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Response of NPSB Blended Fertilizer and Varieties Onyield and Yield Components of Bread Wheat (*Triticum aestivum* L.) at Gimbi District, Western Oromia, Ethiopia

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Abstract: The field experiment was conducted during 2019/2020 cropping season to evaluate the response of different wheat varieties to different rates of NPSB fertilizer at Gimbi District, Western Ethiopia. The experiment was laid out in RCBD with a factorial arrangement with three replications and consisted of four rates of NPSB fertilizers (0, 50, 100, and 150 kg ha^{-1}) and three bread wheat varieties (Liben, Digalu, and Local). The finding discovered that the effect of variety and NPSB fertilizer was significant for days to heading, grain per spikes, above-ground biomass, and straw yield. The varietal effect showed a highly significant effect ($p<0.01$) on grain yield. Grain yield significantly differed for the local wheat variety and the other two varieties (Liben and Digalu). However, grain yield did not significantly differ for Liben and Digalu wheat varieties. The lowest grain yield recorded for the local wheat variety was 1.99 ton ha^{-1}and the highest grain yield was recorded for the two wheat varieties (Liben and Digalu) which were 3.5 and 3.66 ton ha^{-1}, respectively. The highest grain yield was obtained when bread wheat varieties were fertilized by 150 and 100 kg blended fertilizer (4.18 and 3.87 tons respectively), but both rates are not significantly different from each other ($p<0.01$). The varietal effect showed a highly significant effect ($p<0.01$) on the harvest index (HI). The harvest index significantly differed between Local and the other two varieties ($p<0.01$). Based on the current finding, the grain yield was increased by 44.8 % when the two wheat varieties (Liben and Digalu) were used over the local wheat variety in that particular area. Therefore, further research has to be conducted to see the performance of these two wheat varieties in different locations of the district to come up with sound recommendations.

Keywords: Blended NPSB Fertilizers, Varieties, Yield

1. Introduction

Bread wheat (*Triticum aestivum* L.) is the world's leading cereal grain where more than one-third of the world population uses it as a staple food [1, 2]. Wheat is grown on 220 million hectares of the world's arable land having 734.24 million tons of production in 2015 and is the crop that is produced almost all over the world [3]. The challenges of globally low and fluctuating wheat production, rising consumer demand, and higher food prices require efforts that dramatically boost farm-level wheat productivity and reduce global supply fluctuations. Increasing productivity is considered to be one of the long-term solutions to these challenges [4]. Demand for wheat in Africa is growing faster than for any other food crop. In Africa, also, it is cultivated on 34.37 million hectares, and from this area; 87.88 million tons of production was obtained in 2015 [3].

Ethiopia is the second largest wheat producer in sub-Saharan Africa, after South Africa [5, 6]. Wheat is mainly grown in the Highlands of Ethiopia, which lie between 6^{o} and 16° N and 35 and 42°E, at altitudes ranging from 1500 to 3000 meters above sea level and with mean minimum temperatures of 6°C to 11°C [7, 8]. There are two botanical varieties of wheat grown in Ethiopia: Bread Wheat, accounting for 60 percent of production, and Durum Wheat, accounting for the remaining 40 percent [9]. In Ethiopia wheat has become one of the most important cereal crops ranking 4th in total grain production (15.6%) and 4th in area coverage next to teff, maize, and sorghum [10]. Wheat produced in Ethiopia is used mainly for domestic food consumption, seed, and industrial use. For instance, in 2012/13 household consumption accounted for 58 percent of the total wheat produced [5]. Wheat accounts for about 10-15 percent of all the calories consumed in the country [11, 12]. The total wheat consumption (for food, seed, and industrial use) is rapidly increasing at the national level [13]. In terms of caloric intake, it is the second most important food in the country next to maize [6, 12], and is the single most important staple crop imported from abroad and most of the humanitarian food aid [14]. However, Wheat yield in Ethiopia is relatively low. Despite the long history of wheat cultivation and its importance to Ethiopian agriculture, its average yield is still very low, not exceeding 2.4 tons per hectare [10] as compared to the world average of 3.0 tons per hectare [15].

Recent estimates show that farmers in Ethiopia produce on average 2.1 tons per hectare which consistently lagged 32 percent and 13 percent behind the world and Africa's average wheat yields, respectively [7, 16]. These all factors forced the Ethiopian government to import wheat every year because of higher demand than its supply [17]. To feed the growing human population and fill the yield gaps between wheat consumption and production in Ethiopia, increasing the production of wheat is paramount important. The status of wheat production in Ethiopia in 2015 is 4.2 million tons from 1.76 million hectares of land [18]. Oromia accounts for more than half of the national wheat production (54%) followed by Amhara (32 %); Southern Nations, Nationalities, and Peoples (9 %); and Tigray (7 %) [19]. Increasing wheat production in Ethiopia can be possible by increasing the productivity of small holder producers by bringing more improved varieties and other inputs into more areas of wheat production [20].

The low yield of bread wheat could be mainly due to may socio-economic, abiotic, and biotic constraints, which contributed to wheat yield gaps in the country. Factors such as low and poor distribution of rainfall in lowland areas, plant lodging, soil erosions, and disease are the causes of significant wheat yield losses in the country [5]. Weed infestation is another biotic factor that has been reported as a major constraint for wheat production. Grain yield losses due to weed competition have been estimated by various studies and yield gains with proper weed control have ranged from 35 to 85 percent [21]. The major wheat production constraint in Ethiopia is related to the use of modern production-enhancing inputs like improved seeds and fertilizers among wheat farmers in Ethiopia and these regards the use of modern agronomic practice in our country, Ethiopia, is remarkable [22]. Sillanpa [22] reported that, in national input use in the country, only 8.4 percent and 48 percent for improved seed and fertilizer are used, respectively. The application of fertilizer on cultivated land is below the average rate of the recommendation [7, 23]. Only about one percent of the wheat area was cultivated using improved seed-fertilizers packages [24]. Studies also indicate less adoption of improved seed-fertilizer packages over time, due to high costs, insufficient credit, and lack of improved varieties traits farmers needs [25]. As a result, food insecurity and poverty are prevalent in the country. Adequate nutrients at each stage of development are essential for maximum economic yields of wheat. The principles for effective fertilizer use are to select the right source of nutrients, applied rate, place, and time. Soil fertility status also varies within adjacent farms or plots mainly due to preceding individual farmers' soil management practices [26].

There is a high demand by both commercial and small-scale farmers for a wheat crop with higher grain yield and better end-use quality. However, there is little information on the use of different types of fertilizers related to research evidence except for nitrogen and phosphorous (Di Ammonium Phosphate and urea). According to the soil fertility map of 150 districts in our country, Ethiopian soils are deficient in about seven nutrients N, P, S, Cu, Zn, and B [27]. Except for nitrogen and phosphorus, the effect of different types of fertilizers on the overall performance of the Bread Wheat variety is an important knowledge gap that needs investigation. Based on this, NPSB blended fertilizer was recommended for the soil of the district. Before the introduction of this blended fertilizer, farmers of the district used 100 kg ha^{-1} DAP and 50kgha^{-1} urea which was a blanket application. Currently, in the District, Farmers have been using 100kg of NPSB Blended based on ATA tentative recommendations. There is limited research conducted in the area related to NPSB blended fertilizer and its rates. Farmers of this particular area also depend mainly on local wheat rather than using improved varieties and this is one of the important areas to be investigated. Information about the rats of NPSB blended fertilizer and varieties on wheat performance has not been investigated so far in this particular place. *Therefore, the current research was aimed at evaluating the response of different wheat varieties to different rates of NPSB blended fertilizer at Gimbi District, Western Ethiopia.*

1.1. Specific Objectives

1) To determine the response of wheat varieties to different rates of NPSB blended fertilizer at Gimbi district, western Ethiopia
2) To evaluate the performance of different wheat varieties under different levels of NPSB blended fertilizer at Gimbi district, western Ethiopia

1.2. Research Questions

1) Does Wheat performance at different levels of NPSB blended fertilizer differ?
2) Does wheat performance for different varieties of wheat in Gimbi district differ?
3) Which variety of wheat performs best at what levels of NPSB blended fertilizer in the Gimbi district?

2. Materials and Methods

2.1. Descriptions of Experimental Site

The experiment was conducted at Gimbi district of West

Welega Zone, Oromia Regional state, Western Ethiopia. The experimental area is 346 km away from the Capital City of the Country (Finfinne). Gimbi is geographically located at about 9°54'14"N latitude and 37°4'4"E longitude at an altitude of 2372 meters above sea level.

The experiment was conducted under field conditions during the 2019/20 rain-fed cropping season at Farmer's field. The mean maximum and minimum temperatures of the area are 23.50°C and 12.30°C, respectively with an annual rainfall of 1559.3mm.

2.2. Experimental Materials

2.2.1. Wheat Varieties

Three bread wheat varieties, which are adapted to similar agroecology of the area, were used for this experiment. Two varieties, Digalu and Liben were obtained from Jimma Agricultural Research Center (JARC). They have relatively the same area of adaptation and growing period and their description is given in Table 1 below. One wheat variety which is called the local wheat variety and is known by farmers of the area was obtained from farmers around Gimbi (Tole) area.

Table 1. *Description of the three bread wheat varieties used during the experiment (2016).*

Variety	Year of Release	Area of adaptation		Maturity days	Seed Rate	Maintainer	Yield potential (ton/ha)
		Altitude (m)	Rainfall (mm)				
DIGALU	2015	2300-2700	>900mm/annum	125-130	125kg	BARC	4 -5.5
LIBEN	2015	2300-2500	>900mm/annum	122-125	125kg	BARC	4 -5
LOCAL	NK*	NK	NK	NK	NK	NK	

Source: Ethiopian Variety Registration bulletin, (2016) *NK= Not Known

Digalu and Liben varieties were selected based on their yield advantage and tolerance to major Wheat diseases like Septoria, Yellow, Leaf, and stem rusts and suitability of the agroecology which is similar to the experimental area which is discussed by Jimma Agricultural Research Center. Local variety was used as the standard to compare with the above two wheat varieties during the experiment.

2.2.2. Fertilizer

Blended NPSB fertilizer which is recommended for the Gimbi district based on the soil fertility map made was used for the study. Blended NPSB fertilizer contains 18.9% nitrogen, 37.7% phosphorus (in the form of P_2O_5), 6.95% sulfur, and 0.1% boron. Description of the four rates of blended fertilizers which was based on the Ethiopian Soil Information System (2016) tentative recommendation and treatment combination of both varieties with blended fertilizer were given in the following tables (Table 2 and Table 3).

Table 2. *NPSB Blended fertilizer rates used during the experiment (2016).*

Fertilizer	Rate (kg/ha)	N	P	S	B
Blended NPSB	0	0	0	0	0
Blended NPSB	50	9.35	8.228	3.45	0.125
Blended NPSB	100	18.7	16.456	6.9	0.25
Blended NPSB	150	28.05	24.684	10.35	0.375

The base for the rating was ATA's tentative recommendation (EthioSIS, 2016)

Table 3. *Treatment combinations of NPSB blended fertilizer rates and varieties (2016).*

Treatment Combinations	NPSB Blended (kg/ha) Rates and variety
T1	0 + Digalu
T2	0 + Liben
T3	0 + Local
T4	50 + Digalu
T5	50 + Liben
T6	50 + Local
T7	100 + Digalu
T8	100 + Liben
T9	100 + Local
T10	150 + Digalu
T11	150 + Liben
T12	150 + Local

2.3. Experimental Design

The experiment was laid out in a Randomized Complete Block design (RCBD) with a factorial arrangement having 12 (3 x 4) treatment combinations replicated three times. The size of each plot was 3m x 4 m (12 m^2) and the distance between adjacent plots and blocks was kept at 0.5m and 1m apart, respectively. A single plot area has a 7.04 m^2 net plot and 12m^2 gross plot areas. Seeds were sown in rows 20 cm apart by drilling.

2.4. Management of the Experiment

The experimental field was first prepared by a local plow according to the local farmers' conventional plowing practice and prepared as per recommended for the crop. Following the specification of the design, a field layout was made using the 3, 4, and 5 methods of Pythagoras theorem, and each treatment was assigned randomly to the experimental units within a block. The fertilizer application was done based on the recommended rates. A blended NPSB fertilizer was applied at sowing. For all treatments, 50kg UREAha^{-1} was used and applied through a splitting method, 1/3 at sowing, and the remaining 2/3 was done at 35 days after sowing equally. Varieties are sown at 20cm spacing between rows through the drilling system and a 125kg ha^{-1} seed rate was used. All other management activities like weed management, urea application method and time of application, and all other field managements were equally carried out for all treatments. Weeding was carried out three times manually other crop management practices were similar for all experimental units.

2.5. Data Collected

2.5.1. Soil Data

Soil samples (0-30 cm depth) were collected at random from ten points of the experimental field and thoroughly mixed to make one representative composite sample across the experimental field using an auger and bulked before planting and 2kg of representative composite sample was used [28]. The sample was air-dried, ground using a pestle and mortar, and allowed to pass through a 2mm sieve. One kilogram of the working sample was prepared and submitted to the Nekemte Soil testing laboratory and analyzed for selected physicochemical properties mainly; texture, total N, available P, soil pH, organic matter, organic carbon, and CEC based on standard laboratory procedures (Table 4).

Soil texture was expressed by using the Bouyoucos hydrometer method Day et al.[29]. Available P was extracted with a sodium bicarbonate solution at pH 8.5 following the procedure described by Olsen *et al.* [30]. The pH of the soil was measured potentiometrically in the supernatant suspension of a 1:2.5 soil: water mixture by using a pH meter, and Organic Carbon was determined by following Walkley and Black titration method [31]. Cation Exchange Capacity (CEC) was measured by using 1M-neutral ammonium acetate. Total nitrogen was determined by using the Kjedahl method as described by Jackson [32].

2.5.2. Crop-Related Data

(i). Crop Phenology

Days to heading: Days' to heading were measured when the number of days taken from the day of sowing to the date of 50% heading [33, 34].

Days to physiological maturity: Days to physiological maturity were taken when the number of days from sowing to the date when 90% of the peduncle was turned to yellow straw color. It was recorded when no green color remained on the glumes and peduncles of the tagged plant [34, 35].

Plant height (cm): Thirty plants were randomly taken and tagged for measuring plant height. Plant height was, recorded from the soil surface to the tip of the spike at physiological maturity.

(ii). Yield and Yield Components

The number of tillers per plant: First 10 x 20 cm area was demarcated and the number of plants that exist in this demarcated area was recorded. At the heading, the number of plants was recounted and recorded from the first demarcated area. Then, the difference between the first and the second was recorded and used to indicate the number of tillers per plant [4].

The number of productive tillers: Like the number of tillers per plant, a 10 x 20 cm area was demarcated first after the emergency, and the number of plants that existed in that area was counted and recorded [4]. At physiological maturity, recounting was done on the demarked area; because maximum tillers were produced during the vegetative phase and senescence occurs at maturity [36]. Then the difference between the first and the second was recorded. From the difference, productive plants are divided into the first count and recorded as productive tiller per plant.

Number of Grains per Spike: Thirty spikes were randomly taken and threshed from the net plot area and grains were counted manually.

Spike length (cm): The length of the spike was measured after selecting thirty plants randomly and measured from the node (the first spike branch started) to the tip of the spike.

Above Ground Dry Biomass Yield (ton ha^{-1}): Above ground, dry biomass yield was determined by harvesting the entire net plot after sun drying and converted to tons per hectare.

Grain Yield (ton ha^{-1}): Grain yield was obtained by harvesting and threshing the seed yield from the net plot area and converted to ton per hectare.

Straw Yield (ton ha^{-1}): Straw yield was obtained as the difference between the total above-ground plant biomass and grain yield.

Thousand seed weight (g): The seeds were taken from each plot and 1000 seeds were counted by hand and then weighted.

Harvest index: The harvest index was calculated as a ratio of grain yield per plot to total above-ground dry biomass yield per plot.

2.6. Economic Analysis

For economic analysis, a simple partial budget analysis was employed using the CIMMYT approach [36]. For partial budget analysis, the factors with significant effects were considered. The yield was adjusted by subtracting 10% from the average gain yield. Then after, gross yield benefit was obtained by multiplying the adjusted yield by the price of grain (10 birr kg^{-1}), Net benefit was calculated, by subtracting labor cost from gross yield. Finally marginal rate of return (MRR) was obtained, by dividing the marginal net benefit to the marginal cost and expressed as a percentage [36]. The mean market price of wheat was obtained by assessing the market at harvest (2016 cropping season).

2.7. Data Analysis

Measurements were subjected to ANOVA in Randomized Complete Block Design and analysis was performed using SAS software version 9.3. During the analysis, the normality of the data was checked. Data were normally distributed. We used the criterion for declaring significance at (p<0.05). The mean significances of the treatments were separated by Fisher's protected LSD-test (5%) and Pearson's correlation analysis was done to observe the association between different parameters.

3. Results and Discussion

3.1. Physicochemical Properties of the Experimental Soil

The experimental site had been under Noug, Common bean, and maize cultivation before it was used for the present study. The analytical results indicated that the soil texture of the experimental area is clay loam (Table 4). Accumulation of different organic materials during previous growing seasons might have resulted in high organic carbon content

(5%), which might have contributed to the very high level of total N (0.43%) in the soil (Table. 4). Tisdale *et al.* [37] indicated that organic matter influences many soil biological, chemical, and physical properties that favorably influence nutrient availability and also acts as the main storehouse of many nutrients like nitrates, phosphates, and others.

The experimental area has high rainfall which makes the soil pH strongly acidic with a value of 5.39. According to Mengel and Kirkby [38], the optimum pH range for wheat production is from 4.1 to 7.4. Wilson et al. [49] also reported that the preferable pH ranges for most crops and productive soils are 4 to 8. Thus, the pH of the experimental soil was within the range for the production of wheat.

Table 4. *Physical and chemical analysis of soil in the experiment field before planting at Gimbi District, 2019/20).*

Properties	Value	Status /rating	Reference
Chemical properties			
pH 1:2.5 (W/V)	5.39	Moderately acidic	Rayment and Bruce (1984)
OC (%)	5	High	Proffitt (2014)
OM (%)	8.6	High	Proffitt (2014)
CEC (meq/100gm soil)	12.199	Medium	Proffitt (2014)
Total N (%)	0.43	Very high	Tekalign (1991)
Available P (ppm)	8.442	Low	FAO (1990)
Soil texture (%)		Clay Loam	FAO (1990)
Sand	40		
Silt	30		
Clay	30		

OC=organic carbon, OM=organic matter, P=phosphorus, N=nitrogen

3.2. Crop Phenology

Days to heading

There was a significant interaction between variety and NPSB blended fertilizer on days to headings. The days to heading were significant *($p<0.05$)* for variety and blended fertilizer. Days to heading at all rates of NPSB blended fertilizer for local wheat variety was not significantly different. Days to headings at 50, 100 and 150 kg ha^{-1} NPSB blended fertilizer application rate was not significantly different for Digalu and Liben wheat varieties. Similarly, days to heading at (0) and 50 kg ha^{-1} fertilizer application was not significantly different but there is a significant difference between control and the remaining rates (100 and 150 kg ha^{-1}) for Liben wheat variety (Table 5). There was no significant difference in days to heading between Digalu and Liben at all rates of NPSB blended fertilizer and they took the lowest days to heading (56.33 and 56.66 days, respectively) under control (0) blended fertilizer. Local bread wheat variety took the longest days of heading under 150kg ha^{-1} rate of NPSB blended fertilizer application.

The days to heading was varying due to the genetic character of the plant and blended fertilizer application. This is, when nitrogen is applied in excess, a flowering of the crop is delayed because nitrogen facilitates vegetative growth by affecting the supply of photosynthesis during the critical period of the reproductive phase and its activity was increased when other nutrients like boron and sulfur are existed [40, 41]. This could be attributed to the impact of the positive interaction of B in the blended fertilizer, Positive relations between B and N fertilizers for improving crop growth and yields. Fageria *et al*.[42]stated B fertilization along with N fertilizers is required for protein formation, which is associated with high photosynthetic reactivity, vigorous vegetative growth, and dark green color. In line with our finding, Birhanu [43] concluded that the maturity date of bread wheat varieties was delayed at increased nitrogen levels and the difference between maturities at a given rate was due to their genotype and fertilizer rate.

Table 5. *Days to Heading as influenced by blended fertilizer and variety interaction at Gimbi during 2019/20.*

Variety	NPSB Blended Fertilizer rate (kg ha^{-1})	Days to heading
Digalu	0	56.33^{d}
	50	61.33^{b}
	100	61.33^{b}
	150	61.66^{b}
Liben	0	56.66^{cd}
	50	60.66^{bc}
	100	61^{b}
	150	61^{b}
Local	0	74^{a}
	50	74^{a}
	100	74.3^{a}
	150	77.6^{a}
	LSD $_{(5\%)}$	4.17
	CV $_{(\%)}$	3.89

LSD $_{(5\%)}$=Least Significant Difference at 5% level; CV=Coefficient of Variation; Means in the same column followed by the same letters are not significantly different at a 5% level of Significance

Days to physiological maturity

The main effect of variety showed a highly significant effect (*$p<0.01$*) on physiological maturity. Physiological maturity significantly differed between all bread wheat varieties. The longest and the shortest physiological maturity days were recorded for local and Liben wheat varieties, which were 124.16 and 106.75 days, respectively (Table 6). Liben wheat variety matured earlier than local and Buluk wheat varieties. Again, Digalu took significantly shorter days (115.58 days) to mature as compared to the local wheat variety (Table 6). The difference in days to 90% physiological maturity among varieties could be attributed to the genetic variation among varieties. Brady and Weil [44] reported that there is a significant difference in maturity and most of the agronomic parameters of bread wheat are due to the genetic character of variety and seeding rates.

The main effect of NPSB blended fertilizer was significant *($p<0.05$)* on average days of physiological maturity. There was a significant difference on days to physiological maturity between control and 150kg ha^{-1} rates of NPSB blended fertilizer applications. The longest days to physiological maturity were recorded for 150kg ha^{-1} NPSB blended fertilizer application, which was 118.78 days (Table 6).

An increasing rate of NPSB blended fertilizer increased days of physiological maturity. This might be due to the presence of N promoted vegetative growth and delays in maturity. Such delay might be attributed to the extension of the plant's reproductive growth in response to the adequate and/or abundant supply of N. Nitrogen is among the mineral nutrient that is important in promoting vegetative growth including tillering of crops, especially for cereal crop plants [45]. The result was in agreement with the findings of Hussein [46] who reported that the increasing rate of nitrogen fertilizer increase days of physiological maturity.

Plant height: The main effect of variety had highly significant effect *($p<0.01$)* on plant height. Plant height significantly differed between local and the other two wheat varieties (Buluk and Liben). However, plant height was not significantly differed between Buluk and Liben wheat varieties. The highest plant height was recorded for the local wheat variety which was 117.54cm (Table 6). Even though there is no significant difference between them, Buluk had numerically taller Plant height (83.7 cm) than liben (79.69 cm), which might be due to the genotypic variation among varieties like other phenologies which reflects their different response to environmental conditions. This result conforms with the finding of Esayas [34] who reported such significant differences in height among four durum wheat varieties.

Application of NPSB blended fertilizer showed a highly significant effect *($p<0.01$)* on plant height. Plant height was significantly different between control and other rates of NPSB blended fertilizer. However, plant height was not significantly differed between other rates (50, 100, and 150kg ha^{-1}) of NPSB blended fertilizer (Table 6). Significantly lowest plant height was recorded at the control treatment which was 71cm.

The lowest plant height was recorded at the control treatment probably because of nutrient deficiency in the soil. The application of nitrogen and phosphorus probably increased plant height by promoting vegetative growth, which is also similarly reported by Dell and Haung [47] on bread wheat varieties. A report by Mesfin and Zemach [48] indicated that the application of phosphorus facilitates growth and development. The result was again in line with the finding of [34, 49] who reported that the application of different levels of Boron influenced plant height significantly. The highest plant height was recorded when the crop was fertilized with boron. Suleiman [50] indicated that plant height was linearly increased with increasing levels of NP fertilization in a barley crop. Sulfur deficiency results in stunted growth and reduced plant height while the application of Sulfur increase plant height reported by Wilson *et al*.[49].

Table 6. *Effect of blended fertilizer and the varieties on Physiological Maturity and Plant height at Gimbi during 2019/20.*

Variety	PM	PH (cm)
Digalu	115.58^{b}	83.7^{b}
Liben	106.75^{c}	79.69^{b}
Local	124.16^{a}	117.54^{a}
LSD $_{(5\%)}$	3.76	4.65
Fertilizer		
0	112.4^{b}	71^{b}
50	115^{ab}	100.4^{a}
100	115.78^{ab}	100.96^{a}
150	118.78^{a}	101.47^{a}
LSD $_{(5\%)}$	4.34	5.37
CV $_{(\%)}$	3.84	5.86

PM=physiological maturity, PH=plant height, LSD ($_{5\%}$)=Least Significant Difference at 5% level; CV=Coefficient of Variation; Means in the same column followed by the same letters are not significantly different at 5% level of Significance

3.3. Yield and Yield Components

Number of tillers per plant

The main effect of variety showed a highly significant effect *($p<0.01$)* on the number of tillers per plant. The number of tillers per plant has significantly differed between local and the other two wheat varieties Digalu and Liben (Table 7). However, the number of tillers per plant was not significantly differed between Digalu and Liben wheat varieties. The local wheat variety had the lowest number of total tillers per plant (5.64) while the number of tillers per plant for Digalu and Liben did not significantly differ. This might be attributed to the genetic characteristics of varieties in tillering which was in agreement with the finding of [34, 51] reported that there is a significant difference in the number of tillering among wheat varieties.

NPSB blended fertilizer showed a highly significant effect *($p<0.01$)* on the number of tillers per plant. The number of tillers per plant was significantly difference between control and 50kg ha^{-1}; between control and 100 Kg ha^{-1}; between control and 150 kg ha^{-1} NPSB blended fertilizer application (Table 7). However, number of tiller per plant did not significantly differed between 50 and 100 kg ha^{-1} application of NPSB blended fertilizer. Significantly highest number of tillers per plant was recorded at 150kg ha^{-1} NPSB blended fertilizer application, whereas; the lowest number of tillers was recorded under control treatment (Table 7). Generally, there was an increasing trend on number of tillers per plant with increasing NPSB blended fertilizer rates. The probable reason might be that blended fertilizer plays an essential role in plant growth and tillers development whereas low dose caused reduction in above ground vegetative growth of plant. Leghari *et al.*[2] indicated that highest number of tillers was produced with the application of NPKB than control treatment in bread wheat. Increased number of tillers on wheat due to N application was also reported by Zao *et al.*

[53]. Debritu [54] reported that application of B resulted in significant positive effects on number of total tillers per plant.

Number of productive tiller per plant

Variety showed a highly significant effect ($p<0.01$) on number of productive tillers per plant. Number of productive tiller per plant did not significantly differ between Digalu and Liben varieties and produced 7.7 and 6.8 number of productive tillers per plant, respectively. Local wheat variety produced the lowest number of productive tillers per plant (4.56) (Table 7). This is due to different capacity of varieties in tillering which perform differently in different environment. The result is again in line with the finding of [35], who reported that different durum wheat varieties produced different number of productive tillers due to different capacity of the varieties.

Application of NPSB blended fertilizer showed a highly significant effect *($p<0.01$)* on number of productive tiller per plant. Number of productive tiller per plant significantly differed between control (0) and 50; between control (0) and 100; between control and 150 kg ha^{-1} NPSB blended fertilizer applications. Number of productive tiller per plant did not significant differed between 50 and 100kg; between 100 and 150kg ha^{-1} NPSB blended fertilizer applications (Table 7). Significantly, the lowest number of productive tillers was produced under control treatment.

The reasons for significance among the blended fertilizer treatments might be application of nitrogen, phosphorous, sulfur and boron increase the number of effective tillers. Boron improves root elongation, cell division in the developing zone of root tips and leaf growth and increase photosynthesis and flowering of plant [34,49]. Nitrogen is an integral component of many essential plant compounds such as amino acids, which are the building blocks of all proteins including enzymes, nucleic acid and chlorophyll and it promotes rapid growth through increase in height, tiller number, size of leaves and length of roots [46]. Esayas [34] reported that the highest number of effective tiller per plant was produced when the crop was fertilized with boron. Sulfur application can increase the uptake of nitrogen which again promote effective tiller because reproductive growth of wheat appears to be more sensitive to sulfur deficiency [55]. The result is in agree with the finding of Abedin et al. [56], who stated that number of fertile tillers of wheat was significantly improved with application of both N and P fertilizers.

Spike length

Bread wheat variety showed a highly significant effect *($p<0.01$)* on spike length. Spike length significantly differed between local wheat variety and the other two varieties (Digalu and Liben) (Table 7). However, spike length was not significantly differed between Digalu and Liben wheat varieties. The shortest spike length was recorded for local wheat variety 6.17 cm while the longest spike length was recorded for the two wheat varieties (Liben and Buluk) which were 7.22 and 7.76 cm, respectively (Table 7). This is might be due to genetic variation of the varieties. Mahdi [57] reported similar finding on seven durum wheat varieties.

NPSB blended fertilizer showed highly significant effect on spike length. Spike length significantly differed between control and other rates of NPSB blended fertilizer application. However, spike length was not significantly differed between other rates of NPSB blended fertilizer (50, 100 and 150 kg ha^{-1}) (Table 7). The shortest spike length was recorded for control (3.94cm) while the longest spike length was recorded for the other rates of NPSB blended fertilizer application which was 7.6cm, 8.3cm, and 8.37cm, respectively (Table 7). A spike length was highly and positively correlated with grains per spike (0.72**), grain yield (0.71**) and harvest index (0.62**) (Table A1) which shows varieties with high pike length produced highest grain yield. Application of N greatly stimulates leaf area growth, resulting in greater assimilation capacity both before and after anthesis. Similar result of increment of spike length with increasing N on bread wheat was reported [57]. Again, the result was in line with the result of Esayas [34] who reported that there was a significant effect of different levels of boron on spike length of bread wheat.

Table 7. *Effect of blended fertilizer and the varieties on the Number of tiller per plant, Number of productive tillers per plant and Spike length at Gimbi during 2019/20.*

Variety	NTPP	NPTPP	SL
Digalu	9.06^a	7.7^a	7.76^a
Liben	8.17^a	6.8^a	7.22^a
Local	5.64^b	4.56^b	6.17^b
LSD $_{(5\%)}$	1.61	1.45	0.959
Fertilizer			
0	2.26^c	1.88^c	3.94^b
50	7.63^b	6.41^b	7.6^a
100	9.28^b	7.78^{ab}	8.3^a
150	11.32^a	9.33^a	8.37^a
LSD $_{(5\%)}$	1.86	1.68	1.1
CV $_{(\%)}$	24.9	23	16.05

NTPP=number of tiller per plant, NPTPP=number of productive tiller per plant, SL=spike length, LSD (5%)=Least Significant Difference at 5% level; CV=Coefficient of Variation; Means in the same column followed by the same letters are not significantly different at 5% level of Significance

Grains per spike

The result of the experiment showed that interaction between NPSB blended fertilizer and bread wheat variety was significant *($p<0.05$)* for grain yield per spike (Table 8). Grain yield per spike was not significantly different at 50, 100 and 150 kg ha^{-1} NPSB blended fertilizer application for local, Buluk and Liben wheat varieties. Grain yield per spike did not significantly differ for the control (0) between local, Digalu and Liben wheat varieties (Table 8). However, grain yield per spike significantly differed at 50, 100 and 150 kg ha^{-1} of NPSB blended fertilizer applications between local and the other two wheat varieties (Digalu and Liben) (Table 8). The lowest grain yield per spike was recorded for the local wheat variety than the two wheat varieties Digalu and Liben at 50, 100 and 150 kg ha^{-1} application of NPSB blended fertilizer rates. The highest grain per spike was recorded for liben wheat variety at 150 kg ha^{-1} rate of blended fertilizer. Grain yield per spike linearly increased up to 50kg ha^{-1} NPSB blended fertilizer application while its yield remains constant beyond 50 kg ha^{-1} blended fertilizer application for the three wheat varieties.

Generally, grains per plant show increasing tendency with increasing NPSB blended rates. The highest number of grains per spike was probably attributed to genetic character of the varieties and reduction of sterility of wheat as B reduces male sterility of wheat. Menna et al. [58] reported that Grain yield of wheat is depressed by poor number of grains per spike which might result from B deficiency. Result was, again, in agreement with the findings of [2, 34] who reported that, grains per spike of wheat increase with application of Boron. Amsal [59] reported that application of boron could bring improvements in seed yield by increasing number of kernels per spike.

Above Ground Dry Biomass yield

The result of the experiment showed that interaction between NPSB blended fertilizer and variety was highly significant *($p<0.01$)* for above ground biomass yield (Table 8). Above ground biomass yield did not significantly different at control, 50 and 100kg ha^{-1} blended fertilizer application between local, Digalu and Liben wheat varieties. Above ground biomass yield was significantly different at 150kg ha^{-1} NPSB blended fertilizer between local and the other two varieties (Digalu and Liben) (Table 8). Above ground biomass yield was increased with blended fertilizer for Digalu and Liben wheat varieties while its yield decreased after 50kg ha^{-1} blended fertilizer application for local variety. The lowest above ground biomass yield was recorded for the local wheat variety than the two wheat varieties Digalu and Liben at 150kg ha^{-1} blended fertilizer application rate.

Generally, after 50 kg ha^{-1} application rate of NPSB blended fertilizer, local variety starts to lodge due to excessive vegetative growth unlike the other two wheat varieties (Digalu and Liben). The probable reason was optimum nitrogen availability plays an essential role in plant growth whereas low or very high dose of nitrogen caused reduction in above ground vegetative growth of plant [46]. This might be due to, nitrogen rate significantly influence protein content and biomass production [40]. But, excess nitrogen supply, which is governed by genetic character of the plant, causes higher photosynthetic activities, vigorous growth, weak stem, dark green color and finally lodging of the plant [39, 46]. Sulfur is a very important nutrient, which increases the activity of nitrogen nutrient [55]. The finding was in agreement with that of Amsal et al.[59], who reported that biomass yield of wheat showed highly significant response ($p<0.01$) with N, S and P application. Also, the result was in agreement with finding of Debritu [54] who reported that application of blended fertilizer (26N-11P2O5-11K_2O-3.5S-0.15B-0.6Zn) showed a highly significant effect on above ground yield of wheat.

Straw yield

Straw yield was affected significantly by the NPSB blended fertilizer rates and variety interactions *($p<0.05$)*. Straw yield did not show significant different at control treatment for all bread wheat varieties tested (Table 8). There is no significant different between Buluk and Liben wheat varieties at all levels of NPSB blended fertilizer application (Table 8). However, at 50 kg ha^{-1} blended fertilizer application the straw yield for local variety was highly significant different from the other two wheat varieties (Digalu and Liben).

Straw yield, similar to above ground biomass, was linearly increased with NPSB blended fertilizer application rates for both Buluk and Liben bread wheat varieties except for local wheat variety; which was decreased after 50 kg ha^{-1} NPSB blended fertilize application. The lowest straw yield was recorded for the local variety than the two wheat varieties Digalu and Liben at 150kg ha^{-1} NPSB blended fertilizer application rate (Table 8). For local wheat variety, increasing the rate of NPSB blended fertilizer did not increase straw yield due to the same reason mentioned for the above ground biomass probably due to genetic characters of variety and blended fertilizer. The result was in agreement with the finding of Amsal et al.[59] who observed that straw yields of wheat all showed highly significant response ($p<0.01$) when N, P and S applied. The main interest of farmers was grain yield than the straw yield, however, additionally they use wheat straw for different purposes. They used it for animal feed, roof thatching materials and they left over their field to maintain fertility status of their farm land.

Table 8. *Effect of blended fertilizer and variety interaction on Grains per spike, Above Ground Biomass and Straw at Gimbi during 2019/20.*

Variety	NPS rate (kg ha^{-1})	GPS	AGB (ton ha^{-1})	SY (ton ha^{-1})
Digalu	0	18.4^{de}	4.53^{e}	3.36^{e}
	50	42.63^{c}	8.58^{bcd}	5.33^{cd}
	100	47.8^{bc}	10.66^{b}	5.58^{bcd}
	150	48.33^{bc}	13.75^{a}	8.58^{a}
Liben	0	18.73^{de}	5.41^{e}	4.08^{de}
	50	57.66^{ab}	8.41^{cd}	4.49^{cde}
	100	57.43^{ab}	10.41^{bc}	6.05^{bc}
	150	59.86a	12.83^{a}	8.03^{a}
Local	0	12.43^{e}	5.66^{e}	4.7^{cde}
	50	26.03^{d}	10.33^{bc}	8.10^{a}
	100	26.43^{d}	9.83^{bcd}	7.23^{ab}
	150	24.76^{d}	7.83^{d}	5.66^{bcd}
	$LSD_{(5\%)}$	10.12	2.148	1.7
	$CV_{(\%)}$	8.1	14.12	16.9

GPS=grain per spike, ABM= above the ground biomass, SY=straw yield, LSD $_{(5\%)}$=Least Significant Difference at 5% level; CV=Coefficient of Variation; Means in the same column followed by the same letters are not significantly different at 5% level of Significance

Grain yield

Varietal effect showed a highly significant effect *($p<0.01$)* on grain yield. Grain yield significantly differed between local wheat variety and the other two varieties (Digalu and Liben). However, grain yield did not significantly differed between Digalu and Liben wheat varieties. Lowest grain yield was recorded from local which was 1.99 ton ha^{-1} and the highest grain yield was recorded for the two wheat varieties (Digalu and Liben) which was 3.66 and 3.5 ton ha^{-1} respectively. The highest grain yield produced by the two wheat varieties Buluk and Liben was probably because of production of higher number of tiller per plant, number of productive tiller per plant, spike length, grains per spike and thousand seed weight by these two wheat varieties than the local wheat variety. These all variables are directly and highly significantly correlated with grain yield (Appedix Table 1). In a broad sense, growth in cereals is directly related to grain yield. Grain yield is the product of the number of grains per unit area and the weight of individual grains. Grain yield is an important yield component that contributes to overall yield of bread wheat. Our result was in agreement with the finding of Lafarge et al.[35] who reported as a significant different grain yield was obtained from different durum wheat varieties.

Application of NPSB blended fertilizer showed a highly significant effect *($p<0.01$)* on grain yield. Grain yield significantly differed between control and 150kg ha^{-1} application of NPSB blended fertilizer. Similarly, grain yield in ton ha^{-1} significantly differed between 50 and 100; between 50 and 150 kg ha^{-1} application of NPSB blended fertilizer. However, grain yield in ton ha^{-1} did not significantly differed between 100 and 150kg ha^{-1} NPSB blended fertilizer applications which were 3.87 ton ha^{-1} and 4.188 ton ha^{-1}, respectively. The lowest grain yield (1.15 ton ha^{-1}) was recorded from control treatment. The finding indicated that application of NPSB blended fertilizer at 100 and 150 kg ha^{-1} was not significantly different and increased grain yield than control and 50kg ha^{-1} applications of NPSB blended fertilizer. Generally, grain yield was increased linearly up to 100kg ha^{-1} blended fertilizer application rates but increasing above 100kg ha^{-1} does not significantly increased grain yield. At control (0) blended fertilizer, the lowest number of tillers, number of productive tillers, spike length and thousand seed weight was recorded. Next to control treatment, application of 50kg blended fertilizer produced lowest number of productive tillers, grains per spike and thousand seed weight. The effect of these yield related parameters might attributed to the lowest grain yield under control (0) and 50kg ha^{-1} rates of blended fertilizer applications, respectively.

The probable reasons might be due to the presence of low nutrients at both control (0 and 50) NPSB blended fertilizer application. Nitrogen increases grain and dry matter yields, number of kernels per head and plant height of wheat reported by Hussain and Shah [46]. Nitrogen is important in determining the final grain yield of wheat during the rapid phase of crop development because it is required for high rates of spikelet initiation, improvement of spikelet fertility, and increasing grains per fertile spikelet. Increasing levels of nitrogen under different soils and management conditions increase grain and dry matter yields of wheat [60]. Nitrogen application increases the number of effective tillers at late tillering stage of crop growth of wheat which has direct relation with grain yield [47]. Again, boron is very important for seed formation at a critical growth stage of the crop [61]. Adequate application of phosphorus increase grain yield by enhancing many aspects of plant physiology like fundamental process of photosynthesis, flowering and seed formation [46]. The results of Tahir *et al*.[62] also noticed the tremendous leaf expansion and photosynthetic activities improved through the use of boron application that resulted into plant growth. Riley et al.[63] revealed that application of boron was the best method to increase grain yield of wheat. Use of sulphate fertilizers increased 36% wheat grain yield [64]. The result was in line with the finding of Leghari *et al.* [2] that the highest grain yield was recorded when wheat is fertilized with NPKB. Our result was also similar with the finding of Menna *et al.* [58] who reported that grain yield of wheat showed highly significant increase ($p<0.01$) among treatments with applied NPS.

Grain yield was highly and strongly correlated (Appendix Table 1) with spike length (r=0.71**), number of tillers (r=0.87**), number of productive tillers (r=0.86**), grains per spike (r=0.78**) and above ground biomass (r=0.84**) (Appendix Table 1). This indicates that most of yield related parameters have contributed to the grain yield of wheat which was in agreement with the findings of Hussain et al. [46].

Thousand seed weight

There is highly significant effect of variety *($p<0.01$)* on thousand seed weight. Thousand seed weight was significantly differed between local, Digalu and Liben bread wheat varieties. Local wheat variety had the lowest thousand seed weight whereas buluk had the highest thousand seed weight (Table 9). This might be due to different ability of varieties to partition the dry matter into economic (grain) yield. The result was in agreement with the finding of Esayas [34] who reported that there is a variation of thousand seed weight between durum wheat varieties.

Application of NPSB blended fertilizer showed a highly significant effect *($p<0.01$)* on average thousand seed weight. Average thousand seed weight significantly differed between all rates of NPSB blended fertilizer (Table 9). The highest (38.86g) and lowest (24.02 g) thousand seed weight were recorded at 150 kg ha^{-1} application of NPSB blended fertilizer and control treatment, respectively (Table 9). This might be due to phosphorus and boron nutrient increase the development of cell division and elongation of developing root tips and leaf growth, and again facilitate photosynthesis for seed and grain growth [22, 49, 34]. Boron facilitates pollen formation, and seed and grain growth is also improved with boron supply [22]. Sulfur improve seed quality and size [65]. Tanaka.[66] indicated optimum nitrogen application increased thousands seed weight of wheat. These results agree with the findings of Leghari *et al.* [2] who reported that 1000-grain weight of wheat was significantly affected by different NPK and B levels.

Harvest index

Varietal effect showed a highly significant effect *($p<0.01$)* on harvest index (HI). Harvest index is significantly differed between Local and the other two varieties. Harvest index did not significantly differ between Digalu and Liben wheat varieties. The highest harvest index was recorded for Buluk and Liben (0.37 and 0.364, respectively) while the local wheat variety had significantly the lowest harvest index (0.23) (Table 9). Local wheat variety had the lowest productive tillers per plant, spike length, grains per spike and thousand seed weight than Digalu and Liben wheat varieties. These all factors makes the variety to produce lowest grain yield than buluk and liben varieties which makes lowest and higher harvest index between local and the other (Digalu and Liben) wheat varieties, respectively. This might be due to inherent differences between the varieties like other yield components. These results are also similar to those reported by Esayas [35] and Leghari *et al.* [2] were significance difference obtained with different wheat varieties.

The ANOVA result indicate that NPSB blended fertilizer showed a highly significant effect *($p<0.01$)* on harvest index. Harvest index is significantly differed between control and 50; between control and 100; between control and 150 kg ha^{-1} application of NPSB blended fertilizer (Table 9). However, harvest index did not significantly differed between 50 and 150 kg ha^{-1} application of NPSB blended fertilizer. Significantly, the highest harvest index (0.388) was recorded at 100 kg ha^{-1} application of NPSB blended fertilizer while the lowest harvest index was recorded at control treatment which was (0.227) (Table 9).

The results might be due to the fact that Boron helps in fruit setting and grain formation because development of wheat anthers and pollen is affected by B deficiency. Therefore, B has also the most pronounced effect on grain filling. Harvest index in wheat is closely related to the percentage of productive tillers and generally decreased with increase N application [67]. Phosphorus has an important effect on reproduction, photosynthesis and crop maturation (flowering and fruiting including seed formation) thus helping to produce quality and quantity of grain yield and this grain yield has highest correlation with harvest index [46]. Isayas [34] reported that harvest index showed a significant variation due to the application of different levels of B. Leghari *et al.* [2] reported that use of NPK and boron proved maximum crop yield and harvest index than control. The result indicated poor response of wheat at control (untreated) treatments.

Table 9. *Effect of blended fertilizer and the varieties on thousand seed weight and harvest index at Gimbi during 2019/20.*

Variety	TSW	HI
Digalu	36.26^{a}	0.37^{a}
Liben	34.10^{b}	0.364^{a}
Local	30.18^{c}	0.233^{b}
LSD $_{(5\%)}$	1.42	0.044
Fertilizer		
0	24.02^{d}	0.227^{c}
50	34.68^{c}	0.335^{b}
100	36.49^{b}	0.389^{a}
150	38.86^{a}	0.337^{b}
LSD (0.05)	1.64	0.051
CV (%)	5.01	16.15

LSD (0.05)=Least Significant Difference at 5% level; CV=Coefficient of Variation; TSW=Thousand Seed Weight HI= Harvest Index; Means in column followed by the same letters are not significantly different at 5% level of Significance

3.4. Partial Budget Analysis

The net benefit obtained in response to NPSB blended fertilizer applied 0, 50, 100 and 150 kg ha^{-1} were 10,400; 19,400; 33,900 and 35,500 birr respectively(Table 10). The higher marginal rate of return with high net benefit was obtained from 100 kg ha^{-1}. Because the marginal rate of return was above the minimum level (100%). According to CIMMYT [36], the recommendation is not necessarily based on the treatment with the highest marginal rate of return compared to that of neither next lowest cost, the treatment with the highest net benefit, and nor the treatment with the highest yield. The identification of a recommendation is based on a change from one treatment to another if the marginal rate of return of that change is greater than the minimum rate of return. Thus, 100 kg ha^{-1} NPSB blended fertilizer is economically beneficial compared to the other rates.

Table 10. *Partial budget analysis of wheat as influenced by the rate of NPSB blended fertilizer application.*

Treatment	Av. Y (ton ha^{-1})	ADTY (ton ha^{-1})	GFB (birr ha^{-1})	TVC(Birr ha-1)	Net benefit (Birr ha-1)	MRR (%)
0	11.55	10.4	10400	0	10400	-
50	29.9	27	20000	600	19400	1500
100	38.7	35	35000	1200	33900	2417
150	41.88	37.5	37500	2000	35500	267

Av. Y= Average Yield, TVC=Total variable cost, ADTY=adjusted yield, GFB= Gross Field Benefit and MRR=Marginal Rate of Return

4. Summary and Conclusion

The experiment was conducted during the 2019/2020 cropping season at Farmers Training Center of Gimbi district, western Ethiopia. The experiment was laid out in Randomized Complete Block Design with factorial arrangement with three replications and consist four rates of NPSB blended fertilizers (0, 50,100 and 150 kg ha^{-1}) and three bread wheat varieties (Digalu, Liben and Local). The finding revealed that the interaction effect of variety and NPSB blended fertilizer significantly influenced *($p<0.05$)* days of heading, grains per spike, above ground biomass and straw yield. Digalu and Liben bread wheat varieties took the lowest days to heading (56.33 and 56.66, respectively) under control (0) treatment.

The finding indicated that application of NPSB blended fertilizer at 100 and 150 kg ha^{-1} significantly increased grain yield than control and 50 kg ha^{-1} applications. Based on the current finding the grain yield was increased by 44.5 % when the two wheat varieties (Digalu and Liben) were used over the local wheat variety in that particular area. Therefore, from statistical point of view and its cost of production, 100 kg rate of NPSB blended fertilizer and, Digalu and Liben varieties can be used as a recommended fertilizer rate and varieties, respectively for bread wheat production at Gimbi district (Tole kebele). The study was carried out in one season and location, future investigation should emphasize on different seasons and different locations in the district to come up with sound recommendations. Future investigation should also emphasis on the following aspects:

1) Economic analysis of fertilizer applications, taking into account the existing nutrient status of soils and crop rotation practices being followed in the area.
2) Studies on Boron toxicity level in plant tissue demands investigation.

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Conflicts of Interest

The authors declare no conflict of interest.

Appendix

Table A1. *Simple correlation among yield and yield components of bread wheat Gimbi during 2019/20.*

	DH	DM	PH	SL	NT	NTP	GPS	AGB	GY	HI	TSW	SY
DH	1	0.76**	0.84**	-0.07ns	-0.12 ns	-0.15 ns	-0.37*	0.07 ns	-0.26 ns	-0.47**	-0.12 ns	0.34*
DM		1	0.75**	0.06 ns	0.06 ns	0.02 ns	-0.34*	0.17 ns	-0.07 ns	-0.33*	0.04 ns	0.36*
PH			1	0.26 ns	0.20 ns	0.16 ns	-0.05 ns	0.36*	0.08 ns	-0.17 ns	0.22 ns	0.52**
SL				1	0.75**	0.75**	0.72**	0.69**	0.71**	0.62**	0.85**	0.49**
NT					1	0.98**	0.75**	0.84**	0.87**	0.71**	0.89**	0.58**
NTP						1	0.74**	0.82**	0.86**	0.71**	0.88**	0.56**
GPS							1	0.61**	0.78**	0.80**	0.81**	0.29 ns
AGB								1	0.84**	0.47**	0.84**	0.87**
GY									1	0.85**	0.87**	0.48**
HI										1	0.73**	0.01 ns
TSW											1	0.60**
SY												1

DH=Days of Heading, DPM=Days of Physiological Maturity, PH=Plant Height, SL=Spike Length, NTP=Number of Tillers Per Plant, NPTP=Number of Productive Tillers Per Plant, GPS=Grains per Spike, AGB=Above Ground Biomass, GY=Grain Yield, HI=Harvest Index, TSW=Thousand Seed Weight, SY=Straw Yield

References

[1] Jemal, A., Tamado, T. and Firdissa, E., 2015. Response of Bread Wheat (Triticum aestivum L.) Varieties to Seeding Rates at Kulumsa, South Eastern Ethiopia. *Asian Journal of Plant Sciences,* 14(2): 50-58.

[2] Leghari, A. H., Laghari, G. M., Ansari, M. A., Mirjat, M. A., Laghari, U. A., Leghari, S. J., Laghari, A. H. and Abbasi, Z. A., 2016. Effect of NPK and Boron on Growth and Yield of Wheat Variety TJ-83 at Tandojam Soil. *Advances in Environmental Biology, 10(10)*: 209-216.

[3] USDA (United States Department of Agriculture), 2016. Agricultural Outlook Forum. 92nd Annual Forum's Theme.

[4] Bekalu, A. and Mamo, M., 2016. Effect of the rate of N-Fertilizer Application on Growth and yield of Wheat (*Triticum aestivum* L.) at Chencha, Southern Ethiopia. *International Journal of Plant, Animal and Environmental Scine.* 6(3): 2231-4490.

[5] ATA (Agricultural transformation Agency), 2014. Annual report. Transforming Agriculture in Ethiopia, Addis Ababa, Ethiopia.

[6] Yasin, G. 2015. Effect of Integrated Nutrient Management on Wheat: A Review. *Journal of Biology, Agriculture and Healthcare.* Areka Research Center, 5(13), Areka, Ethiopia.

[7] MOA (Ministry of Agriculture), 2012. Ministry of Agriculture. Animal and Plant Health Regulatory Directorate. Crop variety register, Issue No. 15. Addis Ababa, Ethiopia.

[8] Geleta, B., Gorfu, A. and Gebeyehu, G., 1994. Wheat production and research in Ethiopia: constraints and sustainability. Developing Sustainable Wheat. In: Tanner DG (eds). Developing Sustainable Wheat Production Systems. The Eighth Regional Wheat Workshop for Eastern, Central and Southern Africa. Addis Ababa, Ethiopia: CIMMYT.

[9] Bergh, K., Chew, A., Gugerty, M. K. and Anderson, C. L., 2012. Wheat value chain: Ethiopia. EPARB rief No. 204.

[10] CSA (Central statistical Agency), 2014. Agricultural sample survey 2013/2014. Vol. I. Report on area and production for major crops (private peasant holdings, meher season). Statistical Bulletin 532, Central Statistical Agency. Addis Ababa, Ethiopia.

[11] Berhane, G., Paulos, Z., Tafere, K. and Tamiru, S., 2011. Food grain consumption and calorie intake patterns in Ethiopia. ESSP II Working Paper No. 23, International Food Policy Research Institute (IFPRI). Addis Ababa, Ethiopia.

[12] FAO (Food and Agriculture Organization), 2014a. Crop Production Data. Rome.

[13] USDA (United States Department of Agriculture), 2013. Grain: world markets and trade.

[14] Demeke, M. and Marcantonio, F. Di., 2013. Analysisi of incentives and disincentives for wheat in Ethiopia. Techinical notes series *description*. 3rd Edition. Rome.

[15] FAOSTAT (The Food and Agriculture Organization Corporate Statistical Database), 2013. Agricultural production Statistics.

[16] FAO (Food and Agriculture Organization), 2014b. Crop Production Data. Rome.

[17] Bereket, H., Dawit H., Mehretab H. and Gebremedhin, G., 2014. Effects of Mineral Nitrogen and Phosphorus Fertilizers on Yield and Nutrient Utilization of Bread Wheat (*Tritcum aestivum*) on the Sandy Soils of Hawzen District, Northern Ethiopia. *Agriculture, Forestry and Fisheries.,* 3(3): 189-198.

[18] CSA (Central Statistical Agency), 2015. Federal Democratic Republic of Ethiopia, Central Statistics Agency Crop. Agricultural sample survey. Crop and livestock utilization, volume 2.

[19] CSA (Central Statistical Agency). 2013. Agricultural sample survey: area and production of major crops, meher season. Vol. I. Addis Ababa, Ethiopia.

[20] Gerba, L., Getachew, B. and Walelign, W., 2013. Nitrogen fertilization effects on grain quality of durum wheat (*Triticum turgidum* L. var. durum) varieties in central Ethiopia Agricultural Sciences. *Agricultural Sciences*. 4(3): 123-130.

[21] Bogale, A., Nefo, K. and Seboka, H., 2011. Selection of some morphological traits of bread wheat that enhances the competitiveness against wild oat (*Avena fatua* L.). *World Journal of Agricultural Sciences* 7(2): 128-135.

[22] Sillanpae, M. 1982. Micronutrients and nutrients status of Soils, a global study. FAO Soils Bulletin, No. 48, Rome.

[23] Endale, K. 2010. Fertilizer Consumption and Agricultural Productivity in Ethiopia. Addis Ababa, Ethiopia.

[24] CSA (Central Statistical Agency), 2012. Agricultural sample survey: area and production of major crops, meher season. Vol. I. Addis Ababa, Ethiopia.

[25] EEPRI (Ethiopian Economic Policy Research Institute), 2006. Evaluation of the Ethiopian Agricultural Extension with particular emphasis on the Participatory Demonstration and Training Extension System (PADETES). Addis Ababa, Ethiopia.

[26] Norton, RM. and Roberts, T., 2012. Nutrient management to nutrient stewardship. In: "Capturing Opportunities and Overcoming Obstacles in Australian Agronomy". Edited by I. Yunusa. Proceedings of 16th Australian Agronomy Conference, Armidale.

[27] EthioSIS (Ethiopian Soil Information System), 2013. Soil analysis report. Agricultural Transformation Agency (Unpublished).

[28] Jones, C., Jacobs, J. and Olson-Rutz, K., 2014. Soil Sampling and Laboratory Selection. Nutrient Management Module No. 1. Montana State University, Bozeman. P 2-6.

[29] Day, P. R. 1965. Hydrometer method of particle size analysis. In: Back, C. A. (eds.), Method of Soil Analysis. Amer. Soc. Agron. Madison Winscowin. Agron. No 9, Part 2. p. 562–563.

[30] Olsen, S. R., Cole, C. W., Watanabe, F. S. and Dean, L. A., 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate circular 939, US. Department of agriculture.

[31] Walkley. A and IA. Black, 1934. An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 37: 29-38.

[32] Jackson, M. L. 1958. Soil Chemical Analysis Practice Hall of India. New Delhi.

[33] ARIFUR, R. MD., 2012. Effect of Zinc and Boron on the Yield and Yield Attributes of Wheat. A Thesis for Master of Science (M. Sc.) in Agronomy. Department of Agronomy, Bangladesh Agricultural University Mymensingh.

[34] Esayas L. 2015. Effect of Blended Fertilizers on Yield and Yield Traits of Durum Wheat (*Triticum turgidum* L.) Varieties in Ada District, Central Ethiopia. A Thesis Submitted to Postgraduate Program Directorate (School Of Plant Sciences). In Partial Fulfillment of the Requirements for the Degree of Master of Science in Agriculture (Agronomy) Haramaya, Ethiopia, p. 23-35.

[35] Lafarge, T., Tubana, B. and Pasuquin, E., 2004. Yield advantage of hybrid rice induced by its higher control in tiller emergence. In: proceedings of the 4th International Crop Science Congress, Brisbane, Australia, p: 16-17.

[36] CIMMYT (International Maize and Wheat Improvement center) (1988) An Economic Training Manual: from agronomic data recordation. CYMMT. Mexico. pp. 79.

[37] Tisdale, S. L., Nelson, W. L., Beaton, J. D. and Haulin, J. L., 1993. Soil Fertility and Fertilizers (5th ed.). *Macmillan* Publishing Company, USA.

[38] Mengel, K., and Kirkby, E. A., 1996. Principles of Plant Nutrition, Panimo Publishing Corporation, New Delhi, India.

[39] FAO (Food and Agriculture Organization), 2000. Fertilizers and their use. International Fertilizer Industry Association. Food and Agriculture Organization of the United Nations. Rome, Italy.

[40] Marschner, 1995. Mineral nutrition of higher plants. 2nd ed. Academic press, London. p 398. Soils in our environment. Prentice Han of India private limited, New Delhi. P. 342.

[41] Flaete, N. E. S., Hollung, K., Ruud, L., Sogn, T., Faergestad, E. M., Skarpeid, H. J., Magnus, E. M. and Uhlen, A. K., 2005. Combined nitrogen and sulfur fertilization and its effect on wheat quality and protein composition measured by SE-FPLC and proteomics. *Journal of Cereal Science* 41(3): 357–369.

[42] Fageria, N. K., Baligar, V. C. and Clark, R. B., 2002. Micronutrients in crop production*. Adv. agron. J.* 77: 185-268.

[43] Birhanu, D. 2010. Assessment of Bread Wheat Production, Marketing and Selection of N-Efficient Bread Wheat (*Tritium aestivum* L.) varieties for Higher Grain Yield and Quality in North Western Ethiopia. A Thesis Submitted to the Faculty of Agricultural and Environmental Sciences, Department of Plant Sciences, School of Graduate Studies. Bahir Dar University, In Partial Fulfillment of the Requirements for the Degree of Master of Science in Agriculture (Plant Breeding), p. 35-70.

[44] Brady, N. C. and Weil, R. R., 2002. The nature and properties of soil. 13th ed. Person Education Ltd, USA. p. 621.

[45] Damene, D. D., 2003. Yield Response of Bread Wheat (*Triticum aestivum* L.) to Applied Levels of N and P Fertilizers on Nitisol of Dawro Zone, Southwestern Ethiopia. A Thesis Submitted to Alemaya University (AU). In Partial Fulfillment of the Requirements for the Degree of Master of Science in Agriculture (Agronomy). P. 28-56.

[46] Hussain, M. I. and Shah, S. H., 2002. Growth, yield and quality response of three wheat (*Triticum aestivum* L.) varieties to different levels of N, P and K. Int. *J. of Agri. and Bio.,* 4(3): 362-364.

[47] Dell, B. and Haung, L. B., 1997. Physiological response of plants to low boron. *Plant soil.,* 193: 103-120.

[48] Mesfin, K. and Zemach, S., 2015. Effect of Nitrogen and Phosphorus Fertilizer Rates on Yield and Yield Components of Barley (*Hordeum vugarae* L.) Varieties at Damot Gale District, Wolaita Zone, Ethiopia. *American Journal of Agriculture and Forestry*. 3(6): 271-275.

[49] Wilson, C., Lesch, S. M. and Grieve, C. M., 2000. Growth stage modulates salinity tolerance of New Zealand Spinach (Tetragonia tetragonioides, Pall.) and Red Orach (*Atriplex hortensis* L.). *Annals of Botany,* 85: 501-509.

[50] Suleiman, A., Nganya, J. F. and Ashraf, M. A., 2014. Effect of Cultivar and Sowing Date on Growth and Yield of Wheat (Triticum aestivum L.) in Khartoum, Sudan: *Journal Of Forest Products & Industries*, 3(4): 198-203.

[51] Rajput, H. S., Lathwal, O. P., Tej, S. and Singh, T., 1993. Effect of irrigation and nitrogen levels on yield attributions and yield of wheat. *Har. Agron. J.,* 8: 69-73.

[52] Wei, X. M. and Zito, D. F., 1996. Effect of boron application on the growth of winter wheat and the rate of nitrogen use. *Beijing Agric. Sci.* 14(2): 15-18.

[53] Zhao, FJ., Hawkesford, MJ. and Grath, SP., 1999. Sulphur assimilation and effects on yield and quality of wheat. J. Cereal Sci. 30: 1-17.

[54] Debritu, T. 2013. Soil Fertility Characterization and Evaluation of Blended Fertilizer for Wheat *(Triticum Aestivum* L.*)* Production on Vertisols of Woliso District, Southwestern Ethiopia Msc Thesis, Haramaya University.

[55] Woyema, A., Bultosa, G. and Taa, A., 2012. Effect of Different Nitrogen Fertilizer Rates on Yield and Yield Related Traits for Seven Durum Wheat (*Triticum turgidum L. var* Durum) Cultivars Grown at Sinana, South Eastern Ethiopia. African Journal of Food, Agriculture, Nutrition and Development, Volume 12(3): 6085-6087.

[56] Abedin, M., Jahiruddin. M., Hoque. M. S., Islam. M. R. and Ahmed. M. U., 1994. Application of boron improving grain yield of wheat. *Progress Agric*. 5(l): 75-79.

[57] Mahdi, Z., Masoud Z. and Arash, A., 2013. Influence of Potassium and Boron on Some Traits in Wheat (*Triticum Aestivum* cv. Darab2). *The International Journal of Biotechnology,* 2(8): 141-153.

[58] Menna, A., Semoka, J. M., Amuri, N. and Mamo, T., 2015. Wheat Response to Applied Nitrogen, Sulfur, and Phosphorous in three Representative Areas of the Central Highlands of Ethiopia-I. *International Journal of Plant & Soil Science* 8(5)*: 1-11, 2015; Article no. IJPSS, 20055.*

[59] Amsal, T., Tanner, D. and Chanyalew. G., 2000. Agronomic and economic evaluation of the farm N and P response of bread wheat grown on two contrasting soil types in central Ethiopia pp. 239-252. In: The Eleventh Regional Wheat Workshop for Easter, Central and Southern Africa. Addis Ababa, Ethiopia.

[60] Shorrocks, V. 1997. The occurrence and correction of boron deficiency. *Plant Soil,* 193: 121-148.

[61] Dagne, C., 2016. Blended Fertilizers Effects on Maize Yield and Yield Components of Western Oromia, Ethiopia. *Agriculture, Forestry and Fisheries*. 5(5): 151-162.

[62] Tahir, M., Tanveer, A., Shah, T. H., Fiaz, N. and Wasaya, A., 2009. Yield response of wheat (*Triticum aestivum* L.) to boron application at different growth stages*. Pak J Life and Social Science,* 7(1): 39-42.

[63] Riley, N. G., Zhao, F. J. and McGrath, S. P., 2000. Availability of different forms of sulfur fertilizers to wheat and oilseed rape. Plant and Soil, 222(1): 139-147.

[64] Iqtidar, H. A., Muhammad, K. and Ejaz, A. K., 2006. Bread wheat varieties as influenced by different nitrogen levels. *J. Zhejiang Univ Sci.* 7(1): 70-78.

[65] Ryant, P. and Hřivna, L. 2004. The effect of sulphur fertilization on yield and technological parameters of wheat grain. Annales Universitatis Mariae Curie-Skłodowska, *Sec. E.* 59(4): 1669–1678.

[66] Tanaka, A. 1994. Plant characters related to Nitrogen response in rice. In: The mineral nutrition of the rice plant, Proceedings of the rice plant. Vol. 2. Food and Agriculture Policy Research Center, Tokyo, pp 334 – 439.

[67] Miller, R. W. and Danahue, R. L., 1997. Soils in Our Environment (7th ed.); Prentice-Hall of India Private limited, New Delhi.