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Research Article

Response of Field pea (*Pisum sativum* L.) Varieties to Application of Blended NPS Fertilizer in Bore, Southern Ethiopia

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Abstract

Low soil fertility influences plant establishment, growth, seed yield and the profitability of a field pea production in the study area. A field experiment was conducted in Bore on station of Bore Agricultural Research Centre with five levels of NPS (0, 50, 100 and 150) with three varieties of field pea (Arjo-1 and Bilalo) in randomized complete block design with three replications. The aim of the study were to evaluate the effect of blended NPS rates on the yield and yield components of field pea varieties and to identify economically feasible rates of blended NPS that increase the productivity of the field pea. Growth, Yield and yield components of field pea were significantly influenced by different rates of blended fertilizer treatments.

Results showed significant effect of various levels of blended fertilizer on all tested parameters except on days to flowering, days to maturity and number of seed per pod. Variety Arjo-1 showed the highest plant height (182.1 cm), highest grain yield (5023 kg ha^{-1}) and highest net benefit (152299.5 Birr ha^{-1}) with application of 150 kg NPS ha^{-1}. Likewise, variety Bilalo with application of 150 kg blended NPS ha^{-1} fertilizer scored significantly the highest hundred seed weight (271.3 g). The highest number of total pods per plant (89.67) was recorded at application rate of 100 kg NPS ha^{-1} variety Arjo-1 and same application of fertilizer gave the highest agronomic efficiency (1282 %) for Bilalo variety. Although, minimum value of those traits were obtained with 0 kg ha^{-1}. Similarly, application of 50 kg NPS gave net benefit (132111.0 Birr ha^{-1}) with the highest marginal rate of return (129686 Birr ha^{-1}) with Arjo-1 variety. Therefore, production of field pea with the application of 50 kg NPS ha^{-1} was most productive for economical production.

Keywords: Arjo-1; Billalo; Nitrogen; Phosphorus; Sulphur

Introduction

Field pea (Pisum sativum L.) is a cool-season legume crop which grown for different purposes in different parts of the world. It is one of the world's oldest crops, as it was first cultivated with cereals as barley and wheat, 9000 years ago [30]. It is native crop of Syria, Iraq, Iran, Turkey, Israel, Jordan, Ethiopia, and Lebanon. It is also one of the most important food legumes in the world not only for its very old history of domestication, but also for its multipurpose use as vegetables, pulses and forage [5].

Pulse crops production in Ethiopia is 13.24 % (1,652,844.19 ha) of the total area of production [8]. In Ethiopia, the crop is widely grown in mid to high altitude and ranks fourth in area coverage reaching 212,890 ha with an annual production of 2,632,663.87 tons (t) (FAOSTAT, 2012). It is widely grown in the highlands of Ethiopia. It performs well at an altitude of 1800 – 3000 meter above sea level. In addition, the crop also better adapted under low rainfall environments as compared to other highland pulses such as Faba bean, lentil, and chickpea [31]. It is the major food legumes with a valuable and cheap source of protein having essential amino acids (23 to 25%) that have high nutritional values for resource poor households [35]. The crop has important ecological and economical advantages in the highlands of Ethiopia, as it plays a significant role in soil fertility restoration and also serves as a break crop suitable for rotation

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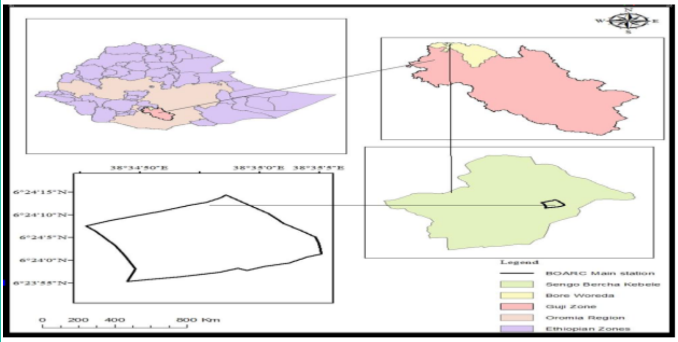

Figure 1: The description of study.

to minimize the negative impact of cereal based mono-cropping [2]. It is also used as a source of income for the farmers and foreign currency for the country [17].

Having all these multiple benefits in the economic lives of the farming communities, however, the average yield of the crop is only 1.24 t ha^{-1} in Ethiopia (FAOSTAT, 2012) which is far below the potential 40 to 50 t ha^{-1} traditionally achieved in Europe (Netherlands, France and Belgium) and the worldwide average yield of 1.7 t ha^{-1} [37]. Limited availability of adaptable high yielding improved varieties resistance to diseases, insects and abiotic calamities for wider/specific location and absence of appropriate agronomic recommendations can be cited as a major reason for this low productivity. Despite the potential for using fertilizers to increase yields and farm income, many smallholder farmers lack the resources to do so. The soil fertility mapping research in Ethiopia has revealed that major Ethiopian soils had insufficient levels of K, S, Zn, B, and Cu in addition to N and P, and as a result, they advise using balanced and personalized fertilizers [14]. This highlights the significance of creating alternative methods to supplement the usual N and P fertilizers with NPS that contains S in order to meet the requirement for nutrients in plants. Thus, the goals of this study were to determine economically viable blended NPS rates that would boost field pea productivity in southern Ethiopia as well as to evaluate the impact of blended NPS rates on faba bean yield and yield features.

Materials and Methods

Description of the Study Area

The experiment was conducted at the Bore Agricultural Research Center, Guji Zone of Southern Oromia, one of the recently created Research Centers of the Oromia Agricultural Research Institute (OARI), for three years in a row during the main cropping season. The site of the Bore Agricultural Research Center lies just off the main road that leads to Addis Abeba via the town of Hawassa, some 8 km north of the town of Bore. The experimental location is located at a height of 2728 m above sea level, between the latitudes of 06°23'55''N and 06°24'15''N and the longitudes of 38°34'45''E and 38°35'5''E. The study area corresponds to the highlands of the Guji Zone, which are known for heavy rainfall and bimodal rainfall distribution. The second rainy season begins in late November and lasts until the beginning of March, while the first rainy season lasts from April to October. Nitosols (red basaltic soils) and Orthic Aerosols are the two main types of soil. The soil has a clay loam texture and a pH of roughly 5.11, making it very acidic.

Experimental Materials

Two field pea varieties; Arjo-1 (kik type) and Bilalo (shiro type) were used. The variety Arjo-1 was released by Bako Agricultural Research Centre in 2005. Bilallo was released by Kulumsa Agricultural Research Center in 2012. Blended NPS (19% N, 38% P_2O_5, 7% S) was used as sources of N, P and S, respectively, for the study.

Treatments and Experimental Design

Two filed varieties, Arjo (kik type**)** and Bilalo (shiro type) were used for the study. The treatments consisted of four rates of NPS (0, 50, 100 and 150kg NPS ha^{-1}**.** The experiment was laid out as a Randomized Complete Block Design (RCBD) with factorial arrangements of 4x2=8 treatment combinations and replicated three times. The size of each plot was 3mx2.40m (7.2 m^2) and the distance between the plots and blocks were kept at 1m and 1.5m apart, respectively. Seeds were sown 40cm between rows and 10cm between plants. Each plot consisted of 6 rows. The net central unit areas of each plot consisting of 4 central rows of 2.4m length each (3.84m^2) were used for data collection and measurements.

Soil Sampling and Analysis

Pre-planting soil samples was taken randomly in a zig-zag fashion from the experimental plots at the depth of 0-30 cm and analyzed for selected physicochemical properties mainly textural analysis (sand silt and clay), soil pH, total Nitrogen (N), Available Sulphur (S), Organic Carbon (OC), Available Phosphorus (P), Cation Exchange Capacity (CEC) using the appropriate laboratory procedures at Horticoop Ethiopia (Horticultural) PLC Soil and Water Analysis Laboratory.

Organic Carbon (OC) was estimated by wet digestion method [43] and organic matter was calculated by multiplying the OC% by a factor of 1.724. Total nitrogen was analyzed by Kjeldhal method (Jackson, 1962). The soil pH was measured potentiometrically in 1:2.5 soil-water suspensions with standard glass electrode pH meter [42]. Cation Exchangeable Capacity (CEC) was determined by leaching the soil with neutral 1N ammonium acetate [14]. Available phosphorus was determined by the Olsen's method using a spectrophotometer [36]. Available sulfur (S) was measured using turbidimetric method [10]. The total nitrogen, phosphorus and sulphur balance were determined according to the following formula:

$$TNB = QNS - QNH \quad (1)$$

$$TPB = QPS - QPH \quad (2)$$

$$TSB = QSS - QSH \quad (3)$$

where TNB: total nitrogen balance, QNS: quantity of nitrogen before sowing, and QNH: quantity of nitrogen at harvest, TPB: total phosphorus balance, QPS: quantity of phosphorus before sowing, QPH: quantity of phosphorus at harvest, TSB: total Sulphur balance, QSS: quantity of sulphur before sowing and QSH: quantity of sulphur at harvest

Data Collection and Measurements

Phenological and growth parameters

Days to flowering: were recorded as the number of days from sowing to when 50% of plants in a net plot produced flower through visual observations.

Days to physiological maturity: were recorded as the number of days from sowing to the time when about 90% of the plants in a plot had mature pods in their upper parts with pods in the lower parts of the plants turning yellow. The yellowness and drying of leaves were used as indication of physiological maturity.

Plant height (cm)**:** was measured as the height (cm) of ten randomly taken plants from the ground level to the apex of each plant at the time of physiological maturity from the net plot area and the means were recorded as plant height.

Yield and yield attributes

Number of pods per plant: Number of pods was counted from ten randomly taken plants from the net plot area at harvest and the average was recorded as number of total pods per plant.

Number of seeds per pod: This was recorded from ten randomly taken pods from each net plot at harvest.

Test weight (g): was determined by taking weight of 100 randomly sampled seeds from the total harvest from each net plot area and the weight was adjusted to 10% moisture level.

Grain yield (kg ha^{-1}): The four central rows were threshed to determine seed yield and the seed yield was adjusted to moisture level of 10%. Finally, yield per plot was converted to per hectare basis and the average yield was reported in kg ha^{-1}.

Agronomic efficiency: was calculated in units of yield increase per unit of nutrient applied (Cleemput et al. 2008). The formula for agronomic efficiency for fertilizer application rate 1,2,3,4 are:

$AE_1 = Y_1\text{-}Y_0/F_1*100$, $AE2 = Y_2\text{-}Y_0/F_2*100$, $AE_3 = Y_3\text{-}Y_0/F*100$, $AE_4 = Y_4\text{-}Y_0/F_4*100$

where $Fertlizer_1$=50 kg NPS ha^{-1}, $Fertlizer_2$=100kg NPS ha^{-1}, $Fertlizer_3$=kg NPS ha^{-1}, $Fertlizer_4$=200 kg NPS ha^{-1} and Yo =Yield obtained from control plot, Y_1=Yield obtained from 50kg kg NPS ha^{-1}, application, Y_2 = Yield obtained from 100 kg NPS ha^{-1}, application, Y_3=Yield obtained from 150 kg NPS ha^{-1}, Y_4 =Yield obtained from 150 kg NPS ha^{-1} application.

Statistical Data Analysis

All the measured parameters were subjected to analysis of variance (ANOVA) appropriate to factorial experiment in RCBD according to the General Linear Model (GLM) of Gen Stat 15th edition [16] and the interpretations were made following the procedure described by Gomez and Gomez (1984). Least Significance Difference (LSD) test at 5% probability level was used for mean comparison when the ANOVA showed significant differences.

Table 1: Description of field pea varieties used for the study.

Characteristics	Varieties	
	Arjo-1	Bilalo
Altitude (masl)		
Rain fall (mm)		
Planting date		
Fertilizer rate (kg ha^{-1})		
Days of 50 flowering		
Days to 95% maturity		
Growth habit		
100 seed weight (g)		
Seed color		
Yield in research site (t ha^{-1})		
Year of release	2005	2012

Source: MoARD (2005 & 2012)

Economic Analysis

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

The Net Benefit (NB) was calculated as the difference between the gross benefit and the total cost. The average yield obtained from experimental plot was reduced by 10% to adjust with the expected farmers' yield by the same treatment. Prices of grain (Birr kg^{-1}) were obtained from local market for each variety: Arjo was 35 Birr kg^{-1} and Bilalo was 30 Birr kg^{-1}, and total sale from one hectare was computed using adjusted yield. Other costs such as cost of fertilizer (3500 Birr 100 kg^{-1} blended NPS) and its application cost were considered as the costs that vary for treatment to treatment.

Results and Discussion

Physico-Chemical Properties of the Experimental Site Soil

According to the soil textural class determination triangle, soil of the experimental site was found to be clay loam (Table 2). According to Tekalign's (1991) rating, the soil reaction of the experimental site is found in very strongly acidic (<4.5) to strongly acidic (4.5-5.2). This implies field pea planting without and with fertilizer was not contributed for changing the soil reaction. In contrary to this result, Tolera *et al*. (2009) crop rotation and N-P amendment significantly increased pH of the soil. The result of laboratory analysis showed that the total nitrogen percentage (0.29%) was optimum as per the rating of EthioSIS (2014). According to EthioSIS 2014 total nitrogen content (TN) of a soil can be classified as very low (<0.1%), low (0.1-0.5), optimum (0.15-0.3), high (0.3-0.5), very high (>0.5). According to this classification, the total nitrogen content of the soils from the study was found to be upper range of the optimum (0.27-0.30%) total nitrogen class. The total nitrogen concentration of site was increased by 3.33% from planting field pea with fertilizer application. This might be attributed due to biological nitrogen fixation of field pea. Similarly Kumar et al. (1983); and Holford and Crocker (1997) reported legumes in crop rotation improve soil fertility, particularly soil N content. A cumulative enhancement of the N-supplying power of the soil in maize-faba bean rotation in Toke Kutaye was reported by Tolera et al. (2015). Available P Olsen method was ranged available P level in the experimental site was from 6.09 to 8.61 and 11.02 to 12.42 ppm and found in low to medium range (Cottenie (1980). This low available phosphorus could be due to fixation in such acidic soils. Planting of field pea under limed was improved the available P was compared to before planting with and without fertilizer application at certain level. Planting of field pea with fertilizer was improved the available P by 2.61- 36.80 % as compared to before planting. Cation exchange capacity is the capacity of the soil to hold and exchange cations. The result showed that the CEC of

Table 2: Selected physico-chemical properties of the experimental soil at pre plant and post-harvest of field pea.

Soil parameters	Soil result at Pre-plant	Post-harvest result [Varieties × Blended NPS Fertilizer rate (kg ha^{-1})]							
		Arjo ×	Bilalo ×	Arjo ×	Arjo ×	Arjo ×	Bilal0 ×	Bilal ×	Bilalo ×
		0 kg	0 kg	50 kg	100 kg	150 kg	50 kg	100 kg	150 kg
pH (1:2.5 H_2O)	5.11	4.72	4.69	4.45	4.46	4.4	4.34	4.75	4.59
OC (%)	3.04	2.6	2.87	3.12	2.88	2.96	2.96	3.03	2.99
OM (%)	5.24	4.48	4.95	5.38	4.97	5.1	5.1	5.22	5.15
TN (%)	0.29	0.29	0.27	0.28	0.28	0.28	0.3	0.29	0.29
C: N (%)	10.48	8.97	10.63	11.14	10.29	10.57	9.87	10.45	10.31
P (mg/kg ppm)	7.85	6.09	6.93	12.42	8.06	11.02	11.24	8.61	6.78
S (mg/kg ppm	21.65	19.43	14.84	20.16	18.93	23.1	18.43	12.25	17.01
CEC (meq/kg soil)	24.61	22.77	24.31	29.04	23.53	30.12	23.74	25.47	26.97

the experimental soil ranged 22.77-32.12 meq/100g soils rated as medium to high according to rating of Landon (1991) and Hazelton and Murphy (2007). This soil has medium to high nutrient holding capacity level, water holding capacity, less susceptible to leaching losses of Mg^{2+} and K^+ and high organic matter contents for crop production. The total carbon content in the soil was found in range of 2.60-3.04% which was rated Medium/moderate to high as per the classification of Tekalign (1991). The nutrient class containing >8.0, 7.0-8.0, 3.0-7.0, 2.0-3.0, <0.2 mg/kg of OM ranging as very high, high, optimum, low and very low respectively as rated by Ethio SIS (2014). Thus, the OM content of the soil ranged from 5.10 - 5.24% which was optimum as rated by Ethio SIS (2014). The nutrient class range identified by Karltun (2013) indicated that soils containing >100, 80- 100, 20-80, 10-20, <10 mg/kg of sulfur ranging as very high, high, medium, low and very low respectively. Thus, the experimental soil was found in range of 12.25- 23.10 mg kg^{-1} which is low to medium in available S (Table 2).

Phenological and Growth Parameters of field pea

Days to flowering and physiological maturity

The analysis of variance showed that the interaction effect of variety and blended NPS application rates and main effects of varieties and blended NPS application rates were not significant,

Plant height

The analysis of variance showed significant ($P<0.05$) effect of varieties, blended NPS rates and their interaction on plant height at physiological maturity. Variety Arjo-1 showed the highest plant height (182.1 cm) with application of 150 kg NPS ha^{-1} whereas the shortest plants (160.4 cm) were seen for same variety without NPS fertilizer application (Table 2). Application of 150 kg NPS rate ha^{-1}increased plant height by 26.24% for Bilalo and 10.76 % for Arjo-1 compared to control (Table 2). The results shown in table below indicated that plant height due to interaction of varieties and application of blended NPSB fertilizer was not consistent for both varieties.

The result signified the vital role of combinations of the three nutrients to improve the plant height of field pea. The possible reason for the largest plant height at the N, P, and S combination of 18:39:7 kg ha^{-1} could be associated with the synergic effect of N, P, and S nutrients, which enhances plant height. Because of the cumulative role of the nutrients in cell division, cell expansion, and enlargement, this might have ultimately contributed to the increase in the plant height of field pea. Consistent with this result, Bekalu *et al*., 2022 reported that the application of mineral N, P, and K fertilizers at 46: 92:30 kg ha^{-1} produced 23.3% more height faba bean plants compared with the control treatment at Wolaita.

Number of Pods Per Plant

Significant ($P<0.05$) effects of blended NPS fertilizer application rate and varieties were observed on the number of total pods per plant. Increasing the rate of fertilizer application significantly and consistently increased the number of pods per plant for both varieties (Table 3). the Consequently, the highest number of total pods per plant (89.67) was recorded at application rate of 100 kg NPS ha^{-1} for variety Arjo-1 which was statistically at par with the number of pods per plant obtained with application 50 and 150 kg NPS ha^{-1} for same variety. However, the lowest average number of pods per plant (20.5) was produced by plants that grew with nil fertilizer variety Bilalo (Table 3). This signifies that the soil of the study area is, in fact, deficient in the availability of these three major nutrients, and an adequate supply of balanced N, P, and S nutrients is required to enhance the number of pods per plant. The increase in number of total pods with the increased NPS rates might possibly be due to adequate availability of N, P and S which might have facilitated the production of plant height, flowering and fruiting which might in turn have contributed for the production of higher number of total pods. In agreement with this result, Deresa *et al.* (2017) found that the number of pods per plant of common bean significantly increased in response to increasing the rate of 250 kg NPS ha^{-1}.

Thousand Seed Weight

The analysis of variance revealed that varieties, blended NPS rate and their interactions had highly significant ($P<0.01$) effect on hundred seed weight. Variety Bilalo with application of 150 kg blended NPS ha^{-1} fertilizer scored significantly the highest hundred seed weight (271.3 g) while the lowest hundred seed weight (198.3 g) was for variety Arjo-1 with 50 kg blended NPS ha^{-1} application rate (Table 3). This might be because nutrient use efficiency by crop was enhanced at optimum level of N, P and S since grain weight indicates the amount of resource utilized during critical growth periods. Sulphur availability and a nutrient-friendly environment throughout the peak development and blooming periods, which eventually led to an increase in the number of pods per plant, the number of seeds per pod,

Table 3: The effects of NPS rates on Phenological and growth parameters field pea at Bore.

NPS rate kg ha^{-1}	Days to flowering		Days to maturity		Plant height (cm)	
	Bilalo	Arjo-1	Bilalo	Arjo-1	Bilalo	Arjo-1
0	81.67	83.33	166.3	165.7	122.3^{f}	162.4^{cd}
50	82.33	83.67	164.7	164.0	128.1^{e}	163.5^{cd}
100	81.67	82.67	164.7	164.0	172.9^{b}	160.4^{d}
150	81.33	83.67	165.3	166.3	165.8^{c}	182.1^{a}
Mean	81.75	83.33	165.25	165.0	147.28	167.1
LSD (5%)	NS		NS		4.19	
CV (%)	1.404		0.9		1.50	

Table 4: The effects of NPS levels on yield and yield components of field pea at Bore.

NPS rate kg ha^{-1}	Number of pod per plant		Number of seed per pod		Test weight (g)		Grain Yield (kg ha^{-1})	
	Bilalo	Arjo-1	Bilalo	Arjo-1	Bilalo	Arjo-1	Bilalo	Arjo-1
0	20.50^{d}	48.92^{c}	5.25	4.92	255.0^{ab}	214.0^{c}	3595^{c}	4051^{b}
50	24.75^{d}	68.75^{b}	5.42	4.92	245.0^{b}	198.3^{c}	3678^{c}	4194^{b}
100	69.42^{b}	89.67^{a}	5.50	5.0	254.7^{a}	207.7^{c}	4319^{b}	4646^{ab}
150	30.50^{d}	84.83^{ab}	5.83	5.0	271.3^{a}	205.7^{c}	4238^{b}	5023^{a}
Mean	36.29	73.04	5.50	4.96	256.50	206.43	3957.5	4478.5
LSD (5%)	16.95		NS		24.95			
CV (%)	17.7		11.3		6.20		0.9	

Table 5: Mean agronomic efficiency of influenced by interaction of NPS rate and Variety of field pea.

Treatment combination	Grain Yield (kg ha^{-1})	Agronomic Efficiency (%)
Arjo × 0 kg ha^{-1}	4051	-
Arjo × 50 kg NPS kg ha^{-1}	4194	286
Arjo × 100 kg NPS kg ha^{-1}	4646	904
Arjo × 150 kg NPS kg ha^{-1}	5023	754
Bilalo × 0 kg ha^{-1}	3995	-
Bilalo × 50 kg NPS kg ha^{-1}	3678	-634
Bilalo × 100 kg NPS kg ha^{-1}	4319	1282
Bilalo × 150 kg NPS kg ha^{-1}	4238	-162

Table 6: Total nitrogen, phosphorus and Sulphur balance in the soil.

Treatment combination	Initial nutrient	Final Nutrient (ppm)			Nutrient Balance (ppm)		
		Final N	Final P	Final S	NB	PB	SB
Arjo 0 kg ha^{-1}	N = 0.29	0.29	6.09	19.43	0.0	-1.76	-2.22
Arjo × 50 NPS kg ha^{-1}	P = 7.85	0.28	12.42	20.16	-0.01	4.15	-1.49
Arjo × 100 NPS kg ha^{-1}	S = 21.65	0.28	8.06	18.93	-0.01	0.21	-2.72
Arjo × 150 NPS kg ha^{-1}		0.28	11.02	23.10	-0.01	3.17	1.45
Bilalo × 0 kg ha^{-1}		0.27	6.93	14.84	-0.02	-0.92	-6.81
Bilalo × 50 kg NPS kg ha^{-1}		0.30	11.24	18.43	0.01	3.39	-3.22
Bilalo × 100 NPS kg ha^{-1}		0.29	8.61	12.25	0.0	0.76	-9.40
Bilalo × 150 NPS kg ha^{-1}		0.29	6.78	17.01	0.0	-1.07	-4.64

N=Nitrogen, P=Phosphorus, S=Sulphur, NB=Nitrogen Balance, PB=Phosphorus Balance, SB=Sulphur Balance

and test weight. Source sink relationships and sink sizes may have improved as a result of enhanced growth characteristics. It might be the nutrient use efficiency by crop is enhanced at optimum level of N, P and S since grain weight indicates the amount of resource utilized during critical growth periods. The enhancement of the hundred seed weight in response to the interaction effect of the three nutrients can be attributed to a balanced supply of the nutrients for uptake by the plants, as suggested by Havlin et al. 2009. The improvement in hundred seed weight with fertilizer application is related to the influence of cell division, phosphorus content in the seeds as well as the formation of fat and albumin. The increase in hundred seed weight as a result of increased P application might be attributed to important roles the nutrient play in regenerative growth of the crop [44], leading to increased seed size (Fageria *et al.,* 2009), which in turn may improve hundred seed weight.

Grain Yield

Grain yields of field pea varieties were responded significantly to the application of blended fertilizer. The highest grain yield was recorded for variety Arjo-1 (5023 kg ha^{-1}) at application of150 kg NPS ha^{-1} which was followed by same variety (4646 kg ha^{-1}) at rate of blended 100 kg NPS ha^{-1} l while the lowest yield (3595 kg ha^{-1}) was observed for variety Bilalo at control fertilizer treatment (Table 3). With the application of fertilizer, a significantly higher seed yield was observed. "This was due to the increased photosynthesis and translocation of nutrients to various plant parts, which improved plant growth and yield-attributing characteristics of the crop as seen in the number of pods/plant and number of seeds/pod. The extra assimilates that had been stored in the leaves were later transferred to sink development, which helped to increase seed output". Differences in grain yield among varieties might also be related to their response to applied N, genotypic variations for P use efficiency and might also be due to increased levels of S, its availability along with major nutrients and higher uptake of crop and influencing growth and yield components of the crop, which ultimately lead to effective, assimilate partitioning of photosynthates from source to sink in post flowering stage and resulted in highest grain yield. Boroomandan *et al.* (2009) also reported that seed yield of soybean increased significantly at 40 kg N ha^{-1} compared to the control treatment. However, application of 80 kg N ha^{-1} decreased seed yield, indicating that there is a limit to the maximum level of nitrogen to be supplied to avoid its detrimental effect on the plant. In agreement with the result of this study, Gobeze and Legese (2015) and Mourice and Tryphone (2012) observed significant variations in grain yield for common bean due to genotypic variations for P use efficiency which may arise from variation in P acquisition and translocation and use of absorbed P for grain formation in common bean. application of S with or without P recorded significantly higher seed yield up to 40 kg S ha^{-1} on chickpea [39]; and on blackgram [24].

Agronomic Efficiency

Agronomic Efficiency (AE) was high significantly affected by NPS rates. The highest agronomic efficiency (1282 %) was obtained at application of 100 kg NPS ha^{-1} for Bilalo variety followed by agronomic efficiency of 100 kg NPS ha^{-1} for Arjo-1 while the lowest value (286%) was recorded for 50 kg NPS ha^{-1}.

The increase in agronomic efficiency at lower rate of NPS application and its decrease at higher rates might be due to the rate of increase in seed yield was lower than the rate of increase in NPS supply. In agreement with this result, [17] and (Davi *et al*., 2013) have reported decreases in agronomic efficiency with increasing in P supply for common bean and soybean respectively.

Nutrient Balance in the Soil after Cultivation

The results show that, at the end of the experiment, the total nitrogen, phosphorus and sulphur balance in the cultivation soil of most treatments are negative. Indeed, initial nitrogen, phosphorus and phosphorus in the soil were 0.29 ppm, 7.85 ppm and 21.65 ppm of soil respectively. However, at the end of the experiment, the result noted that decrease in the initial amount of nutrients in the soil. Thus, the amount of total nitrogen at harvest for treatment Bilalo×50 kg NPS kg ha^{-1} was higher than on the other treatments. Similarly, the higher amount of total phosphorus (12.42 ppm) and sulphur (23.10 ppm) at harvest

Table 7: Summary of partial budget analysis for the effects of NPS fertilizer application rates and variety.

Treatment combination	Grain Yield (kg ha^{-1})	Adjusted Grain Yield (kg ha^{-1})	Total variable cost (ETB ha^{-1})	Total Benefit (ETB ha^{-1})	Net Return (ETB ha^{-1})	MRR (%)
Arjo 0 kg ha^{-1}	4051	3645.9	562.5	127606.5	127044	
Bilalo 0 kg ha^{-1}	3995	3595.5	562.5	113238.0	112675.5	
Arjo × 50 kg NPS kg ha^{-1}	4194	3774.6	2425	132111.0	129686	913.32
Arjo × 100 kg NPS kg ha^{-1}	4646	4181.4	4175	146349.0	142174	713.60
Arjo × 150 kg NPS kg ha^{-1}	5023	4520.7	5925	158224.5	152299.5	578.60
Bilalo × 50 kg NPS kg ha^{-1}	3678	3310.2	2425	99306.0	96881	1583.39
Bilalo × 100 kg NPS kg ha^{-1}	4319	3887.1	4175	116613.0	112438	888.97
Bilalo × 150 kg NPS kg ha^{-1}	4238	3814.2	5975	114426.0	108451	-221.50

was obtained from treatment Arjo×50 NPS kg ha^{-1} and Arjo × 150 NPS kg ha^{-1} respectively. The N and S balance in the crop soils of almost all treatments are negative except Bilalo × 50 kg NPS kg ha^{-1} and Arjo×150 NPS kg ha^{-1} treatments respectively. Amazing positive P balance was resulted from both varieties at application of 50 kg NPS kg ha^{-1}. This result is further corroborated with the finding of Rasmata et al., who reported the soil nitrogen balance was generally positive with an increase of 0.326 g N kg^{-1} of soil, which represents a nitrogen input from the mung bean contributing to the improvement of the soil nitrogen status in Burkina Faso.

Economic Analysis

The agronomic data upon which the recommendations are based must be relevant to the farmers' own agro-ecological conditions, and the evaluation of those data must be consistent with the farmers' goals and socio-economic circumstances [6].

The net benefit was computed due to field pea, application of blended NPS fertilizer and interaction of variety with application of blended NPS fertilizer. The economic analysis revealed that highest net benefit (152299.50 ETB ha^{-1}) was obtained from application of 50 kg NPS ha^{-1} for Arjo-1 followed by treatment Arjo×100 kg NPS kg ha^{-1}.

On the other hand, the highest marginal rate of return (MRR) (1583.39 %) was obtained from the treatment of Bilalo×50 kg NPS kg ha^{-1} followed by treatment Arjo×50 kg NPS kg ha^{-1} (913.32 %). In contrast, the lowest net benefit was recorded from application of 50 kg NPS ha^{-1} (96881 ETB ha^{-1}) and 150 kg NPS ha^{-1} (108451 ETB ha^{-1}) for Bilalo (Table 8). The highest cost (5975 ETB ha^{-1}) and (5925 ETB ha^{-1}) was recorded for Bilalo×150 kg NPS kg ha^{-1} and Arjo×150 kg NPS kg ha^{-1} respectively. This implies an increased fertilizer rate increased the costs of products directly through increased seed cost, seed treatments, and crop management. &e partial budget, marginal analysis, and minimum rate of return together give the information necessary to arrive at a tentative or candidate recommendation. Therefore, production of field pea with the application of 50 kg NPS ha^{-1} gave the highest net benefit with a MRR which was higher than the minimum rate of return (100%) for economical production. Kiros and Atsede (2020) reported the highest net benefit (67132.20 ETB ha^{-1}) with maximum marginal rate of return (4106.68%) was gained when chickpea was inoculated with rhizobium and 125 kg ha^{-1} NPSB application at Laelay Maichew of Tigray.

Conclusion

Results showed significant effect of various levels of blended fertilizer on all tested parameters except on days to flowering, days to maturity and number of seed per pod. Variety Arjo-1 showed the highest plant height (182.1 cm), grain yield (5023 kg ha^{-1}) and net benefit (152299.5 Birr ha^{-1}) with application of 150 kg NPS ha^{-1}. Likewise, variety Bilalo with application of 150 kg NPS ha^{-1} fertilizer scored significantly the highest hundred seed weight (271.3 g). The highest number of total pods per plant (89.67) was recorded at application rate of 100 kg NPS ha^{-1} variety Arjo-1 and highest agronomic efficiency (1282 %) for Bilalo variety at 100 kg NPS ha^{-1}. Although, minimum value of those traits were obtained with 0 kg ha^{-1}. Similarly, application of 50 kg NPS gave net benefit (132111.0 Birr ha^{-1}) with the highest marginal rate of return (129686 Birr ha^{-1}) with Arjo-1 variety. Results of the partial budget analysis showed that the highest net benefit with acceptable marginal rate of return (>100%) was obtained from Bilalo × 50 kg NPS kg ha^{-1}. Therefore, production of field pea with the application of 50 kg NPS ha^{-1} was most productive for economical production and can be recommended for highlands of Guji Zone.

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