4] T. Wossen, "Determination of optimum rate of blended fertilizer for pod yield of snap bean (Pharsalus vulgaris L.) at Teda, North Gondar, Ethiopia," *International Journal of Sciences: Basic and Applied Research*, vol. 32, pp. 66–79, 2017.

[5] Ethiopia Soil Information System, *Soil Fertility Status and Fertilizer Recommendation Atlas of the Southern Nations*, Nationalities and Peoples Regional State, Awasa, Ethiopia, 2016.

[6] T. Tesfaye and A. Balcha, "Effect of phosphorus application and varieties on grain yield and yield components of common bean (Phaseolus vulgaris L.)," *American Journal of Plant Nutrition and Fertilization Technology*, vol. 5, no. 3, pp. 79–84, 2015.

[7] Agricultural Transformation Agency (Ata), *Transforming Agriculture in Ethiopia*, Annual Report, Agricultural Transformation Agency (ATA), Addis Ababa, Ethiopia, 2014.

[8] M. Kumar, L. Baishaya, D. Ghosh et al., "Productivity and soil health of potato (Solanum tuberosum L.) field as influenced by organic manures, inorganic fertilizers and biofertilizers under high altitudes of eastern himalayas," *Journal of Agricultural Science*, vol. 4, no. 5, 2012.

[9] H. Marschner, *Mineral Nutrition of Higher Plants*, Academic Press, Amsterdam, The Netherlands, 2nd edition, 2002.

[10] N. S. Rana and R. Singh, "Effect of nitrogen and phosphorus on growth and yield of French bean (Phaseolus vulgaris L.)," *Indian Journal of Agronomy*, vol. 43, pp. 367–370, 1998.

[11] J. L. Havlin, J. D. Beaton, S. L. Tisdale, and W. L. Nelson, "Soil fertility and fertilizers: an highlands of Ethiopia," *African Journal of Agricultural Research*, vol. 3, no. 10, pp. 688–699, 1991.

[12] J. Landon, *Booker Tropical Soil Manual: A Hand Book for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics*, John Wiley & Sons, New York, NY, USA, 1991.

[13] S. R. Olsen, C. Cole, F. Watanabe, and L. Dean, *Estimation of Available Phosphorous in Soils by Extraction with Sodium Bicarbonate*, Department of Agriculture, Washington, DC, USA, 1954.

[14] H. Chopra and J. Kanwa, *Analytical Agricultural Chemistry*, Kalyani publisher Ldiana, New Delhi, India, 1976.

[15] P. R. Day, "Hydrometer method of particle size analysis," in *Methods of Soil Analysis*, C. A. Black, Ed., American Society of Agronomy, Wisconsin Argon, Madison, MI, USA, pp. 562-563, 1965.

[16] A. Walkley and I. A. Black, "An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration," *Soil Science*, vol. 37, no. 1, pp. 29–38, 1934.

[17] M. Jackson, *Soil Chemical Analysis*, Prentice Hall Grice, Englewood Cliffs, NJ, USA, 1973.

[18] H. D. Chapman, "Cation exchange capacity," in *Methods of Soil Analysis*, C. A. Black, Ed., American Society of Agronomy, Madison, WI, USA, pp. 891–901, 1965.

[19] U. Gupta, "Deficiency and toxicity symptoms of boron in plants," in *Boron and its Role in Crop Production*, U. C. Gupta, Ed., CRC Press, Boca Raton, FL, USA, 1993.

[20] Food and Agricutural Organization (Fao), *Fertilizers and Their Use*, Food and Agricultural Organization of the United Nations International fertilizer industry Association, Rome, Italy, 4th edition, 2014.

[21] N. Fageria, V. Baligar, and Y. Li, "The role of nutrient efficient plants in improving crop yields in the twenty first century," *Journal of Plant Nutrition*, vol. 31, 2015.

[22] Rao and Srivastava, "Soil test based fertilizer use a must for sustainable agriculture," *Fertiliser News*, vol. 45, pp. 25–38, 2000.

[23] Cimmyt, "From agronomic data to farmer recommendations: an economics work book. climate change", agronomy, vol. 3, no. 2, pp. 433-461, component of haricot bean (phaseolus vulgaris L.) in the semi-arid zones of the components of chickpea (cicer arietinum L.)," *Journal Agricultural. Biological. Science*, vol. 3, no. 4, pp. 220–223, 1988.

[24] Sas (Statistical Analysis System), *Soft ware Version 9.3*, SAS institute, Cary, NC, USA, 2012.

[25] H. Haleh, A. Tobeh, A. holipouri, A. Asghari, H. Mostafaei, and S. Jamaatie, "Effect of nitrogen and phosphorous on yield and protein content of lentil in dry and condition," *American-Eurasian Journal of Agricultural & Environmental Sciences*, vol. 8, no. 2, pp. 185–88, 2010.

[26] M. Lake and S. Jemaludin, "The response of common bean (phaseoluse vulgaris L.) to various levels of blended fertilizer," *International Journal of Research in Agriculture and Forestry*, vol. 5, no. 7, pp. 15–20, 2018.

[27] V. K. Singh, P. Gautam, G. Nanda et al., "Soil test based fertilizer application improves productivity, profitability and nutrient use efficiency of rice (oryza sativa L.) under direct seeded condition," *Agronomy*, vol. 11, no. 9, p. 1756, 2021.

[28] M. Turuko and A. Mohammed, "Effect of different phosphorus fertilizer rates on growth, dry matter yield and yield components of common bean (Phaseolus vulgaris L.)," *World Journal of Agricultural Research*, vol. 2, no. 3, pp. 88–92, 2014.

[29] A. Girma, "Effect of NP fertilizer and moisture conservation on the yield and yield components of haricot bean (phaseolus vulgaris L.) in the semi-arid zones of the central rift valley in Ethiopia," *Advances in Environmental Biology*, vol. 3, pp. 302–307, 2009.

[30] D. Tesfaye, *Response of Common Bean (Phaselous Vulgaris L.) to Application of Thesis*, University of awassa, Awassa College of Agriculture, Awasa, Ethiopia, 2015.

[31] M. J. Malakouti, "The effect of micronutrients in ensuring efficient use of Macronutrients," *Turkish Journal of Agriculture and Forestry*, vol. 32, pp. 215–220, 2008.

[32] C. Jones, R. Olson, and C. Dinkins, *Nutrient Uptake Timing by Crops: To Assist with Fertilizing Decisions*, Montana State University, Bozeman, MT, USA, 2011.

[33] N. Tedesse and N. Dechassa, "Effect of nitrogen and sulphur application on yield components and yield of common bean (Phaseolus vulgaris L.) in Eastern Ethiopia," pp. 23–25, Haramaya University of Agriculture, Haramaya, Africa, 2012, M.Sc. Thesis.

[34] A. Amanuel and A. Girma, "Production status, adoption of improved common bean (Phaseolus vulgaris L.) varieties and associated agronomic practices in Ethiopia," *Journal of Plant Science and Research*, vol. 5, no. 1, p. 178, 2018.

[35] Csa (Central Statistical Agency), "Agricultural sample survey 2015/2016: report on area and production of major crops (private peasant holdings, meher season). Volume-I," *Statistical Bulletin 584*, Standford Libraries, Addis Ababa, Ethiopia, 2016.