

Effect of Blended Fertilizer Types and Rates on Growth, Yield and Yield Components of Bread Wheat (*Triticum aestivum* L.) in Wondo District, Southern Ethiopia

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Abstract – Soil fertility decline is one of the principal factors contributing to low productivity of crops and food insecurity in Ethiopia. The information available with regards to effect of blended fertilizer type and rates on growth and yield performance of bread wheat (*Triticum aestivum* L.) for optimum production on loam soils of Wondo district is very limited. Therefore, a field experiment was conducted on loam soils of Wondo district Bachel Gigissa Peasant Association Farmers training center during 2018 cropping season to assess the effect of different blended fertilizer types and rates on growth, yield and yield components of bread wheat. The treatments studied consist of: control and three blended fertilizer formula NPS, NPSB, and NPSBZn each with four different rates (50, 100, 150 and 200 kg ha⁻¹). Recommended rate of Urea (100 kg ha⁻¹) was used equally for all treatments in spilt application and Danda'a variety was used as a test crop. The treatments were laid out in a Randomized Complete Block Design with three replications. Soil and crop data were collected and analyzed using the SAS statistical package program version 9.4 and LSD at 5% probability level was used to establish the difference among the means. The soil result revealed that the experimental soil site texture was classified as loam. The highest (30.06 kg⁻¹) agronomic efficiency obtained from 150 kg ha⁻¹ NPSB. The results revealed that application of blended fertilizers (NPS, NPSB and NPSBZn) delayed days to flowering, and physiological maturity by (13, 9, 10) and (15, 14 and 11) days, respectively as compared to control plot. Leaf Area Index and Straw yield were significantly ($p \leq 0.01$) affected by the application of different blended fertilizer rates and significantly ($p \leq 0.05$) by the main effect of blended fertilizer types and interaction effect. Grains per spike and grain yield were significantly ($p \leq 0.01$) affected due to the main effects of blended fertilizer types and rates, they were also significantly ($p \leq 0.05$) affected due to the interaction effect. Above ground biomass was significantly ($p \leq 0.01$) affected due to main effect of blended fertilizer rates and the interaction effect however, non-significant ($p > 0.05$) due to blended fertilizer types. This study also revealed that, blended fertilizer types and rates significantly ($p \leq 0.05$) affected DH, NFTm², DPM, PH, SL and HI while TSW was significantly ($p \leq 0.05$) affected only by the main effect of blended fertilizer rates. Blended fertilizers had improved Agronomic nutrient use efficiency of wheat as compared to the control treatment. The highest (6.17 t ha⁻¹) grain yield was obtained from 200 kg ha⁻¹ NPSB + 100 kg ha⁻¹ urea application followed by (6.11 t ha⁻¹) from 150 kg ha⁻¹ NPSB + 100 kg ha⁻¹ urea, while minimum (1.95 t ha⁻¹) grain yield was attained from the control treatment. However, the application of 150 kg ha⁻¹ NPSB + 100 kg ha⁻¹ urea had highest marginal rate of return (MRR %) and Net benefit. Therefore, it would be advisable to use blended fertilizer 150 kg ha⁻¹ NPSB + 100 kg ha⁻¹, for wheat production in Wondo area. Furthermore, based on yield, net benefit and relatively low total cost of production the farmers of Wondo area also can use 100 kg ha⁻¹ NPSB + 100 kg ha⁻¹ urea. However, since the experiment was conducted only for one season and one site, repeating the trial at different site as well as in the same experimental site would be important in order to draw sound recommendation.

Keywords – Blended Fertilizer, Grain Yield, Net Benefit, Nutrient Use Efficiency.

I. INTRODUCTION

Wheat is one of the world's leading cereal grains serving as a staple food for more than one-third of the global

population. Globally, it is cultivated on approximately 218 million hectares of land with average yields of 3.3 t ha⁻¹ (FAO, 2015a). Wheat is one of major cereal crops grown in the highlands at altitudes ranging from 1500-3000 m a.s.l., situated between 6 –16°N and 35 – 42°E; however, the most suitable agro ecological zones for wheat production fall between 1900-2700 m a.s.l. (Hailu, 1991).

Cereal grains are major contributors to human nutrition throughout of the world and covers about 87.42% (about 25,384,723.96 tones) of the grain production in Ethiopia. Among cereals, wheat took up to 13.49% (1,696,082.59 hectares) with production of 15.63% (4,537,852.34 tones). Ethiopia is the second largest wheat producer in sub-Saharan Africa, next to South Africa (Demeke *et al.*, 2013), with annual average bread (60%) and durum wheat (40%) production of about 1.6 million hectares (CSA 2015). It ranks 4th after tef (*Eragrostis tef*), maize (*Zea mays*) and sorghum (*Sorghum bicolor*) in area coverage and 3rd in total production for 2016/17 summer season that play a substantial role in assuring food security (CSA, 2017). The national average yield of bread wheat in the country is 2.7t ha⁻¹ (CSA, 2017). The major wheat producing regions of the country are: Oromia region, Amhara, Tigray and SNNPR region (CSA, 2017) that share more than 83% of wheat production.

The total areas of wheat production in the Oromia Region in 2017 were reported as 898,455.57 ha with average yields of 2.97 t ha⁻¹ (CSA, 2017). Wheat in Wondo district is the 3rd most important crop during main cropping season in terms of total production after maize and tef with total land coverage of more than 1200 ha with average yields of 2.73 t ha⁻¹ (Wondo District Agricultural Office, 2018) which is below the regional average yield of 2.96 t ha⁻¹ (CSA, 2017). Soil fertility depletion and blanket fertilizer application to correct the fertility problem are the major constraints of wheat production in Ethiopia (MoARD, 2008). Complete removal of crop residues from farm lands for fodder and fuel, low level of fertilizer application, limited use of manure, lack of appropriate soil conservation practices and cropping systems are among the main factors contributing to the decline in soil productivity (Haileselassie *et al.*, 2005).

Based on the national soil data base, in addition to the macro-nutrients, some of the micro-nutrients like Zn, B and Cu are depleted from the soil of the major crop producing area of the country mainly due to prolonged years of cultivation (Ethio SIS, 2016). Balanced fertilization not only guarantees optimal crop production, better food quality and benefits for the growers, but is also the best solution for minimizing the risk of nutrient losses to the environment.

Thus, this experiment was conducted to evaluate the effect of three different blended fertilizers containing 3-5 nutrient each with four levels on growth, yield and yield performance of bread wheat and to determine the economic feasibility as compared to the control treatment in Wondo District, West Arsi Zone of Southern Ethiopia with the following specific objectives:

- To determine the effect of different types of blended fertilizer rates on growth and yield performance of bread wheat.
- To identify the type and optimum rate of blended fertilizer for wheat production.
- To estimate the economic feasibility of the blended fertilizer type and rates for wheat production in the study area.

II. MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted under rain-fed condition during the main cropping season from August – December, 2018 at Wondo District, West Arsi Zone, Oromia Regional state. The specified study area is located at 7°4'42''N and 38°41'59'' E having an altitude of 2538m a.s.l. The topography of the district is slightly undulating estimated to be 5% mountainous, 60% valley and 35% plain with an altitudinal range of 1600 – 2580 m.a.s.l (Wondo District annual report, 2018). Its annual rainfalls are around 900-1200 mm and mean annual temperature fall between 10°C and 21 °C. The average annual rainfall in 2009-2018 and the average total rainfall during the growing season were 1105.8 mm and 472.1 mm, respectively. The dominant soil type of Wondo district is sandy loam and the farming system in the area is crop and livestock mixed agriculture.

Treatments and Experimental Design

The experimental treatments consisted of the control and three blended fertilizer types (NPS, NPSB and NPSBZn) with four levels (50, 100, 150 and 200 kg ha⁻¹). The blanket recommended N (100 kg ha⁻¹ Urea) was top dressed for all treatments. The experiment was laid out in a randomized complete block design (RCBD) with total of 13 treatments replicated three times. The plots within a block were separated by 1 m, whereas the blocks were separated by 1.5 m. The plot size was 3m x 4m (12 m²) having 15 planting rows plot⁻¹ spaced 20 cm apart. In order to avoid boarder effects, the two outer most rows from both sides of each plots as well as 40cm at both ends of each row were left. Hence, 7.04m² (2.2m x 3.2m) of net plot size were used for the data collection.

Table 1. Treatment Combination and Perspective Codes.

Blended fertilizer	Application rate (kg/ha)	Rate of UREA (kg/ha)	Rate of nutrient (kg/ha)					Treatment code	Treatment number
			N	P	S	B	Zn		
Control	0	100	46.00	-	-	-	-	BFT0	1
NPS (BFT1)	50	100	55.50	19.00	3.50	-	-	BFT1-R1	2
	100	100	65.00	38.00	7.00	-	-	BFT1-R2	3
	150	100	74.50	57.00	10.50	-	-	BFT1-R3	4
	200	100	84.00	76.00	14.00	-	-	BFT1-R4	5
NPSB (BFT2)	50	100	55.05	18.05	3.35	0.355	-	BFT2-R1	6
	100	100	64.10	36.1	6.70	0.71	-	BFT2-R2	7
	150	100	73.15	54.15	10.05	1.065	-	BFT2-R3	8
	200	100	82.20	72.20	13.40	1.42	-	BFT2-R4	9
NPSBZn (BFT3)	50	100	54.90	17.85	3.85	0.34	1.10	BFT3-R1	10
	100	100	63.80	35.70	7.70	0.67	2.20	BFT3-R2	11
	150	100	72.70	53.55	11.55	1.01	3.30	BFT3-R3	12
	200	100	81.60	71.40	15.40	1.34	4.40	BFT3-R4	13

BFT = Blended fertilizer types, R: Blended Fertilizer rates.

The experiment was conducted using improved bread wheat variety Danda'a (Damphae-1) as a test crop which was released from Kulumsa agricultural research center in 2010.

Experimental Procedure and Management

The experimental field was prepared using oxen plow as farmer's conventional farm practices. In order to create good seed bed for proper crop growth, the experimental plots were plowed three times to a depth of 25–30 cm. Seeds of bread wheat were sown by hand drilling on August 7, 2018 with the recommended seed rate of 125 kg ha⁻¹. All blended fertilizers were applied at planting time as per treatments while N in the form of Urea was applied in split doses 1/3 at planting and the remaining 2/3 top dressed 35 days after sowing and all agronomic practices were carried out according to recommendation for wheat.

Data Collection and Analysis

Soil Sampling and Analysis

The soil samples of the experimental site were collected before planting from 0-20 cm plough depth. A representative soil samples were taken from an experimental field randomly and composited to one sample for soil characterization.

The collected soil samples were analyzed for the selected chemical properties cation exchangeable capacity (CEC), Electrical conductivity (EC), Organic Carbon, Total N, exchangeable K, available (P, S, B, and Zn). Soil samples were analyzed for texture with a hydrometer (Bouyoucos, 1962). The pH of the soil is determined with the potentiometer method (1:2.5 soil: water as described by Chopra and Kanwar (1976). Available P in soil was determined by Olsen *et al.* (1954) extraction procedures, with a sodium bicarbonate solution. Total nitrogen was measured using Kjeldhal method (Rainst *et al.*, 1999).

Agronomic Data Collection

For grain yield, above ground biomass and straw yield, all the wheat discarding the outside rows and the end 40cm of the plot both sides 2.2m x 3.2m = 7.04 m² area was harvested. Randomly 10 plants were collected from each plot for growth and yield component Plant height and Spike length data measurement but, for Leaf area index and Grain per spike 5 plants were used. Finally, the grain yield and yield component parameters were recorded. Sampling, harvesting and data collection and recording for each parameter were explained as follows: Phenological parameters (Days to 50% heading, Days to 90% physiological maturity): Growth parameters (Leaf area index, Plant height (cm), Spike length (cm): Yield and yield components (Number of fertile spikes m⁻², Number of grains per spike, Total above ground biomass (t ha⁻¹, Grain Yield (t ha⁻¹), Straw yield (t ha⁻¹), Thousand kernels weight (g) and Harvest index.

Agronomic Nutrient use Efficiency (NUE) in Wheat

$$\text{Agronomic efficiency (AE)} = \frac{\text{Yield obtained from fertilized plot (kg ha}^{-1}\text{)} - \text{Yield obtained from control plot (kg ha}^{-1}\text{)}}{\text{Quantity of nutrient applied (Fa) (kg)}} \quad (1)$$

Statistical Analysis

The mean values of the parameters recorded were subjected to Analysis of Variance (ANOVA) using statistical

analysis Software (SAS version 9.4) with proc-mixed model of SAS. Treatment mean separated were done using least significance difference (LSD) test at 5% probability level and simple Pearson correlations were done in determining association of parameters by using correlation analysis. Graphical presentation of the data was carried out by using Microsoft Excel.

Economic Analysis of Treatment Effects

Economic analysis was performed to investigate the economic feasibility of the treatments by using partial and marginal profit analyses according to CIMMYT (1988). To make a rational choice of alternative blended fertilizers based on their economic benefit the partial budget and marginal rate of return (MRR) were analyzed for wheat production (CIMMYT, 1988).

$$\text{MRR (\%)} = (\text{NB}/\text{TVC}) * 100 \quad (2)$$

Where: NB = Net benefit, TVC = Total variable cost and MRR = marginal rate of return.

III. RESULTS AND DISCUSSIONS

Physico-chemical Properties of Soil before Planting

The parameters tested and their corresponding values are indicated below.

Table 2. Major Soil physico-chemical properties of the experimental site before planting.

Parameters	Amount	Rating	References
Sand %	32.4	Loam	Soil textural triangle (Marcel Dekker Inc., 2004)
Silt %	42.0		
Clay %	25.6		
pH	6.63	Neutral	Olsen (1954)
OC %	0.98	Very low	(Jones, 2003)
OM %	1.67	Low	
TN %	0.08	Low	Tekalign (1991)
Available (mg kg ⁻¹)			
P	5.03	Low	Olsen (1954)
S	14.0	Low	Olsen (1954)
Exch. K (ppm)	182.0	High	(Jones, 2003)
B	0.22	Low	Daryl, (2004) & Gerwing and Gelderman, (2005)]
Zn	1.09	High	
EC (ds/m)	0.45	Non-saline	Thiagalingam (2000)
CEC (cmol/kg)	32	High	Hazeton & Murphy (2007)
Cu	0.468	High	Daryl, (2004) & Gerwing and Gelderman, (2005)]
Fe	1.33	Low	
Mn	1.072	High	
C/N	12.19:1	N available to plant uptake & mineralization occur	

OM = Organic matter, TN = Total nitrogen, Av P, Av S, Av B, Av Zn = Available (phosphorus, sulfur, boron and zinc) respectively, Exch. K (Exchangeable potassium), EC = Electrical conductivity, CEC = Cation exchangeable capacity, ppm = parts per million.

Phenological Parameters

Days to 50% heading

The analysis of current results revealed that highly significant ($p \leq 0.01$) differences among the blended fertilizer types and rates on days to 50% heading however, non-significant due to the interaction effect. The longest days to 50% heading (70 days) was recorded from blended fertilizer types NPS, while the shortest days (57 days) were recorded from the control (Table 3). The variation in days to 50% heading among the blended fertilizer types could be attributed to the high level of N in the NPS fertilizers.

Regarding to rates, the longest days to 50% heading (71 days) was recorded from 150 kg ha⁻¹ blended fertilizer and the shortest days to 50% heading (63 days) was recorded from 50 kg ha⁻¹ blended fertilizer rates (Table 3). This result is in conformity with the findings of Mekonen (2005), who reported that, days to heading was significantly delayed when N fertilizer was, applied the highest rate for wheat and barley production compared to the lowest rate. Radhid *et al.*, (2007) also reported that NP application significantly increased days to heading of barley. Generally, date of heading was delayed as NPS level increment in blended fertilizer rates, but was reduced with the increment of B and Zn rates in blended fertilizer.

Table 3. Effects of blended fertilizer types and rates on wheat phenology conducted at Wondo district of Oromia region, during 2018 cropping season.

Treatments Blended Fertilizer types (T)	DH	DPM
Control	57 ^c	128 ^c
NPS	70 ^a	143 ^a
NPSB	66 ^b	142 ^a
NPSBZn	67 ^b	138 ^b
LSD	2.37	2.22
Blended fertilizer rate (R) (kg ha ⁻¹)		
50	63 ^c	134 ^b
100	67 ^b	144 ^a
150	71 ^a	146 ^a
200	70 ^a	143 ^a
LSD	2.45	2.29
T*R	NS	NS
CV	3.18	1.43

R = Blended fertilizer rate, T = Blended fertilizer types, NS = Non-significant, LSD = Least significance difference, CV = Coefficient of variation, DH = Days to plant heading, DPM = Days to plant physiological maturity, Means in a column followed by the same letters are not significantly different at 5% level of significance.

Days to 90% of Physiological Maturity

The analysis of the current study revealed that, days to 90% of physiological maturity of wheat was significantly ($p \leq 0.01$) affected by the application of blended fertilizer types and rates. However, their interaction did not show significant effect on days to physiological maturity. The earliest days to physiological maturity (128 days) was recorded from the control and the latest maturity date (143 days) was recorded from NPS blended fertilizer types (Table 3).

Regarding to rates, the longest days to physiological maturity (146 days) was recorded from 150 kg ha⁻¹ blended fertilizer rates which had statistically similar with 100 and 200 kg ha⁻¹ blended fertilizer rates. However, the shortest (134 days) was recorded from 50 kg ha⁻¹ (Table 3). This result agrees with the findings of Hussein and Leitch (2007) indicated that applications of higher doses of N enhanced vegetative growth and increased days to maturity. Similarly, Woineshet (2007) reported that increasing N rates delayed days to maturity of wheat.

Growth Parameters

Leaf Area Index

The results of the current research showed that the main effect of blended fertilizer rates had highly significant ($P \leq 0.01$) and blended fertilizer types and their interaction had significant ($P \leq 0.05$) effects on LAI. The highest (6.03) mean LAI was recorded from 200 NPS kg ha⁻¹ blended fertilizer rate followed by (6.01) from 150 NPSB kg ha⁻¹ while the lowest (2.58) mean was obtained from the control treatment (Figure 1). The leaf area index increment with the blended fertilizer application might be attributed due to better photo assimilate supply related to combination of macro and micro nutrients like B and N used for high vegetative growth that makes the plants to have broader leaves (Brady and Weil, 2008). This result was also in line with the findings of Salam *et al.* (2004) who reported that, application of B resulted in increased plant growth, LAI, and root length of crops.

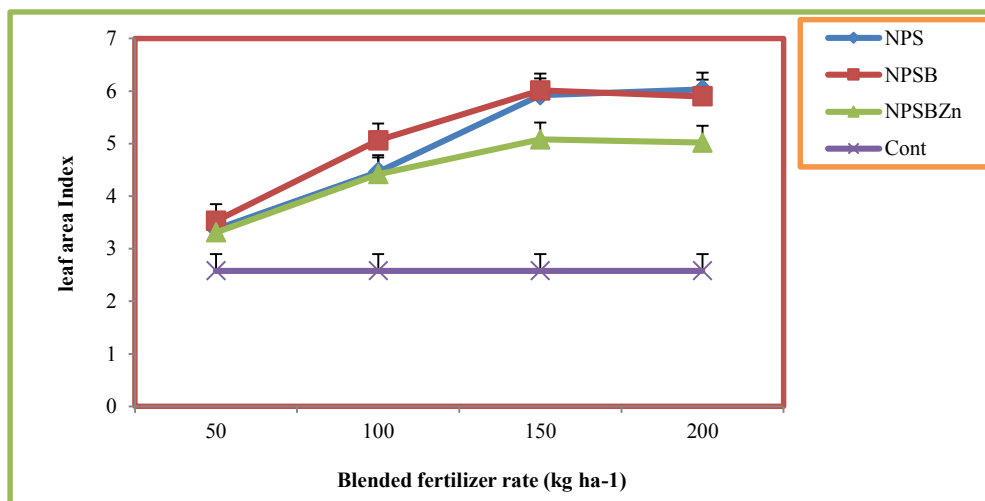


Fig. 1. Interaction effect of blended fertilizer types and rates on LAI of wheat.

Vertical lines on bars represent standard error of the statistical means.

Plant Height

The results of the current study showed that wheat plant height was significantly ($p \leq 0.01$) affected by the application of different blended fertilizer types and rates, while the interaction effect was non-significant. In this

study NPS blended fertilizer showed significantly tallest plant height (114.35 cm) whereas, the shortest (69.2 cm) was recorded from the control treatment (Table 4). In conformity with the result of this study, Berhan (2012) also reported that application of blended fertilizer brought significant difference in plant height. Similarly, Bakala (2018) reported application of blended fertilizer under balanced N increased plant height. Regarding to blended fertilizer rates, the tallest plant height (118.06 cm) was recorded from the application of 200 kg ha⁻¹ blended fertilizer statistically similar magnitude with 150 kg ha⁻¹. The shortest plant height (86.2 cm) was recorded from 50 kg ha⁻¹ blended fertilizer rates (Table 4). In conformity with the result of this study, Sate (2012) reported that plant height of teff was significantly affected by application of P and N with blended fertilizer. On the other hands, N and S nutrients have synergistic effects on plant growth and yield attributes resulting in greater translocation of photosynthesis from source to sink (Channabasamma *et al.*, 2013).

Table 4. Effects of blended fertilizer types and rates on wheat growth parameters conducted at Wondo district of Oromia region, during 2018 cropping season.

Blended Fertilizer types	Plant Height (cm)	Spike Length (cm)
Control	69.2 ^d	6.14 ^d
NPS	114.35 ^a	7.59 ^e
NPSB	106.42 ^b	9.37 ^a
NPSBZn	98.67 ^c	8.3 ^b
LSD	7.49	0.66
Blended fertilizer rate (kg ha ⁻¹)		
50	86.2 ^c	7.53 ^b
100	107.57 ^b	8.37 ^a
150	114.08 ^{ab}	8.6 ^a
200	118.06 ^a	9.18 ^a
LSD	7.74	0.82
T*R	NS	NS
CV	6.49	7.14

NB: Means in a column followed by the same letters are not significantly different at 5% level of significance.

Spike Length

The results of this study depicted that, spike length was significantly ($p \leq 0.01$) affected by the application of blended fertilizer types and rates, while the interaction effect was non-significant (Table 4). The highest (9.37 cm) mean spike length was recorded from NPSB blended fertilizer types whereas the lowest (6.14 cm) was from the control (Table 4). The spike length increment with the blended fertilizer application might be attributed due to better photo assimilate supply (Berhan, 2012). He also suggested that the higher the length of spike the higher would be grain produced spike⁻¹ leading to higher yield.

As regards to rates, the highest (9.18cm) spike length was recorded from 200 kg ha⁻¹ that had the same magnitude with 150 and 100 kg ha⁻¹ blended fertilizer rates. However, the shortest (7.53cm) was recorded from 50 kg ha⁻¹ which was the only significant from the other treatments.

Yield and Yield Components
Number of Fertile Tiller m⁻²

The result of the current study indicated that the main effects of blended fertilizer types and rates had significant ($P \leq 0.05$) and highly significant effect ($P \leq 0.01$) on number of productive tillers, respectively. Whereas, the interaction effect of blended fertilizers types and rates did not bring significant effect.

Number of productive tillers is one of the most crucial yield determining components and has directly related to the grain yield of wheat. However, among the blended fertilizer types the maximum number of productive tillers m⁻² (306) was obtained from NPSB, while the minimum (179) from the control treatment (Table 5). Similarly, among blended fertilizer rates the maximum and minimum numbers of productive spikes m⁻² (318 and 219) were recorded from 200 and 50 kg ha⁻¹ blended fertilizer rates, respectively which were with statistically significant difference (Table 5). This result was in line with the findings of Berhan, (2012) who reported that application of blended fertilizer brought significant difference in spikes number plant⁻¹ and fertile spikes m⁻². He also reported that the number of spikes plant⁻¹ has a vital role in controlling yield of wheat which shows the more number of spikes, the better will be the stand of the crop, which ultimately increases the yield.

Thousand Seed Weight

The results of this study showed that, application of different blended fertilizer rates had a significant ($p \leq 0.05$) effect on thousand seed weight, while the main effect of blended fertilizer types and interaction effects were non-significant (Table 5). Thousand seed weight is a key factor in determining yield and makes larger contributions towards grain yield of wheat. The highest (47.56 g) thousand seed weight of wheat was obtained from 200 kg ha⁻¹ blended fertilizer + 100 kg ha⁻¹ urea with statistically similar magnitude with that of 150 and 100 kg ha⁻¹, while the lowest (38.16 g) from 50 kg ha⁻¹ blended fertilizer rate which was the only significantly different from others (Table 5).

This variation on thousand seed weight might be due to more dry matter accumulation in the seed enhanced because of S, P and B. Debnath *et al.*, (2011) found a significant effect of B application on thousand seed weight on wheat. Similarly Fageria (2009) confirmed that S can increase the size and weight of grains and enhances the efficiency of N for protein synthesis.

Table 5. Effects of blended fertilizer types and rates on wheat yield and yield components in the study conducted at Wondo district of Oromia region during 2018 cropping season.

Blended Fertilizer types	NFTm ⁻²	TSW (g)	HI (%)
Control	179 ^c	32.29	28.09 ^b
NPS	260 ^b	43.1	29.64 ^b
NPSB	306 ^a	45.6	36.44 ^a
NPSBZn	272 ^b	44.39	37.08 ^a
LSD	33.16	NS	3.8
Blended fertilizer rate (kg ha ⁻¹)			

50	219 ^c	38.16 ^b	31.67 ^{bc}
100	271 ^b	44.32 ^a	33.12 ^{ab}
150	308 ^a	47.4 ^a	35.8 ^{ab}
200	318 ^a	47.56 ^a	36.96 ^a
LSD	34.25	5.68	3.93
T*R	NS	NS	NS
CV	10.96	11.36	10.07

NFTm² = Number of fertile tiller per square meter, TSW = Thousand seed weight, HI= Harvest index.

Harvest Index

The analysis result of the current study showed that application of blended fertilizer types and rates had a significant ($p \leq 0.01$, $p \leq 0.05$) effect on wheat harvest index, respectively however, non-significant due to interaction effect (Table 5). The highest (37.08%) harvest index was recorded from NPSBZn followed by (36.44%) that was obtained from NPSB blended fertilizer which were statistically similar while the lowest (28.09%) was obtained from the control treated plot (Table 5). Regarding to blended fertilizer rates, the highest (36.96%) harvest index was recorded from 200 kg ha⁻¹ blended fertilizer that had the same magnitude with 150 kg ha⁻¹ and the minimum (31.67%) was recorded from 50 kg ha⁻¹ blended fertilizer (Table 5). Tahir *et al.*, (2009) articulated that a higher transfer of assimilates to the grain would maximize the harvest index and reduce the proportion of dry matter produced. Similarly this result is supported by the findings of Tagesse *et al.*, (2018), who reported that harvest index was significantly affected by the interaction of blended NPS and supplemental N rates. Mengel and Kirkby (1996) also reported that harvest indices of modern wheat cultivars normally range from 35.0 to 40.0% which were almost in consistent with this study that ranges harvest index from 28.09 to 37.08% (Table 5). Comparable reports by Berhan (2012) also showed that treatments received blended fertilizers had high harvest index compared with the control treatments.

Number of Grains Spike⁻¹

The analysis of the current result indicated that the main effects of types and rates of blended fertilizers had highly significant effect ($P \leq 0.01$) on number of grains spike⁻¹. Likewise, the interaction effect of types and rates of blended fertilizers also revealed significant ($P < 0.05$) differences on the number of grains spike⁻¹. The maximum grains spike⁻¹ (101) was obtained from (200 kg ha⁻¹ NPSB + 100 kg ha⁻¹ urea) followed by 99, 95 and 91 that was obtained from (150 NPSB, 200 NPSBZn and 100 NPSB kg ha⁻¹) along with 100 kg ha⁻¹ urea, respectively with statistically similar magnitude while the lowest (47) was obtained from the control (Figure 2). The application of 200 kg ha⁻¹ NPSB along with 100 kg ha⁻¹ urea increased the relative grain spike⁻¹ by 53.4% compared to the control treatment. The current results is in conformity with the findings of Bereket *et al.*, (2014) who reported that NP treatment resulted a significant improvement in the number of grain spike⁻¹ within a range of 29.8 to 38.5. Dewal and Pareek (2004) reported that the number of seed spike⁻¹ increased as the sulfur doses increased and they found the highest number of grains spike⁻¹ with 40 kg S ha⁻¹ application in wheat.

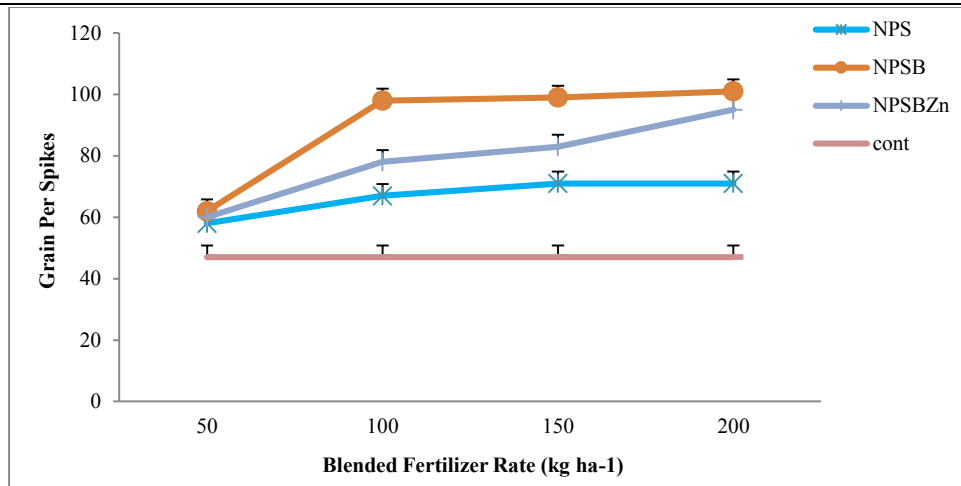


Fig. 2. Interaction effect of blended fertilizer types and rates on Grain per Spike of wheat.

Above Ground Biomass

The analysis result of the current study indicated that the application of different blended fertilizer rates had a significant ($p \leq 0.01$) effect on the above ground biomass. Similarly the interaction effect of the two factors was significant, while the main effect of blended fertilizer types was non-significant (Figure 3). The highest above ground biomass (16.82 t ha^{-1}) was obtained from 200 NPS +100 urea kg ha^{-1} followed by 200 NPSB and 150 NPSB kg ha^{-1} , while the minimum (6.99 t ha^{-1}) was recorded from the control which was with only 46 N kg ha^{-1} treated plot (Figure 3).

The result was in conformity with the findings of Adera (2016) and Bereket *et al.*, (2014), who showed that above ground dry biomass yield was significantly affected by the application of different blended fertilizer rates. The result also agrees with the findings of Woubshet *et al.*, (2017) who reported that, application of 150 kg ha^{-1} NPSB blended fertilizer along with compost increased the crop biomass. This could be due to the combined actions of sulfur which enhanced the formation of chlorophyll and encouraged vegetative growth while B helped in N absorption. Application of 200 kg ha^{-1} NPS along with 100 kg ha^{-1} urea increased the relative biomass by 9.83 t ha^{-1} (58.4%) as compared to the control treatment.

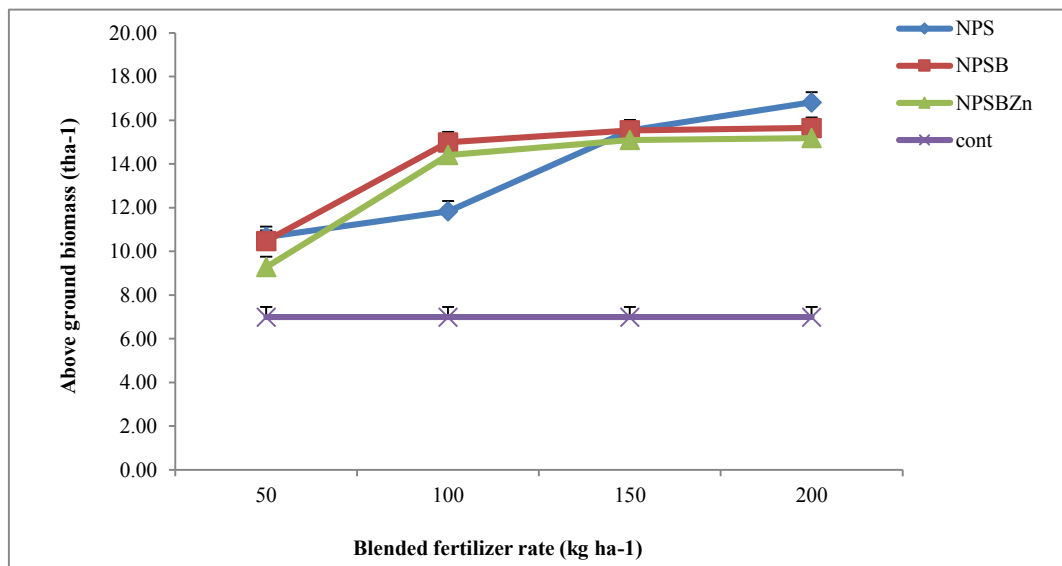


Fig. 3. Interaction effect of blended fertilizer types and rates on above ground biomass of wheat.

Grain Yield

The analysis of the current study revealed that application of different blended fertilizer types and rates had significant ($p \leq 0.01$) effect on grain yield of wheat on the other hand, significant ($p \leq 0.05$) effect was observed due to interaction effect. The highest (6.17 tha^{-1}) grain yield was obtained from 200 kg ha^{-1} NPSB + 100 kg ha^{-1} urea followed by ($6.11, 5.85, 5.81$ and 5.55 tha^{-1}) that was obtained from ($150 \text{ NPSB}, 200 \text{ NPSBZn}, 150 \text{ NPSBZn}$ and $200 \text{ NPS kg ha}^{-1}$) along with 100 kg ha^{-1} urea with statistically similar magnitude while the minimum (1.95 tha^{-1}) was obtained from the control treatment (Figure 4). In this regard, S and N show strong interactions in their nutritional effects on crop growth, yield and quality due to their mutual occurrence in amino acids and proteins Kowalenko (2004).

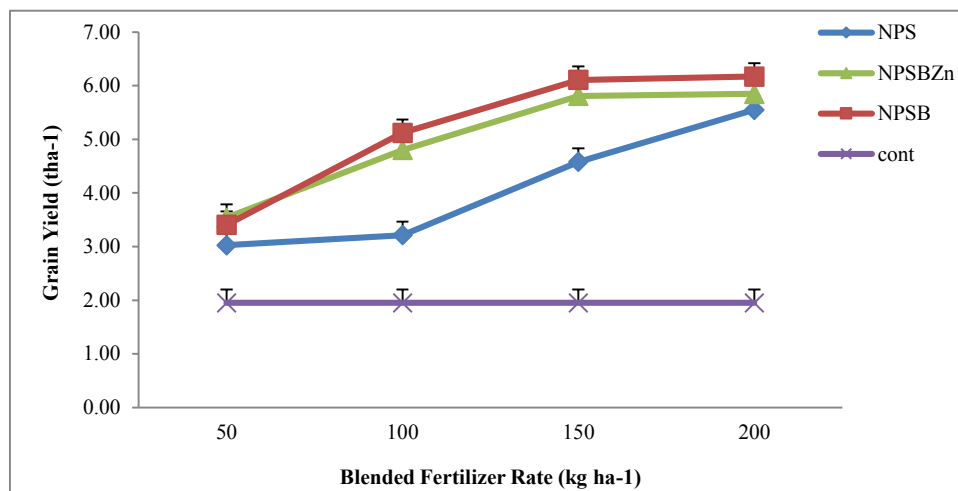


Fig. 4. Interaction effect of blended fertilizer types and rates on grain yield of wheat.

Similarly Lemlem (2012) reported that application of blended fertilizer, along with DAP and urea significantly increased tef grain yield in two soils regosols and vertisols. Similarly, Fageria *et al.*, (2011) also indicated that application of S enhanced the photosynthetic assimilation of N in crop plant. The current result also inconformity with the findings of Helder *et al.*, (2007) which states that, the application of 2 kg ha^{-1} boron produced significantly highest yield in wheat. Plots supplied with blended fertilizer rates of 200 kg ha^{-1} NPSB and 150 kg ha^{-1} NPSB showed yield increment of 4.22 tha^{-1} (68.4%) and 4.16 tha^{-1} (68%) respectively as compared to control plot (Figure 4). This result agrees with the previous finding of Woubshet *et al.*, (2017) who investigated that application of 150 kg ha^{-1} NPSB blended fertilizer with compost increased the grain yield by 4.8 t ha^{-1} . Klikocka *et al.*, (2016) also found a positive reaction of N and S fertilization on grain yield, which was the highest grain yield (5.4 tha^{-1}) was obtained from the application of 80 kg N ha^{-1} increasing by 13.1% with compared to the control whereas S fertilization increased grain yield by 3.58%. An increase in grain yield may be attributed due to proper nutrition of B, which play an important role in hormone synthesis and translocation, carbohydrate metabolism and DNA synthesis and probably contributes to additional growth and yield (Raza *et al.*, 2014). In general balanced application of fertilizers resulted in higher yield than the application of nutrients alone.

Straw Yield

The analysis of this study revealed that application of different blended fertilizer types and rates as well as their interaction effect had significant ($p \leq 0.05$) influence on straw yield of wheat (figure 5). The highest (10.52 t ha^{-1}) Straw yield was obtained from 200 kg ha^{-1} NPS + 100 kg ha^{-1} urea that had statistically similar magnitude with

150 kg ha⁻¹ NPS +100 kg ha⁻¹ urea which yielded 10.33 t ha⁻¹ while the lowest (4.77 t ha⁻¹) straw yield was obtained from the control (Figure 5). The application of 200 kg ha⁻¹ NPS along with 100 kg ha⁻¹ urea increased the relative straw yield by 54.6% as compared to the control treatment. The current results agree with Sharshar *et al.*, (2000) who stated that optimum NP fertilizer enhanced growth, yield and nutrient uptake in wheat; Nitrogen alters plant growth more than any other mineral nutrient. Similarly this result agrees with the findings of Woubshet *et al.*, (2017) who reported that the application of 150 kg ha⁻¹ NPSB blended fertilizer with compost increased the straw yield by 5.9 t ha⁻¹.

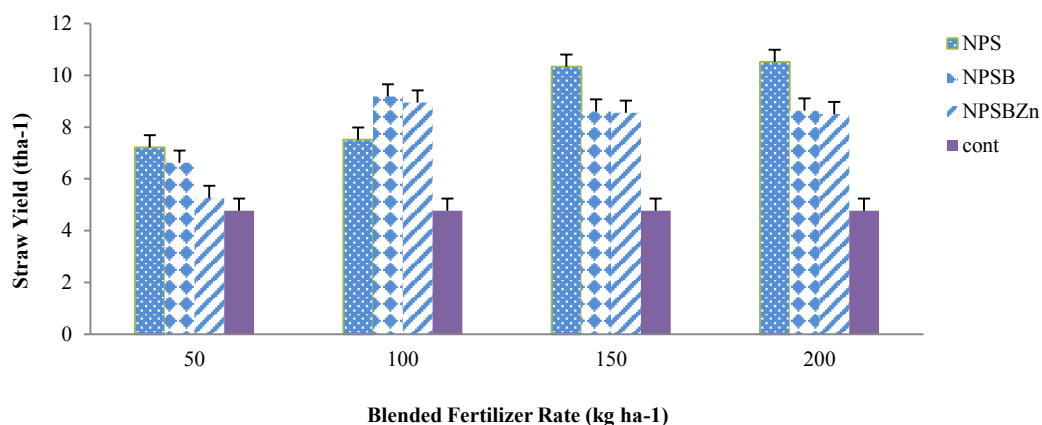


Fig. 5. Interaction effect of blended fertilizer types and rates on straw yield of wheat.

Relationship between Agronomic Parameters

The Pearson correlation coefficient in (Table 6) revealed that grain yield had highly significant and positive correlations with above ground biomass ($r = 0.88$), spike length ($r = 0.78$), thousand kernels weight ($r = 0.72$), harvest index ($r = 0.72$) and number of grain spike⁻¹ ($r = 0.84$). Straw yield had highly significant positive correlation with above ground biomass yield ($r = 0.93$), plant height ($r = 0.77$) (Table 6). Harvest index had a negative significant correlation with straw yield ($r = -0.05$) (Table 6). According to Abebe (2012) grain yield was significantly and positively correlated with plant height, straw yield, thousand seed weight and biomass of wheat.

Table 6. Simple correlation coefficients (r) amongst grain yield and agronomic traits of Wheat as affected by different blended fertilize rates (2018).

	PH	SL	GPS	AGB	GY	SY	TSW	HI
PH	1	0.57**	0.61**	0.79***	0.65**	0.77***	0.64*	0.15 ^{NS}
SL		1	0.79***	0.67**	0.78***	0.48*	0.71**	0.57*
GPS			1	0.73**	0.84***	0.53*	0.60**	0.60*
AGB				1	0.88***	0.93***	0.69**	0.31 ^{NS}
GY					1	0.64*	0.72**	0.72**
SY						1	0.56*	-0.05 ^{vc}
TSW							1	0.46*
HI								1

***, ** and * = significant at 0.1%, 1% and 5% probability level respectively and NS= Non-significant. PH = Plant height, SL = Spike length, GPS = Grain per spike, GY = Grain yield, SY = Straw yield, TSW = Thousand seed weight and HI = Harvest index.

Agronomic Nutrient use Efficiency

The results of the current study showed that, agronomic use efficiency (ANUE) increased with increasing combination of macro and micro-nutrient application (Table 7). The highest 30.06 kg kg⁻¹ agronomic nutrient use efficiency was found in plot treated with 150 kg ha⁻¹ NPSB blended fertilizer followed by (29.46 and 27.16) which were obtained from 100 kg ha⁻¹ NPSB and 150 kg ha⁻¹ NPSBZn blended fertilizer respectively (Table 7). Whereas, the minimum value of agronomic nutrient use efficiency 11.50 kg ha⁻¹ was obtained from the plot received 100 kg ha⁻¹ NPS blended fertilizer (Table 7). This result is in line with the findings of Jones *et al.*, (2011) who stated matching appropriate essential macro and micronutrients with crop nutrient uptake could optimize nutrient use efficiency and crop yield.

Table 7. Agronomic and Nutrient use Efficiency.

Treatments Code	Nutrient applied (kg ha ⁻¹)	Yield (kg ha ⁻¹)	PFP	ANUE	NUE (kg kg ⁻¹)	PUE
Control	46	1950	42.40	-	-	-
50NPS	78	3025	38.80	13.78	19.40	56.60
100NPS	110	3215	29.20	11.50	19.50	33.30
150NPS	142	4580	32.25	18.52	35.30	46.10
200NPS	174	5550	31.89	20.69	42.90	47.40
50NPSB	76.8	3405	44.30	18.95	26.40	80.60
100NPSB	107.61	5120	47.60	29.46	49.5	87.80
150NPSB	138.4	6110	44.10	30.06	56.90	76.80
200NPSB	169.22	6170	36.46	24.94	51.30	58.40
50NPSBZn	78.04	3540	45.40	20.37	29.20	89.10
100NPSBZn	110.07	4800	43.60	25.89	45.30	79.80
150NPSBZn	142.11	5810	40.90	27.16	54.10	72.10
200NPSBZn	174.14	5850	33.60	22.40	48.90	54.60

PFP = Partial factor productivity, ANUE = Agronomic nutrient use efficiency, NUE = Nitrogen use efficiency and PUE = Phosphorus use efficiency. NB: 46 kg ha⁻¹ N as urea applied for all treatments and also considered in the calculation.

Economic Analysis

According to the analysis the highest net return of 61104 Eth-birr was obtained from plots treated with 150 kg ha⁻¹ NPSB blended fertilizer which as economically superior treatment followed by 200 kg ha⁻¹ NPSB and 150 kg ha⁻¹ NPSBZn, blended fertilizers, which had a total net benefit of 60974 and 57614 Eth-birr respectively. While, the lowest net benefit (18394 Eth-birr) was obtained from the control (with only 100 kg ha⁻¹ urea) (Table 8). From the economic point of view, it was apparent that the application of 150 NPSB kg ha⁻¹ showed the highest (61104 ETB) net return and profitability than the rest of treatments.

According to the dominance analysis of mean values over the control treatments including; 100 NPS, 100 NPSBZn, 150 NPS, 150 NPSBZn and 200 NPSBZn kg ha⁻¹ were dominated by other treatments, hence eliminated from further economic analysis, since value with increased in yield is not enough to compensate the increase in

costs (Table 8). Therefore, according to the result of the yield response and economic indicators, it would be better to apply 150 NPSB kg ha⁻¹ blended fertilizers for wheat production in the study area of Wondo district, West Arsi Oromia region.

The economic analysis result of this study revealed that, the maximum marginal rate of return (4252.17%) was obtained from the application of 150 kg ha⁻¹ of NPSB blended fertilizer which was superior when compared to the control and other blended fertilizer treatments (Table 8). This implies that for every one Birr invested in Urea and blended fertilizer application, farmers can expect to recover the 1 Birr ha⁻¹ and obtain 42.50 Birr ha⁻¹.

Table 8. The dominance analysis, MRR, B: C and ranking of economic profitable treatments based on NB value for blended fertilizer types and rates application on wheat at Wondo district.

Treatments Kg ha ⁻¹	UREA Kg ha ⁻¹	Yield (kg ha ⁻¹)		TVC ETB ha ⁻¹	NB ETB ha ⁻¹	Dominance	B:C	MRR	Rank
		Av. GY	Adj. SY						
Control	100	1950	4770	4262	18394		4.3	----	----
NPS50	100	3025	7220	5486	29628		5.4	916.4	
NPSB50	100	3405	6619	5850	33449		5.7	1049.73	
NPSBZn50	100	3540	5256	6015	34598		5.8	697	
NPS100	100	3215	7510	6226	31070	D		----	----
NPSB100	100	5120	9180	7584	51393		6.8	1070.43	2 nd
NPSBZn100	100	4800	8950	7588	47755	D		----	----
NPS150	100	4580	10331	7612	45463	D		----	----
NPS200	100	5550	10517	8780	55236		6.3	321.15	
NPSB150	100	6110	8560	8918	61104		6.9	4252.17	1 st
NPSBZn150	100	5810	8494	9023	57614	D		----	----
NPSB200	100	6170	8680	9741	60974		6.3	-15.67	----
NPSBZn200	100	5850	8550	9925	57171	D		----	----

IV. CONCLUSIONS

Based on yield response and economic indicators, applying the treatment 150 kg ha⁻¹ NPSB blended fertilizer along with 100 kg ha⁻¹ urea would be advisable for wheat production at Bachel gigissa site Wondo district. Application of blended and other fertilizer should be done based soil-test and site specific conditions since the availability of an element can vary depending on the nature of the soil.

Based on the results of the current study on various parameters including yield and yield components of wheat, economic feasibility and agronomic efficiency, the following recommendations could be forwarded:

- Application of 150 kg ha⁻¹ NPSB blended fertilizer along with 100 kg ha⁻¹ urea should be adopted to improve most of the wheat growth, yield and yield components and the economics of fertilizer and obtain the highest net benefit and marginal rate of return as well as to improve some soil chemical properties of the experimental site.

Therefore, it is advisable to farmers to use the treatment (150 NPSB + 100 urea) kg ha⁻¹ which contains NPSB proportion of (N = 73.15, P₂O₅ = 54.15, S = 10.05, B = 1.065) kg ha⁻¹ with highest yield, high marginal rate of return, high net benefit and relatively small total cost of production for wheat in the study area. Furthermore, based on yield, net benefit and relatively low total cost of production the farmers of Wondo area also can use 100 kg ha⁻¹ NPSB + 100 kg ha⁻¹ urea.

Furthermore, emphasis and consideration required to the issue in the future research study,

- Since the experiment was conducted only for one growing season at one site, repeating the trial at different location as well as in the same trial site should be important in order to draw sound recommendation.

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