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Effect of Different Blended Fertilizer Formulation on Yield and Yield Components of Bread Wheat (Triticum aestivum L.) in Siyadebrenawayu District, North Shewa, Ethiopia

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Abstract
Wheat **(**Triticum aestivum L.**)** is one of the most important cereal crops in Ethiopia. However, the yield of the crop is low mainly due to low soil fertility and poor soil fertility management practices. Field experiment was conducted during 2017 cropping season in Siyadebrenawayu district , central Ethiopia with the objective to evaluate the effect of different blended fertilizer formulation of S, B, Zn and K on yield and yield components of bread wheat. The 14 treatments used for the field experiment were (1) control, (2) recommended NP(175 kgha^{-1}N+125 kgha^{-1} P_2O_5), (3) S_1(10.5 kgha^{-1}), (4) S_2(15.75 kgha^{-1}), (5) S_3(21 kgha^{-1}), (6) S_1B_1(10.35 S, 0.15B) kgha^{-1}, (7) S_2B_2(15.5 S, 1.5B) kgha^{-1}, (8) S_3B_3(20.7 S, 3B) kgha^{-1}, (9) $S_1B_1Zn_1$ (11.1S, 0.15B, 3.3Zn) kgha^{-1}, (10) $S_2B_2Zn_2$(16.65S, 1.5B, 4.95Zn) kgha^{-1}, (11) $S_3B_3Zn_3$(22.2S, 3B, 6.6Zn) kgha^{-1},(12) S_1B_1 Zn_1K_1 (11.1S, 0.15B, 3.3Zn, 50K) kgha^{-1}, (13) $S_2B_2Zn_2K_2$ (16,65S, 1.5B, 4.95Zn, 100K) kgha^{-1}and (14) $S_3B_3Zn_3K_3$(22.2S, 3B, 6.6Zn, 150K) kg ha^{-1}. The recommended NP fertilizers are equally applied to all treatments except control. The experiment was conducted in randomize complete block design with three replications. Data were collected on yield and yield components. Yield and yield components of bread wheat was significantly affected by the treatments except 1000-grain weight. The highest above ground dry biomass yield (14.29 tha^{-1}), highest grain yield (5.77 tha^{-1}) and straw yield (8.51 tha^{-1}) was recorded from additional application of S, B, and Zn at T9 ($NPS_1B_1Zn_1$). The application of blended fertilizer $NPS_1B_1Zn_1$ increased the straw and grain yield by 35.45% and 19% respectively as compared to the recommended NP fertilizer. The highest net return (58443ETB ha^{-1}) with (MRR %) 742.18 was obtained with application of blended fertilizer $NPS_1B_1Zn_1$. It is clearly observed from collected data and soil analysis that application of K fertilizer is not responsive in study area but, S, B and Zn application at the minimum rate is responsive and economically feasible. Therefore, application of blended fertilizer $NPS_1B_1Zn_1$ (175 kgha^{-1}N+125 kgha^{-1}P_2O_5+11.1 kgha^{-1}S+3.3 kgha^{-1} Zn+0.15 kg ha^{-1} B) can be recommended for higher yield particularly in the study area and it is also economically feasible.
Keywords: Biomass yield, blended fertilizer, economic feasibility, grain yield
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1. INTRODUCTION

Wheat (*Triticum* spp.) is one of the major cereal crops grown in the highlands of Ethiopia and this region is regarded as the largest wheat producer in Sub-Saharan Africa (Efrem *et al*., 2000). In Ethiopia wheat has become one of the most important cereal crops ranking fourth both in total grain production (4.54 million tons) and area coverage (1.69 million hectare) next to teff, maize and sorghum (CSA, 2017). Though Ethiopian agro-climatic condition is suitable for wheat production, the productivity is low (2.67 tha^{-1}) (CSA, 2017). This is because of depleted soil fertility, low levels of chemical fertilizer usage, limited knowledge on time and rate of fertilizer application, and the unavailability of other modern crop management inputs (Anderson and Schneider, 2010). As summarized by Tekalign *et al*. (2001), nitrogen (N) is deficient in almost all soils and phosphorus (P) is deficient in about 70% of the soils in Ethiopia. This low nutrient content is due to erosion and absence of nutrient recycling.

Most research work focus on NP requirements of crops, limited information is available on various sources of fertilizers K, S, Zn and B and other micronutrients. Therefore, application of other sources of nutrients beyond urea and DAP, especially those containing K, S, Zn and other micro-nutrients increase crop productivity (CSA, 2011). This can be achieved by application of blended fertilizers, the mechanical mixture of two or more granular fertilizer materials containing N, P, K and other essential plant nutrients such as S, Zn, and B, recently known to Ethiopia. Recently, it was reported that crops have been suffering from deficiencies of several nutrients throughout the country. According to the atlas of soil fertility made by EthioSIS, seven soil nutrients (N, P, K, S, Zn, B and Cu) are found to be deficient in the soils of Amhara region (ATA, 2016). Application of balanced fertilizers could be the basis to produce more crop output from existing land under cultivation and nutrient needs of crops according to their physiological requirements and expected yields (Ryan, 2008). Experience in Malawi provides how N fertilizer efficiency for maize can be raised by providing S, Zn, B, and K which increased maize yields by 40% over the standard N-P recommendation alone (John *et al*., 2000).

Understanding plant nutrients requirement of a given area has vital role in enhancing crop production and productivity on sustainable basis. Nevertheless, little information is available on blended fertilizers requirement including macro and micro plant nutrients in the study area. Increasing yields through the application of nitrogen and phosphorus alone can deplete other nutrients (FAO, 2000). However, crop productivity can also be limited because of toxicity and/or deficiency of essential plant nutrients. Therefore, understanding the plant nutrients requirement of an area could help to implement demand-driven soil fertility management practices. Hence, the objective of this study was to evaluate the effect of different blended fertilizer formulation rates of S, B, Zn and K on yield and yield components of bread wheat in Siyadebrenawayu District and to evaluate the economic feasibility of the fertilizers.

2. MATERIALS AND METHODS

2.1. Description of the Experimental Site

The experiment was conducted at Siyadebrenawayu District Siyadebre Kebele, in North Shewa Amhara Regional State, during the 2017 main cropping season. The site is located at 09^{0}47'12.4" north latitude and 039^{0}04'19.5 "east longitude with an elevation of 2600 masl and 147 km north of Addis Ababa (Figure 1). The average annual rainfall at Siyadebre (2008 to 2017), the nearby metrological station, is 829.5 mm having minimum and maximum temperatures of 6.9 and 22.7 ^{0}C, respectively. The area was predominantly found to have clay textural class with a swelling and cracking nature of black colored *vertisols* soil type.

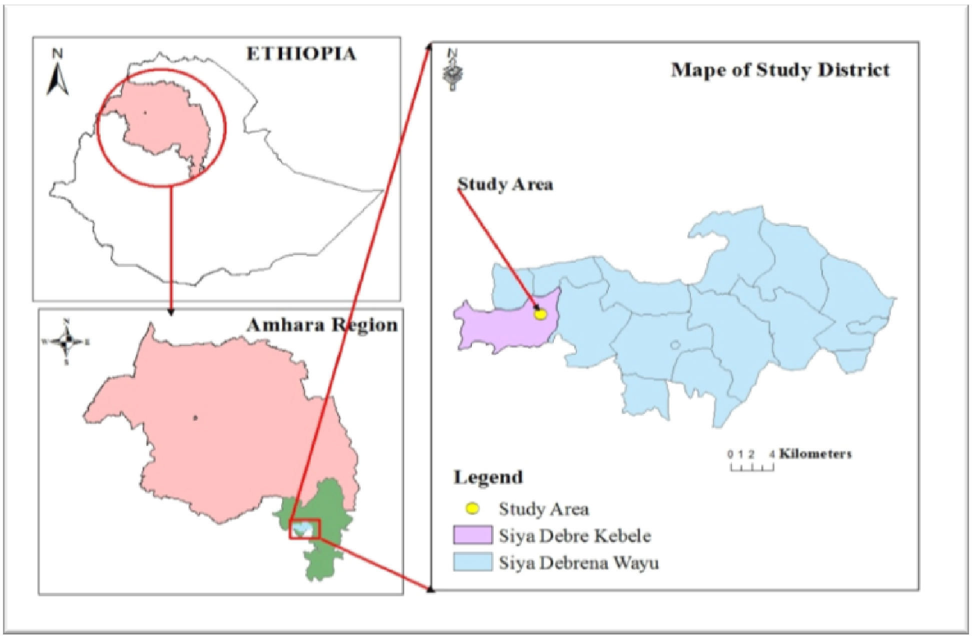

Figure 1. Location map of the experimental site

2.2. Treatments, Experimental Designs and Procedures

The experiment was laid out in randomized complete block design (RCBD) with three replications. The 14 treatments of the experiments were as in Table 1. The size of each experimental plot was 3m x 2m (6m^2), with a total of 42 plots. Spacing between rows, plots, and blocks was 0.2 m, 0.5 m, and 1 m respectively. Bread wheat variety Danda'a @100 kg seed ha was used and sown uniformly drilled into the rows made by hand hoe on 28 July 2017. The full dose of DAP, all blended fertilizers and one-third of fertilizer N were applied uniformly within the rows at sowing. The remaining two-thirds of each N fertilizer treatment were top-dressed on the inter-row spaces by hand at the mid-tillering stage. During the different growth stages of the crop, all the necessary field management practices were carried out as per the practices followed by the farming community around the areas. Net plot size 4.8 m^2 was used for the data collection.

Table. 1. Treatments description, fertilizer rates and their composition

Treatments	Nutrients (kg ha^{-1})					
	N	P_2O_5	K_2O	S	Zn	B
T1 (Control)	-	-	-	-	-	-
T2 (Recommended NP)	175	125	-	-	-	-
T3 (NPS1)	175	125	-	10.5	-	-
T4 (NPS2)	175	125	-	15.75	-	-
T5 (NPS3)	175	125	-	21	-	-
T6 (NPS1B1)	175	125	-	10.35	-	0.15
T7 (NPS2B2)	175	125	-	15.5	-	1.5
T8 (NPS3B3)	175	125	-	20.7	-	3
T9 (NPS1B1Zn1)	175	125	-	11.1	3.3	0.15
T10 (NPS2B2Zn2)	175	125	-	16.65	4.95	1.5
T11 (NPS3B3Zn3)	175	125	-	22.2	6.6	3
T12 (NPS1B1Zn1K1)	175	125	50	11.1	3.3	0.15
T13 (NPS2B2Zn2K2)	175	125	100	16.65	4.95	1.5
T14 (NPS3B3Zn3K3)	175	125	150	22.2	6.6	3

2.3. Agronomic Data Collection

Data on plant basis was recorded from the eight central rows (4.8 m^2) out of the ten rows per plot. The crop data collected include days to 50% heading, days to 90% maturity, plant height, number of total tillers per plant, number of effective tillers per plant, number of seeds per spike, spike length, thousand seed weight, aboveground dry biomass yield, grain yield, straw yield and harvest index.

Data on days to 50% heading (DH) and days to 90% maturity were recorded when 50% and 90% of wheat stands reached the respective phenological stages. Measurements of yield attributes were taken at physiological maturity of the crop prior to harvest. Plant height, number of tillers (effective tillers and total tillers) per plant, spike length and number of seeds per spike was recorded from10 randomly selected plants from the central unit area. Plant height was recorded from ground level to the top of the spike excluding awns.

The crop was harvested from the net plot areas manually using sickle at the ground level and dry mater yield of the above ground biomass was determined. Grain moisture content was determined and grain yield was adjusted to 12.5 % moisture content. Straw yield was calculated as the difference between above-ground biomass and grain yield. Harvest index was calculated as the percentage ratio of grain yield to the total above ground biomass yield. Thousand seed weight was determined by using seed counter and weighting 1000 seeds sample taken from each plot.

2.4. Soil Sampling and Analysis

Twenty soil samples (0-30 cm depth) were collected from the experimental field by Auger sampler using a zigzag pattern from the whole experimental plots and composited into one sample before sowing the crop. From this mixture, a sample weighing one kg was taken. Air dried soil sample was ground with a pestle and mortar. Before analysis, the sample was sieved through a 2-mm sieve for selected chemical and physical soil properties. Organic carbon content was determined by the volumetric methods (Walkley and Black, 1947). Total N was analyzed by the Micro-Kjeldhal digestion method with sulphuric acid (Jackson, 1962). The pH of the soil was determined according to FAO (2008) using 1:2.5 (weight/volume) soil sample to H_2O ratio using a glass electrode attached to a digital pH meter. To determine the Cation exchange capacity (CEC), the soil sample first was leached using 1 M ammonium acetate, washed with ethanol and the adsorbed ammonium was replaced by sodium (Na). Then, the CEC was determined titrimetrically by distillation of ammonia that was displaced by Na (Hesse, 1972). Available P was determined by the Olsen's method (Olsen *et al*., 1954).The exchangeable bases (K and Na) in the soil were determined from the leachate of 1 molar ammonium acetate (NH_4OAc). Available B was determined using hot water method (Berger and Truog, 1939). Available S was determined by monocalcium phosphate extraction method or turbidimetric estimation (Johnson and Fixen, 1990) and available Zn was determined by DTPA (dietylene triamine penta acetatic acid) method (Lindsay and Norvell, 1978). Particle size distribution was determined by the hydrometer method according to FAO (2008) using particles less than 2 mm diameter.

2.5. Economic Analysis

Economic analysis was performed to investigate the economic feasibility of the treatments. Partial budget and marginal analyses were used. Current prices of wheat, urea, DAP and blended fertilizer were used for the analysis. The potential response of crop towards the added fertilizer and price of fertilizers during planting ultimately determine the economic feasibility of fertilizer application (CIMMYT, 1988).The market cost of wheat was 11.80 Ethiopian Birr (ETB) kg^{-1}. Field prices for Blended fertilizer (NPS, NPSB, NPSZnB), KCl, Borax, P and N from DAP and urea were taken as 11.70 Birr kg^{-1}, 14.50 Birr kg^{-1}, 12.50 Birr kg^{-1}, 14.60 Birr kg^{-} 1, and 9 Birr kg^{-1} of nutrient, respectively. The cost of application and transport for fertilizer was taken to be 45 Birr 100 kg^{-1}. The costs of harvesting and bagging were taken at 60Birr 100 kg^{-1} of grain harvest. Analysis of marginal rate of return (MRR) was carried out for non-dominated treatments, and the MRRs were compared to a minimum acceptable rate of return (MARR) of 100% in order to select the optimum treatment.

2.6. Data Analysis

The data was subjected to analysis of variance (ANOVA) as per the design used in the experiment SAS version 9.4 Statistical Software. Comparisons among treatment means were made using Duncan's Multiple Range Test (DMRT) at 5% level of significance (SAS Institute, 2015). Pearson correlations were done to determine linear associations between agronomic parameters.

3. RESULTS AND DISCUSSION

3.1. Selected Soil Physical and Chemical Properties of the Site

Soil analysis indicated that the textural class of the surface soil was clay and the soil was moderately acidic (pH 6) with low organic carbon and total nitrogen N contents (Landon, 1991) (Table 2). The cation exchange capacity (CEC) of the soil was high and exchangeable K concentrations in the soil were adequate for crop production. Available phosphorus (P) content (20.05 ppm) was high (Olsen *et al.* 1954). It could be due to repeated P fertilizer application to the study area. Available B and Zn (ppm) contents of the soil in the study area were low (Jones, 2003). According to Havlin *et al*. (2003) available S (ppm) content of the soil in the study area is 0.231 which is low. Exchangeable K content of experimental site soil was 0.844 (cmol(+)kg soil) which is high (Berhanu, 1980). Generally, the result of the study showed that the soils of the study site had low available S, B and Zn which indicated that potentially limited the yield of wheat crops. However, the soils of the study site had high exchangeable K. Thus, additional application of S, B and Zn had increased the grain yield of wheat but, additional application of K had not increased grain yield of wheat crop.

Table 2. Selected Soil physical and chemical characteristics of the study area before sowing.

Soil Characteristic	Value
Texture Class	Clay
pH-H2O (1:2.5)	6.0
OC (%)	1.19
OM (%)	2.05
Total N (%)	0.12
CEC (cmol(+)kg soil)	36.56
P (ppm)	20.05
S (ppm)	0.231
B (ppm)	0.45
Zn (ppm)	0.36
Exchangeable K (cmol(+)kg soil)	0.844
Exchangeable Na (cmol(+)kg soil)	0.72

3.2. Phenological Parameters and Plant Height

3.2.1. Days to 50% heading

The analysis of variance revealed that blended fertilizer application significantly ($P < 0.01$) influenced days to 50% heading (Table 3). Application of blended fertilizers reduced the days to 50% heading by 11 days as compared to control. This finding indicated that the combination of NP fertilizer with K, S, Zn and B, enhanced the early heading of wheat (Table 3).

The result also indicated that the recommended treatment (T2) had no significant difference with all blended treatments. Since N and P are major nutrients, which are important for promoted vegetative growth and dates of flowering of crops. This result is in line with Debritu (2013) who reported that the supply of N and P are important to vigorous growth and early heading of wheat crop. On the contrary Adera (2016) reported that with the increase in blended fertilizer rates of S, B, Zn, the number of days required for flowering, maturity and grain filling period was reduced in teff.

3.2.2. Days to 90% physiological maturity

Days to 90% physiological maturity was significantly ($P<0.01$) affected by blended fertilizer application as compared to control treatment (Table 3). All the blended fertilizer formulations resulted in significantly reduced days to attain maturity than the control treatment (T1). The results revealed that addition of K, S, Zn and B in each fertilizer formulation brought earliness in days to 90% physiological maturity than unfertilized plot (Table 3). To some extent the presence of Zn and B in blended fertilizer might have also helped in enhancing the days to attain physiological maturity early. This could be due to the presence of Zn and B which played an important role in protein synthesis, formulation of some growth hormone and promote seed maturation and production (Tisdale *et al*., 2002). Similarly, Siddiqui *et al*. (2009) who reported that incorporation of Zn with macro nutrients (NPK) fertilizer increased the nutrient uptake of N, P and B which in turn facilitated grain filling process and shortened the maturity period in sunflower.

3.2.3. Plant height

Plant height is one of the main vegetative growth parameter of wheat plant which represents the genetic variation and fertilizer effect. The mean of plant height and the analysis of variance are shown in (Table 3). There were significant variations ($P< 0.001$) among the fertilizers types on wheat height. Application of blended fertilizer significantly increased plant height as compared to the control. Similarly, the recommended NP fertilizers also significantly increased plant height as compared to the control. However, supplementation of S, B and Zn to the recommended NP fertilizers did not bring about a significant difference in plant height. The increment in plant height might be due to increase in cell elongation and more vegetative growth attributed to different nutrient content of blended fertilizer containing NPS and micronutrients. On the other hand the least plant height in unfertilized plots might have been due to low soil fertility level in the study area. In conformity with the results obtained from this study, plant growth and development may be retarded significantly if any of nutrient elements is less than its threshold value in the soil or not adequately balanced with other nutrient elements (Landon, 1991).

Table 3. Effect of blended fertilizer rates on days to 50% head emergence (DH), days to 90% physiological maturity (DPM) and plant height (PH) of bread wheat

Treatments	**DH**	**DPM**	**PH (cm)**
T1. Control	78.33^{a}	130.67^{a}	53.6^{d}
T2. Recommended(NP)	69.00^{bc}	123.67^{b}	83.6^{ab}
T3. NPS1	72.00^{b}	122.33^{b}	80.83^{abc}
T4. NPS2	70.67^{bc}	123.00^{b}	80.33^{abc}
T5. NPS3	71.00^{bc}	123.33^{b}	82.9^{ab}
T6. NPS1B1	73.00^{b}	125.00^{b}	85.5^{ab}
T7. NPS2B2	71.67^{b}	125.00^{b}	83.23^{ab}
T8. NPS3B3	72.67^{b}	125.00^{b}	85.73^{ab}
T9. NPS1B1Zn1	66.67^{c}	122.67^{b}	86.67^{a}
T10. NPS2B2Zn2	70.67^{bc}	123.00^{b}	83.1^{ab}
T11. NPS3B3Zn3	72.33^{b}	124.00^{b}	77.87^{bc}
T12. NPS1B1Zn1K1	70.67^{bc}	124.00^{b}	84.87^{ab}
T13. NPS2B2Zn2K2	68.67^{bc}	123.33^{b}	81.17^{abc}
T14. NPS3B3Zn3K3	71.00^{bc}	123.00^{b}	73.9^{c}
Significant	**	**	***
CV (%)	3.56	1.43	5.00

Note: Mean values followed by the same letters in each column and treatment showed no significant difference by DMRT ($p = 0.05$). **, ***, denotes significance at $p = 0.01, 0.001$, respectively

The result also indicated that recommended treatment and all blend fertilizer treatment except T_{14} had similarly influenced on plant height. The reason might be the constant level of nitrogen and phosphorus used throughout all blend fertilizer treatment, which stimulated vegetative growth uniformly but, T_{14} had significance difference and shorter plant height as compared to T_2. The result revealed that additional application of K at higher formulation on NPSBZn might have not influenced on plant height to significant levels and it also may be due to nutrient imbalance caused by high rate of K application. This finding is in line with Debnath *et al*. (2011) reported that boron application had significant effect on the plant height of wheat. On the Contrary, Riffat *et al*. (2007) reported that Zn application between 0 and 10 kg ha^{-1} levels has showed statistically non-significant difference on plant height of wheat.

3.3. Yield and Yield Components

3.3.1. Number of total and effective tillers per plant

The analysis of variance showed that application of blended fertilizers significantly ($P < 0.01$) influenced number of total and effective tiller per plant (Table 4). Application of blended fertilizer significantly increased number of total and effective tiller per plant as compared to the control. Similarly, the recommended NP fertilizers also significantly increased number of total tiller and effective per plant as compared to the control. The minimum number of total and effective tillers per plant was recorded at control (Table 4).

The result indicated that blended fertilizers with different macronutrients (K, S) and micronutrients (B, Zn) did not bring any significant effect on number of total tillers and effective tillers per plant compared with recommended treatment (T_2). Additionally, the uniform dose of N and P in all the treatments might have played a significant role in the formation of total and effective tiller number per plant (Tilahun *et al*., 2000).

In line with this result, Frehiwot (2014) reported that N and P fertilizer had potential role in number of total and effective tiller production per plant. On other hand, applications of blended fertilizers (NPS+ZnB) were on parity with the blanket recommendation of DAP and Urea fertilizers and gave significantly higher number of total and effective tillers of wheat (Hailu, 2014). On the contrary, Esayas (2015) reported that no significant difference in total and productive of tillers per plant among the application of different blended fertilizers in wheat.

3.3.2. Number of seeds per spike

The analysis of variance showed that application of blended fertilizers significantly ($P < 0.01$) influenced the number of seeds produced per spike as compared to unfertilized plots (Table 4). Plants grow in field experiment with blended fertilizer application enhanced number of seeds per plant by 54%, 52% and 51% over the control treatments (T_9, T_{10}, and T_{12}) respectively. It also indicated that blended fertilizer application enhanced number of seeds per plant by 8%, 6% and 5.6% over the recommended NP (T_9, T_{10}, and T_{12}) treatments respectively. This shows the combined effect of macro and micro nutrients throughout the growing period did not caused the plants in nutrient stress at any stage and results in increased seed number per spike and grain production. In agreement with this result, Debnath *et al*. (2011) reported that B application results in significant improvement in the number of seeds per spike of wheat.

Table 4. Effect of blended fertilizer rates on number of total tiller (TT), effective tillers (ET), number of seed (NS) and spike length (SL) of bread wheat.

Treatment	TT (plt^{-1})	ET (plt^{-1})	NS (Sp^{-1})	SL (cm)
T1. Control	3.57^{e}	2.43^{f}	32.73^{c}	5.5^{d}
T2. Recommended(NP)	6.97^{a}	5.17^{abc}	46.67^{ab}	8.2^{abc}
T3. NPS1	6.13^{abc}	4.7^{bcd}	47.77^{ab}	8.03^{abc}
T4. NPS2	6.33^{abc}	4.7^{bcd}	46.47^{ab}	8.17^{abc}
T5. NPS3	5.43^{bcd}	4.13^{cde}	47.76^{ab}	8.13^{abc}
T6. NPS1B1	7.2^{a}	5.87^{a}	47.13^{ab}	9.0^{a}
T7. NPS2B2	5.37^{cd}	3.93^{de}	45.57^{ab}	8.17^{abc}
T8. NPS3B3	5.8^{bcd}	4.6^{bcde}	45.36^{ab}	8.27^{ab}
T9. NPS1B1Zn1	7.1^{a}	5.85^{a}	50.47^{a}	8.97^{a}
T10. NPS2B2Zn2	6.03^{abcd}	4.6^{bcde}	49.6^{a}	8.53^{ab}
T11. NPS3B3Zn3	5.73^{bcd}	4.17^{cde}	40.9^{b}	7.73^{bc}
T12. NPS1B1Zn1K1	6.3^{abc}	4.67^{bcd}	49.3^{a}	8.2^{abc}
T13. NPS2B2Zn2K2	6.3^{abc}	4.7^{bcd}	47.3^{ab}	7.83^{bc}
T14. NPS3B3Zn3K3	4.7^{d}	3.6^{e}	46.67^{ab}	7.2^{c}
Significant	**	**	**	***
CV (%)	11.86	11.74	9.04	6.56

Note: pit-per plant, Sp^{-1}-per spike. Mean values followed by the same letters in each column and treatment showed no significant difference by DMRT ($p = 0.05$). **, ***, denotes significance at $p = 0.01$, 0.001, respectively

3.3.3. Spike length

Spike length was highly and significantly ($P<0.001$) affected by the application of blended fertilizer as compared to the control (Table 4). Plants grow in field experiment with blended fertilizer application increased spike length by 64% and 63% over the control treatments (T_6 and T_9) respectively. The results also indicated that there were no significant difference in spike length among different levels of blended fertilizer T_3, T_4, T_5, T_7, T_{11}, T_{12}, T_{13}, T_{14} and also recommended rate (T_2) which have higher spike length than control plots. The result indicated that macro nutrient (S, K) and micro nutrient (Zn, B) increased spike length of plant, even if it was parity with recommended treatment which is also N and P had also play major role for cell division and elongation of spike length. This is in agreement with Nasser (2009) and Debnath *et al*. (2011) who reported that the spike length of wheat significantly increased as a result of applying Zn and B blended with macronutrient.

3.3.4. Thousand Seed weight

Analysis of variance revealed that no significant difference was observed among treatment level treated with blended fertilizer treatments on thousand seed weight (Table 5). The result is consistent with that of Debnath *et al*. (2011) who found that application of B fertilizer had no significant effect on thousand grain weight of wheat crop. Esayas (2015) also reported that blended fertilizer (NPS, NPSB, NPSZnB) application had no significance effect on thousand grain seed weight of wheat. On the contrary Fayera *et al*. (2014) reported that thousand grain weights had significant difference with application of micronutrients (zinc + boron) and macronutrients in blended form of fertilizer markedly increased thousand grain seed weight of teff crop.

3.3.5. Aboveground dry biomass yield

Analysis of variance revealed that aboveground dry biomass yield was highly significantly ($P<0.001$) influenced by the blended fertilizers (Table 5). The highest (14.29 t ha^{-1}) above ground dry biomass yield was recorded from $NPS_1Zn_1B_1$ (175kgha^{-1}N+125kgha^{-1}P+11.1kgha^{-1}S+3.3kgha^{-1}Zn+0.15kgha^{-1}B) (T_9). However, it was statistically at par with the recommended treatment and all blended fertilizer treatments except T_3- NPS_1 and T_{14}-$NPS_3Zn_3B_3K_3$ (Table 4). Plants grow in field experiment with blended fertilizer application (T_9) increased above ground dry biomass yield by 322% over the control treatments. This might be due to better crop nutrition through applied blended micronutrients (Zn and B) with macronutrients (N, P, and S), which may result in improved vegetative growth of crops. The result also indicated that even in the absence of K, the blend of fertilizer contributed to enhance the aboveground dry biomass yield of wheat plants grow in field experiment. This could be due to the higher K in the soil and due to nutrient imbalance. The result also indicated that recommended treatment and blended fertilizer had similarly influenced on aboveground dry biomass yield. This might be the constant level of nitrogen and phosphorus used throughout all blend fertilizer treatment, which stimulated vegetative growth uniformly. In agreement with this finding Fayera *et al*. (2014) reported that above ground dry biomass yield of teff was significantly influenced by application of blended fertilizer. Shiferaw (2012) also indicated that above ground dry biomass yield was significantly affected by application of blended fertilizer and NP.

3.3.6. Grain yield

Analysis of variance revealed that grain yield was highly significantly ($P<0.001$) influenced by the blended fertilizers (Table 5). The highest grain yield (5.77 t ha^{-1}) was recorded as a result of $NPS_1B_1Zn_1$ (175kgha^{-1}N+125kgha^{-1}+11.1kgha^{-1}S+3.3kgha^{-1}Zn+0.15kgha^{-1}B) (T_9), which had no significant difference with blended fertilizer T_5-NPS_3 (5.08tha^{-1}) and T_6-NPS_1B_1 (5.09tha^{-1}). From blended fertilizer, the minimum grain yield (3.56 t ha^{-1}) was obtained from the application of $NPS_3Zn_3B_3K_3$ (T_{14}), which was statically comparable with T_3-NPS_1 and T_{11}- $NPS_3Zn_3B_3$, but it was higher than control treatment (Table 5). Moreover, application of $NPS_3Zn_3B_3K_3$ (T_{14}) had lower yield than the recommended NP (175kgha^{-1}N+125kgha^{-1}) (T_2). This could be due to the presence higher concentration of K in soil, that lead to lower yield of T_{14} than T_2 and also nutrient imbalance in the blended fertilizer caused by higher rate of K.

The highest grain yield was recorded from T_9, this might be due to the combined effect of nutrients like N, P, S, Zn and B in blended fertilizer which might have boosted growth and development of crop compared to the rest of the formulations. Application of blended fertilizer NPS_1B_1 Zn_1 (T_9) increased grain by 19% over the recommended NP. The result is in conformity with the finding of Lemlem (2012) who showed that application of blended fertilizer, DAP and urea significantly increased the N, P, K, Zn, Mg and S concentration of teff grains and increased grain yield in both Regosols and Vertisols. Berhan, (2017) also indicated that grain yield of malt barley was significantly influenced by N application.

The significant increase in yield with the application of $NPS_1B_1Zn_1$ (T_9) over the other treatments except control treatment was showing at a range of 13.4 to 62.1%. The response of wheat to blended fertilizers (NPS, NPSB, NPSBZn, and NPSBZnK) didn't show constant variation between treatments, but it indicated that additional application of S, B, and Zn was significant for wheat crop production. Feyera *et al*. (2014) reported that the agronomic performance was improved through application of blend of macro with micronutrient in a suitable form in nutrient deficient soil, as a result it improved nutrient use efficiency of teff which increased the grain yield. In line with this result, Debnath *et al.*, (2011) also indicated that grain yield of wheat was significantly influenced by boron application, which increased the yield progressively up to 2.25 kg ha^{-1} B and thereafter declined at higher rate 3 kg ha^{-1} B

3.3.7. Straw yield

Analysis of variance revealed that straw yield was significantly ($P<0.01$) influenced by the blended fertilizers (Table 5). The highest straw yield (8.52 t ha^{-1}) was recorded from the application of $NPS_1B_1Zn_1$ (175kgha^{-1}N+125kgha^{-1}+11.1kgha^{-1}S+3.3kgha^{-1}Zn+0.15kgha^{-1}B) (T_9), which had no significant difference with blended fertilizer T_4, T_5, T_6 and T_{13}. However, the lowest straw yield was obtained from the control treatment. The highest straw yield was recorded from T_9, this could be due to the combined effect of nutrients like N, P, S, Zn and B in blended fertilizer which might have boosted growth and development of crop compared to the rest of the formulations. The recommended NP treatment has no significant difference with all the blended fertilizer treatment except T_9. Additional application of blended fertilizer $S_1B_1Zn_1$ (T_9) increased straw yield by 35.5% and 19.8% over recommended NP and control treatment respectively. This result is in line with that of Teklay and Girmay (2016) who reported that, straw yield of teff was significantly affected by application of blended fertilizer which exceeds 7% and 490% over the recommended NP and control plots respectively.

3.3.8. Harvest index

Harvest index is the relationship of the economic yield to the total or biological yield expressed as coefficient of effectiveness. Thus, harvest index (HI) is the balance between the productive parts of the plant and the reserves, which form the economic yield. Harvest index was significantly ($P<0.01$) affected by blended fertilizer as compared to control treatment (Table 5). However, the effect of blended fertilizer treatments did not show significant influence on HI which might be due to the constant amount of NP which are major nutrients

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responsible for grain yield of a crop. It was also found that HI had increased with addition of fertilizers over the control.This result is supported by Esayas (2015) who reported that, application of blended fertilizer has no significant effect on harvest index in wheat.

Table 5. Effect of blended fertilizer rates on thousand seed weight (TSW) , aboveground dry biomass yield (AGDBY), grain yield (GY), straw yield (SY) and harvest index (HI) of bread wheat.

Treatments	TSW (g)	AGDBY(tha^{-1})	GY(tha^{-1})	SY (tha^{-1})	HI
T1. Control	64.81	3.39^{c}	0.49^{d}	2.88^{e}	0.14^{b}
T2. Recommended(NP)	71.01	11.15^{ab}	4.86^{b}	6.29^{bc}	0.44^{a}
T3. NPS1	68.49	9.6^{b}	4.19^{bc}	5.41^{cd}	0.44^{a}
T4. NPS2	61.67	11.95^{ab}	4.61^{b}	7.34^{ab}	0.38^{a}
T5. NPS3	66.05	12.94^{ab}	5.08^{ab}	7.86^{ab}	0.39^{a}
T6. NPS1B1	71.81	12.5^{ab}	5.09^{ab}	7.41^{ab}	0.41^{a}
T7. NPS2B2	68.02	10.58^{ab}	4.7^{b}	5.88^{bd}	0.44^{a}
T8. NPS3B3	64.08	11.28^{ab}	4.63^{b}	6.65^{bc}	0.42^{a}
T9. NPS1B1Zn1	64.28	14.29^{a}	5.77^{a}	8.52^{a}	0.41^{a}
T10. NPS2B2Zn2	70.79	11.41^{ab}	4.66^{b}	6.75^{bc}	0.41^{a}
T11. NPS3B3Zn3	74.76	10.61^{ab}	4.16^{bc}	6.45^{bc}	0.39^{a}
T12. NPS1B1Zn1K1	71.63	10.64^{ab}	4.83^{b}	5.81^{bcd}	0.45^{a}
T13. NPS2B2Zn2K2	70.49	12.22^{ab}	4.61^{b}	7.61^{ab}	0.38^{a}
T14. NPS3B3Zn3K3	70.16	9.28^{b}	3.56^{c}	5.72^{bcd}	0.38^{a}
Significant	NS	***	***	**	**
CV (%)	7.7	17.69	10.88	20.39	18.96

Note: Mean values followed by the same letters in each column and treatment showed no significant difference by DMRT (p = 0.05). **, ***, denotes significance at p = 0.01, 0.001, respectively.

3.4. Correlations

Significant positive correlation of grain yield with all the yield and yield components were observed which indicating that grain yield could invariably increase by increasing those characteristics. Positive associations of grain yield with number of effective tillers produced per plant (r= 0.821***), number of tillers produced per plant (r= 0.765***), aboveground dry biomass yield (r= 0.967***), harvest index (r= 0.738***) spike length (r= 0.698**), number of seed per spike (r=0.629**) and thousand seed weight (r= 0.63**) (Table 6).The result shows that the applied fertilizers have positive contribution to the economic yield. This result was supported by the recent findings of Teklay and Girmay (2016) who reported that strong significant positive correlation of grain yield with plant height, panicle length, panicle seed weight, straw yield and harvest index was observed on teff. Similarly, in wheat, significant positive associations of grain yield with number of fertile spikes produced per meter square, number of tillers produced per plant, biological yield and harvest index (Firehiwot. 2014).

Table 6. Correlation coefficients between mean agronomic traits of bread wheat grown under blended fertilizers.

	ETPP	TTPP	PH	SL	NSPS	AGDBy	GY	HI	TSW
ETPP	1.000								
TTPP	0.26*	1.000							
PH	0.55***	0.68***	1.000						
SL	0.33**	0.28**	0.88***	1.000					
NSPS	0.53^{NS}	0.79**	0.66*	0.62***	1.000				
AGDBY	0.37***	0.25**	0.74**	0.45***	0.20**	1.000			
GY	0.82***	0.76***	0.37**	0.69**	0.63**	0.97***	1.000		
HI	0.46^{NS}	0.57*	0.19^{NS}	-0.11^{NS}	0.08^{NS}	-0.61**	0.74***	1.000	
TSW	0.32^{NS}	0.71^{NS}	-0.32*	0.54^{NS}	0.15^{NS}	0.64**	0.63**	0.02^{NS}	1.000

Note: ETPP- effective tillers plant^{-1}, TTPP- total tillers plant^{-1}, PH-plant height, SL-spike length, NSPS- number of seed spike^{-1}, AGDBY- aboveground dry biomass yield, GY-grain yield, HI-harvest index, TSW- thousand seed weight, NS, *, ** and *** = non-significant, significantly different at 5%, 1%, and 0.1%, respectively.

3.5. Economic feasibility analysis

In this study the partial budget analysis was done considering all variable costs and all benefits (grain yield and straw yield). The partial budget analysis revealed that highest net benefit of 58443 Birr ha^{-1} was recorded in the treatment 9 that received $NPS_1B_1Zn_1$ (175 kgha^{-1} N+125 kgha^{-1}P2O_5+11.1 kgha^{-1} S+3.3 kgha^{-1} Zn+0.15 kgha^{-1} B). The lowest net benefit of 5707 Birr ha^{-1} was obtained from control treatment (Table 7). To identify treatments with the optimum return to the farmer investment, marginal analysis was performed over the control treatment. For a treatment to be considered as worthwhile option to farmers, between 50% and 100 % marginal rate of return (MRR) was the minimum acceptable rate of return (CMMYT, 1988). The highest marginal rate of return (MRR %) 742.18 was recorded from the application of $NPS_1B_1Zn_1$ (175kgha^{-1}N+125kgha^{-1}P_2O_5+11.1kgha^{-1}S+3.3kgha^{-1}Zn+0.15kgha^{-1}B). The economic analysis result also supported the biological yield and grain yield; plots received $NPS_1B_1Zn_1$ had the highest net benefit indicating economic feasibility of the treatment.

Table 7. Economic analysis of blended fertilizers in terms of partial budget and marginal rate of return (MRR) for bread wheat production.

Treatment	Return and cost items									MRR (%)
	Gross return Birr/ha			Cost Birr/ha					Net Return	
				Purchasing and Transportation Cost		Daily Labor Cost	Total Variable Cost	Change in Cost		
	Grain	Straw	Total	Seed	Fertilizer					
1	5303	2124	7427	1450	-	270	1720	-	5707	-
2	51625	5157	56782	1450	1825	5335	8610	6890	48172	716.33
3	44567	4428	48995	1450	1755	5869	9074	7354	39921	565.24
4	48977	6010	54987	1450	2633	6126	10209	8489	44778	560.25
5	53956	6445	60401	1450	3510	6413	11373	9653	49028	548.78
6	54103	6076	60179	1450	1757	5475	9560	7840	50619	672.85
7	49925	5289	55214	1450	2647	6176	10273	8553	44941	558.71
8	49310	4821	54131	1450	3548	6211	11209	9489	42922	492.19
9	61397	6978	68375	1450	1757	6724	9932	8212	58443	742.18
10	49523	5535	55058	1450	2647	6170	10267	8547	44791	463.92
11	44265	5289	49554	1450	3548	5955	10953	9233	38601	456.26
12	51367	6240	57607	1450	2482	6215	10147	8427	47460	595.46
13	48955	4764	53719	1450	4083	6125	11658	9938	42061	465.81
14	37759	4690	42449	1450	5685	5628	12763	11043	31406	317.14

4. CONCLUSION AND RECOMMENDATION

Wheat (*Triticum* spp.) is one of the major cereal crops grown in the highlands of Ethiopia and this region is regarded as the largest wheat producer in Sub-Saharan Africa. Low soil fertility is one of the major constraints responsible for the low productivity of wheat in Ethiopia. This may be caused as a result of removal of surface soil by erosion, crop removal of nutrients from the soil, total removal of plant residues from farm lands, low or absence of fertilizer use and lack of proper crop rotation program. Increasing yields through the application of nitrogen and phosphorus alone can deplete other nutrients. Therefore, understanding the plant nutrients requirement of an area could help to implement demand-driven soil fertility management practices. Hence, the objective of this study was to evaluate the effect of different blended fertilizer formulation rates of S, B, Zn and K on yield and yield components of bread wheat in Siyadebrenawayu District and to evaluate the economic feasibility of the fertilizers.

The soil analysis indicated that soil of the experimental field was clay in texture with a pH of 6.0 which was moderately acidic in reaction. The CEC was high. Experimental field had low organic carbon (1.19%), high available P (20.05 ppm) and high Exchangeable K (0.844 cmol (+) kg soil) content of the soil. The soil had low available B (0.45 ppm), available S (0.231 ppm), total N (0.12%) and Zn (0.36 ppm).This indicated that the soil is deficient in available Zn, B and S but, K is not and application of these nutrients have yield responses except K.

Application of blended fertilizer treatment and recommended NP significantly affected days to 50% heading, days to 90% maturity, plant height, spike length, number of total and effective tiller per plant, grains per spike, grain yield, biomass yield and harvest index, but 1000-grain weight was not significantly affected by blended fertilizer treatment and recommended NP. The highest above ground dry biomass yield (14.29 tha^{-1}), highest grain yield (5.77 tha^{-1}) and straw yield (8.51 tha^{-1}) was recorded from additional application of S, B, and Zn at T9 ($NPS_1B_1Zn_1$). The application blended fertilizer $NPS_1B_1Zn_1$ increased the straw and grain yield by 35.45% and 19% respectively as compared to the recommended NP fertilizer. The highest net return (58443ETB ha^{-1}) with (MRR %) 742.18 was obtained with application of blended fertilizer $NPS_1B_1Zn_1$. It is clearly observed from collected data and soil analysis report application of K fertilizer is not responsive in study area but, S, B and Zn application at the minimum rate is responsive and economically feasible. Therefore, application of blended fertilizer $NPS_1B_1Zn_1$ (175 kg ha^{-1} N + 125 kg ha^{-1} P_2O_5 + 11.1 kg ha^{-1} S + 3.3 kg ha^{-1} Zn + 0.15 kg ha^{-1} B) can be recommended for higher yield particularly in the study area and it is also economically feasible. Further researches have to be continued to recommend blended fertilizer formulation types.

Conflicts of interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

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