EJED 2022 4(2):39–55

Ethiopian Journal of Environment and Development

http://www.du.edu.et/duj

Response of Growth and Yield of Bread Wheat Varieties to Blended NPSB Fertilizer Application Rates

Muzayin Kamil Haji[1], Dargie Tsegay Berhe*[2] and Semu Moshago Shahebo[1]

[1] *College of Agriculture & Natural Resources, Werabe University, Werabe, Ethiopia*
[2] *Department of Horticulture, College of Agriculture & Natural Resources, Dilla University, Ethiopia*
**Corresponding author, Email: tsegadar@yahoo.com; P.O.Box. 419 Dilla, Ethiopia*

Received: 17th November 2022 *Accepted: 02nd September 2022*

DOI: **10.20372/ejed.v04i2.03**

Abstract

Low soil fertility and poor crop management practices are among the major constraints limiting the productivity of bread wheat in Ethiopia in general and Hulbareg District in particular. Therefore, a field experiment was conducted in Hulbareg District during the 2019 main cropping season to evaluate the effect of blended NPSB fertilizer rates on yield and yield components and to determine the economically feasible rates for bread wheat production. Factorial combination of three improved bread wheat varieties (Ogolcho, Kekeba and Kingbird) and five rates of NPSB fertilizers (0, 50, 100, 150 and 200) were laid out in randomized complete block design with three replications. The results revealed that the plant height, number of kernels per spike, thousand kernel weight, straw yield, number of total tillers and productive tillers were substantially (P <0.01) affected by the main effects of NPSB.. The interaction effect of fertilizer and variety was also statistically affected the days to physiological maturity, total aboveground dry biomass and grain yield. The maximum grain yield (6500 kg ha^{-1}) and above ground dry biomass kg ha^{-1} (15389), were recorded at the combination of the highest rates of NPSB, i.e., 200 kg with variety Ogolcho. Generally, the economic feasibility of the fertilizer over varieties combination indicated that application of 200 kg NPSB ha^{-1} to Kekeba variety resulted in maximum marginal rates of return of 4202%. The partial budget analysis revealed that the highest net return (72, 495 Birr ha^{-1}) with MRR 2711.9% was obtained for Ogolcho from application of 200 kg NPSB ha^{-1}. Based on the result of this study, it can be concluded that bread wheat variety Ogolcho and NPSB rate of 200 kg ha^{-1} to be appropriate for bread wheat production in the study area.

Keywords/Phrases: Blended fertilizer, Biomass, Bread wheat, Grain yield, NPSB

1 Introduction

Wheat (*Triticum aestivum* L.) belongs to the family Poaceae, subfamily Pooideae and tribe Triticeae (Clayton *et al*., 2015). Synonyms include *Triticum vulgare* and there are also many synonyms for subspecies and cultivars (Clayton *et al*., 2015). Wheat is the world's leading cereal grain where more than one-third of the population of the world uses as a staple food (Curtis, 2002). Bread wheat is the most widely grown food crop in the world. Wheat Production in 2018 was 731.46 million tons. This year's (2019) production of 764.49 million tons could represent an increase of 33.03 million tons or 4.52% in wheat production around the globe. It ranks first in the world cereal crops accounting for 30% of all cereal food worldwide (USDA, 2022).

Wheat is an important staple food crop all over the world (Mathpal *et al*., 2015). It is one of the most important cereals cultivated in Ethiopia (Jemal *et al*., 2015). Ethiopia is one of the largest wheat producers in the Sub-Saharan Africa, with yearly estimated production of 4.5 million tons on 1.69 million hectares of land in 2018/19 (CSA, 2019) with 2.66 ton yield per hectares (CSA, 2019). Durum and bread wheat are the two major wheat species produced in the country. However, bread wheat surpasses durum wheat in recent years (Godebo *et al.*, 2021) due to its wide agro-ecological adaptation and better productivity. Wheat is a leading source of protein in human food (Yong *et al.*, 2011). It is one of the daily diets of the Ethiopian population that contributes significantly to the calorie and protein intake. In terms of caloric intake, it is the second most important food in the country next to maize (FAO, 2014).

Wheat is one of the most important cereals cultivated in Silte Zone and ranks first in area coverage and total production. The total wheat area and production in the Silte Zone is 55,063.25 *ha* and 132,151.8 tons respectively with the productivity of 2.4 tons ha^{-1} in 2018/19 cropping season (CSA, 2019) which is lower than the national average 2.66 tons ha^{-1} (CSA,2019) and the world 2.8 tons ha^{-1} (USDA, 2022).

There are several factors that lowered the wheat productivity in Ethiopia and in the experiment area such as lack of knowledge about improved wheat production technologies by farmers, poor extension support, biotic stress, low soil fertility, and lack of improved management practices, high cost and inadequate supply of agri-inputs (Demeke & Di Marcantonio, 2013). The yield gap of Silte zone suggests the potential for increasing production through improved soil and crop management practices, particularly increased use of fertilizers and adequate soil fertility maintenance program with the appropriate varieties for the area. Continuous cropping and inadequate replacement of nutrients, nutrients removed in crop harvest or lose through erosion and leaching are the major causes of soil fertility decline in Ethiopia (Hillette *et al.*, 2015).

Among the above constraints, low soil fertility and slow progress in developing wheat cultivars with durable resistance to diseases are considered the most important constraints limiting wheat production in Ethiopia (Teklu & Teklawold, 2009). Crop growth requires sufficient, but not excessive supply of essential mineral elements for optimal productivity. An insufficient supply of mineral elements may limit plant growth and development (Godebo *et al.*, 2021; Nadian *et al.*, 2010). Thus, addition of nutrients such as *N*, *P*, *S* and *B* to less fertile soil is important to increase wheat yield.

For the last four to five decades, Ethiopian agriculture depended solely on urea and Di-ammonium phosphate (DAP), as sources of *N* and *P*, respectively. However, recently it is perceived that the production of such high protein cereals like wheat can be limited by the deficiency of *S* and other nutrients (Assefa *et al.*, 2015). It is true that farmers and Agriculture extension workers can aim at increasing crop yields only in quantity by applying significantly higher amounts of *N* from urea and DAP. But, in such conditions, failure to supplement *S* in balanced-fertilizer programmes can rapidly deplete available soil reserve leading to hidden *S* deficiency (Assefa *et al.*, 2015).

Nitrogen is considered as the most deficient nutrients in soils of Ethiopia (Asnakewet al., 1991). Nitrogen fertilizer may not be fully utilized if *S* is deficient and correct *S* fertilization improves quality of grains. The capability of nitrogen fertilizer is to increase protein content, while sulfur fertilizer affects protein composition (Luo *et al.*, 2000). Further, Boron is essential for cell division and elongation in meristematic tissues, floral organs and for flower male fertility, pollen tube germination along with its seed/fruit formation. Boron deficiency impairs grain setting in wheat, resulting in increased number of open spikelet's and decreased number of grains per spike (Marschner, 1995).

Varieties are one of the factors which play an important role in producing higher yield of wheat (Alam & Jahan, 2013). Efficient use of fertilizers depends on performances of variety. So that cultivar selection that optimally utilizes the applied fertilizers plays a very important role in determining grain yield and quality (Brian *et al.*, 2007). A study was conducted to know the response of three wheat cultivars (Ogolcho, Kekeba and Kingbird) and five NPSB rates (0, 50, 100, 150 and 200 *kg* NPSB ha^{-1}) at Hulbareg. The result showed that variety Ogolcho out smart variety Kekeba and Kingbird in grain yield at fertilizer rate of 200 *kg* NPSB ha^{-1}.

Recent studies have indicated that elements like *N*, *P*, *K*, *S* and *Zn* levels as well as *B* and *Cu* are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country (ATA, 2014). Further studies showed that most Ethiopian soils are deficit in macronutrients (*N*, *P*, *K* and *S*) and micronutrients (*Cu*, *B* and *Zn*) (EthioSIS, 2014). Macro-nutrients as well as micronutrients are of primary importance in our agriculture system but due to unawareness of the farmers about importance of applying micronutrients and unavailability, the soils are becoming deficient in micronutrients (Muhammad *et al*., 2009). Micronutrients are essential for plant growth and play a vital role in increasing crop yields as they develop plant nutrition and increase soil efficiency (Hamzeh & Florin, 2013). The increases in crop yields from application of *B*, *Cu*, *Fe*, *Mn*, *Mo*, and *Zn* occur in many parts of the world (Martens & Westermann, 1991). Therefore, this study was aimed to assess the effect of blended (NPSB) fertilizer rates on yield and yield components of bread wheat varieties, and to estimate its economic feasibility.

2 Materials and Methods

2.1 Description of the Study Site

The field experiment was conducted at AngamoYede Farmers Training Center (FTC) in Hulbareg District from July to November 2019 under rain fed conditions. Hulbareg Districtis located in the Southern Nations Nationalities and Peoples Region (SNNPR). The Districtis located at 7^o45’42"N latitude and 38^o46’41"E longitude. The elevation at study area is 2100 *m* above sea level. The District has two Agro-ecological Zones; 95% *Weinadega* and 5% *Kolla* climatic type. The soil of the experimental site is classified as sandy loam in texture with *pH* of 5.1. The mean annual rainfall of the area ranges between 800 and 1200 *mm* and the annual average minimum and maximum air temperatures are 9.84^{o}C and 23.57^{o}C, respectively.

2.2 Soil Sampling and Analysis

Soil samples were taken in zigzag pattern before planting from the experimental site at a depth of 0 - 30 *cm* across the experimental field from 10 spots using auger before planting and was composited. Then, the composite sample was air-dried at room temperature under shade and the samples were mixed thoroughly to produce 1.0 *kg* of a representative sample. The composite sample was submitted to Soddo soil testing laboratory and Areka Agricultural Research Center. Then in the laboratory, it was ground to pass through a 2 *mm* sieve for soil analysis whereas for organic carbon (*OC*) and nitrogen (*N*) determination, the soil was ground to pass through a 0.2 *mm* sieve. The soil sample was analyzed for selected physicochemical properties mainly for soil texture, soil *pH*, organic carbon, cation exchange capacity (*CEC*), total *N*, and available *P* following standard laboratory procedures at Wolaita Soddo soil testing laboratory and the available *S* and *B* was analyzed at Areka Agricultural Research Center soil testing laboratory.

Organic carbon was determined by Walkley and Black oxidation method (Walkley & Black, 1934). Total nitrogen was analyzed by Kjeldhal method (Dewis & Freitas, 1975). The *pH* of the soil was determined by potentiometric test method on 1:2.5 (weight/volume) soils to water ratio using a pH meter (Motsara & Roy, 2008). The *CEC* was measured after saturating the soil with 1N ammonium acetate (NH_4OAc) and displacing it with 1N *NaOAc* (Chapman, 1965). Available phosphorus was determined by the Olsen method (Olsen *et al*., 1954) and the available sulfur ($mg/kg\ SO_4^{-2}$) was measured by ammonium acetate method (Chapman, 1965). The available *B* was done by dilute *HCl* methods and azomethine reducing agent (Havlin *et al*., 1999).

Plant Material

Seeds of three bread wheat varieties, which were adapted to the agro-ecology of the areawere used as test/experimental material. The varieties where released by Kulumsa Agricultural Research Center (KARC) and their detail description is provided in Table 1.

Fertilizer Materials

The blended NPSB fertilizer (18.9% of *N*, 37.7% of P_2O_5, 6.95% of *S* and 0.1% of *B*) and urea (46% *N*) as *N* sources were used for the experiment.

Table 1. Description of bread wheat varieties used in the experiment

Variety	Year of release	Rainfall	Maturity (days)	Adaptation (m.a.s.l.)	Yield (t ha^{-1})
Ogolcho	2012	400-500	102	1600-2100	3.3-5.0
Kekeba	2010	500-800	90-120	1500-2200	3.3-5.2
Kingbird	2015	500-800	90-120	1500-2200	3.3-5.2

Source: (MOA, 2012).

2.3 Treatments and Experimental Design

The experimental treatments consisted of factorial combination of three bread wheat varieties (Ogolcho, Kekeba, and Kingbird), and five levels of blended NPSB (0, 50,100, 150, 200 $kg\ ha^{-1}$) fertilizer in which treatments arranged in a randomized complete block design (RCBD) with three replications (Table 2). The experimental field was ploughed with oxen to a fine tilth four times and the plots were leveled manually. Then, a field layout was made and each treatment was assigned randomly to the experimental units within a block. Bread wheat seed was sown at the recommended seed rate of 150 $kg\ ha^{-1}$ in rows of 20 *cm* spacing manually by drilling. The currently recommended 100 kg ha-1 of urea was applied for all treatments equally except for the control. The gross plot size was 10 rows of three meter length (3 m×2 m =6 m^2) and the net plot/ harvestable rows consist of 8 with 2.8 m length (2.8 m×1.6 m=4.48 m^2). The spacing between rows, plots and blocks were 0.20, 0.5 and 1 m, respectively. The whole amount of blended (NPSB) and 1/2 of the urea were applied at sowing, and the remaining 1/2 urea top-dressed at tillering. Weeding was done as needed; and harvesting and threshing was done manually.

Table 2. Rates of fertilizer treatment used with their nutrient contents in $kg\ ha^{-1}$ for the experiment

S. No.	Treatments	Total composition of the respective nutrients in the treatment ($kg\ ha^{-1}$)			
	Fertilizer rates	*N*	P2O5	*S*	*B*
1	0 kg NPSB ha^{-1} + 0 kg urea ha^{-1}	0	0	0	0
2	50 kg NPSB ha^{-1} + 100 kg urea ha^{-1}	55.45	18.85	3.475	0.05
3	100 kg NPSB ha^{-1} + 100 kg urea ha^{-1}	64.9	37.7	6.95	0.10
4	150 kg NPSB ha^{-1} + 100 kg urea ha^{-1}	74.35	56.55	10.425	0.15
5	200 kg NPSB ha^{-1} + 100 kg urea ha^{-1}	83.8	75.4	13.9	0.20

2.4 Data Collection Procedures

Days to Physiological Maturity (DTM): Days to physiological maturity was determined as the number of days from sowing to the date when 90% of the panicles turned to yellow straw color. It was recorded when no green color remained on glumes and panicles of the plants, i.e. when grains are difficult to break with thumb nail.

Plant Height (PH): Plant height was measured from the soil surface to the tip of the spike (awns excluded) of 10 randomly tagged plants from the net plot area at physiological maturity.

Number of Total Tillers (NTT): number of total tillers was determined from 0.5 m length of two rows from the net plot and converted to per meter square of net plot at physiological maturity by counting the number of tillers.

Number of Productive Tillers (NPT): number of productive tillers was determined at maturity by counting all kernel bearing spikes from 0.5 m length of two rows from the net plot and converted to per meter square of net plot at physiological maturity.

Number of Kernels per Spike (NKPS): Ten main plants were taken randomly from the net plot area of each plot and number of kernels per spike was counted carefully and then the mean was determined.

Thousand Kernels Weight (TKW): The TKW was determined by weighing 1000 kernels sampled from the net plot yield of wheat after moisture content is measured using grain moisture meter and weighed using a sensitive balance and the seed mass was adjusted to 12.5% moisture content.

Aboveground Dry Biomass (AGB): The above ground dry biomass was determined from plants harvested from the net plot area after sun drying and converted to $kg\ ha^{-1}$.

Grain Yield (GY): Grain yield was taken by harvesting and threshing the grain yield from net plot area. The grain yield was adjusted to 12.5% moisture content as:

Adjusted grain yield=$\frac{Grain\,yield\,obtained\,(kgha^{-1})^{*}(100-MC)}{100-12.5}$

Where, MC is the moisture content of bread wheat grains at the time of measurement and 12.5 is the standard moisture content of bread wheat in percent. Finally, yield per plot was converted to $kg\ ha^{-1}$

Straw Yield (SY): Straw yield was obtained by subtracting grain yield from the total above ground dry biomass yield for respective treatment and expressed in $kg\ ha^{-1}$.

2.5 Statistical Data Analysis

The experiment was subjected to two-way (NPSB rates x Variety) analysis of variance (ANOVA) in RCBD design. The significance level was set at $\alpha = 0.05$ and means were separated using Tukey's honestly significant difference test. The statistical analysis was performed using R-Software (version 4.2.1, 2022).

2.6 Partial Budget Analysis

The economic analysis was carried out by using the methodology described in CIMMYT (1988) in which prevailing market prices for inputs at planting and for outputs at harvesting were used. All costs and benefits were calculated on hectare basis in Birr.

Actual yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield that the farmers could expect from the same treatment. Adjusted grain yield (AGY) ($kg\ ha^{-1}$) was the average yield adjusted downward by a 10% to reflect the difference between the experimental yield and yield of farmers.

Gross field benefit (GFB) ($ETB\ ha^{-1}$) was computed by multiplying field/farm gate price that farmers receive for the crop when they sell it as GFB = AGY x field/farm gate price for the crop. Total variable cost (TVC) ($ETB\ ha-1$) was calculated by summing up the costs that vary, including the cost of NPSB, Urea and the application costs. The cost of each variable was as follows; NPSB ($Birr$ 12.20 kg^{-1})), urea ($Birr$ 10.42 kg^{-1}) and bread wheat seed ($Birr$ 16 kg^{-1}) during sowing time (July 22, 2019). The labour cost for application of NPSB was 7 persons ha^{-1}, each 60 ETB day^{-1}, and two split of urea application was 8 persons ha^{-1}, each 60 ETB day-1). The costs of other inputs and production practices such as the cost of seed, labour cost for land preparation, planting, weeding, harvesting and threshing were considered the same for all treatments or plots. The average open price of bread wheat grain at Hulbareg market was $Birr$ 12.50 kg^{-1} and straw price was $Birr$ 0.50 kg^{-1} in December 2019 during harvesting time.

The net benefit (NB) was calculated as the difference between the gross benefit and the total cost that vary (TCV) using the formula:

NB = (GY x P) – TCV

Where GY x P = Gross Field Benefit (GFB), GY = Adjusted Grain yield per hectare and P = Field price per unit of the crop.

Marginal rate of return refers to net income obtained by incurring a unit cost of fertilizer. For each pair of ranked treatments based on net income, % marginal rate of return (MRR) was calculated using the formula:

MRR(%) = $\frac{Change\,in\,NB\,(NB_b - Nb_a)}{Changes\,in\,TCV\,(TCV_b - TCV_a)}$ x 100

Where NB_a is NB with the immediate lower, NB_b is NB with the next higher, TCV_a - is the immediate lower TCV and TCV_b is the next highest TCV.

The dominance analysis procedure as described in CIMMYT (1988) was used to select potentially profitable treatments from the range that was tested. The discarded and selected treatments using this technique were referred to as dominated and undominated treatments, respectively. Then the treatment with the highest net benefit and marginal rate of more than 100% was considered for the recommendation as described by CIMMYT (1988).

3 Results and Discussions

3.1 Soil Physicochemical Properties

Soil physicochemical properties analysis indicated that the soil textural class was sandy loam with a particle size distribution of 60% sandy, 23% silt and 17% clay (Table 3). According to Hailu (1991), soil types used for wheat production vary from well-drained fertile soils to waterlogged heavy Vertisols. Thus, the soil of experimental site is suitable for the production of wheat. The *pH* of the soil was 5.1, which is highly acidic (Ethiosis, 2013). FAO (2019) reported that the preferable *pH* ranges for most crops and productive soils are 4 to 8. Mengel and Kirkby (1996), reported optimum *pH* range of 4.1 to 7.4 for wheat production. Thus, the *pH* of the experimental soil was within the range for productive soils for wheat.

The soil of the study site had 2.16% of organic carbon (*OC*) (Table 3), which is low according to the rating of Tekalign (1991), who rated soils having *OC* value in the range of 0.86 to 2.59% as low, indicating low potential of the soil to supply nitrogen to plants through mineralization of organic carbon. The low amount of soil organic carbon might be due to low addition of crop residues as smallholder farmers use the biomass of wheat for animal feed in the study area. Tekalign (1991) has classified soil total *N* content of <0.05% as very low, 0.05-0.12% as poor, 0.12-0.25% as moderate and > 0.25% as high. According to this classification, the soil samples were found to have moderate level of total *N* (0.13%) (Table 3) that indicating the nutrient as a limiting factor for wheat production in the study area.

The analysis revealed that the available *P* of the soil was 13.73 $mg\ kg^{-1}$ (Table 3). Indicative ranges of available phosphorus have been established by Olsen *et al.* (1954), as <5 $mg\ kg^{-1}$ (very low), 5-15 $mg\ kg^{-1}$ (low), 15-25 $mg\ kg^{-1}$ (medium), and >25 $mg\ kg^{-1}$ of soil (high). Thus, the soil of the experimental site was considered as low in available *P* content. The medium available phosphorus in the soil is not satisfactory to get potential yield from the crop. Thus, it is important to apply phosphorus fertilizer from external sources based on the recommended rate. The analysis for Available sulfur value of the study area was 19.16 $mg\ kg^{-1}$ (Table 3). Based on EthioSIS soil classification for *S* values lies on low range. The classification is < 9 very low, 10-20 low, 20-80 optimum, and > 80 $mg\ kg^{-1}$ high. So, addition of fertilizer which contains *S* is relevant. This low in sulfur content of the soil may be due to loss of *OM* and lacking of using *S* source mineral fertilizer. It was also related to continuous cultivation which result intensive mining of *S* from the soil. This might be mainly due to poor sulfur containing parent material of soil, land degradation, crop residue removal, crop uptake, low soil organic matter, use of non-*S* containing fertilizers (only *N* and *P* containing fertilizers used). The results of the analysis also indicated that the soil has medium available Boron (0.67 $mg\ kg^{-1}$) according to the rating of Horneck *et al.* (2011).

Cation exchange capacity (*CEC*) is an important parameter of soil, because it gives an indication of the type of clay mineral present in the soil and its capacity to retain nutrients against leaching. According to Landon (1991), top soils having *CEC* greater than 40 cmol (+) kg^{-1} are rated as very high and 25-40 cmol kg^{-1} as high, and 15-25, 5-15 and <5 cmol kg^{-1} of soil are classified as medium, low and very low, respectively, in CEC. According to this classification, the soil of the experimental site had low CEC (8 cmol kg^{-1} soil), indicating its low capacity to retain cations.

Table 3. Selected physicochemical properties of the soil of the experimental site

Parameter	Values	Rating	Reference
Soil texture			
Clay (%)	17		
Sand (%)	60		
Silt (%)	23		
Textural Class	**Sandy loam**		
pH (1:2.5 H_2O)	5.10	highly acidic	Tekalign (1991)
Total *N* (%)	0.13	moderate	Tekalign (1991)
Organic Carbon (%)	2.16	low	Tekalign (1991)
CEC [cmol kg^{-1} soil]	8.00	low	Landon (1991)
Available *P* ($mg\ kg^{-1}$)	13.73	low	Olsen (1954)
Available *S* ($mg\ kg^{-1}$)	19.16	low	Ethiosis (2014)
Available *B* ($mg\ kg^{-1}$)	0.67	medium	Horneck *et al.* (2011)

3.2 Days to physiological maturity

The main effect of varieties as well as the interaction effect of fertilizer treatments and varieties showed significant (p <0.01) effect on days to physiological maturity and main effect of NPSB fertilizer did not show significant effect on days to physiological maturity. The longest days to physiological maturity (108 days) was recorded at the NPSB rate of 150 $kg\ ha^{-1}$ whereas the shortest (103 days) was obtained from 50 kg NPSB ha^{-1}. The number of days required to 90% physiological maturity varied between 103.0 for variety Kingbird to 108.00 for variety Ogolcho (Table 4). The significant difference between varieties might be due to genetic difference among the varieties coupled with the favourable environmental condition and as a result there is difference on enhancing or delaying the physiological maturity of wheat varieties. In line with this study, Rai *et al*. (2012) reported a significance effect of physiological maturity among wheat varieties.

Generally, the number of days to physiological maturity recorded at the highest rate of NPSB was significantly higher than that of unfertilized plot and lower rate of NPSB fertilizer. The increase in days to maturity of wheat at the highest rate of NPSB might be due to the three nutrients interaction and synergetic effect of them, especially *N* and *S*. Nitrogen is involved in all major processes of plant development and yield formation. Besides, a good supply of nitrogen to the plant stimulates root growth and development as well as uptake of other nutrients (FAO, 2019; Weil and Brady, 2017). An adequate supply of *N* is associated with high photosynthetic activity, vigorous vegetative growth, and dark green colour as result it delayed the crop maturity. On the other hand sulfur is an essential element best known for its role in the synthesis of proteins, oils, vitamins and flavored compounds and it is essential not only for plant growth and quality produce, but also enhances other nutrients use efficiency. The current result is in line with the study by Melesse Harfe (2017) who reported that increasing the *N*/*P* fertilizer from zero level to 69/30 kg $N/P_2O_5\ ha^{-1}$ for wheat, prolonged the physiological maturity from 124.87 to 127 days. Similarly, Manna *et al*. (2007) reported that combined application of *NP* and organic fertilizers promoted vegetative growth, leading to prolonged days to maturity. Legesse (2004) have also reported that *N* fertilization delayed the physiological maturity of tef due to extended vegetative growth instead of reproductive growth.

Table 4. Days to physiological maturity (days) of bread wheat as influenced by the interaction of blended NPSB fertilizer and bread wheat variety

Blended NPSB ($kg\ ha^{-1}$)	Variety		
	Ogolcho	Kekeba	Kingbird
0	103.33^{de}	104.67^{bcde}	105.33^{bc}
50	104.33^{cde}	103.00^{e}	104.00^{cde}
100	106.33^{ab}	103.67^{cde}	103.33^{de}
150	108.00^{a}	104.00^{cde}	103.00^{e}
200	104.67^{bcde}	105.00^{bcd}	104.00^{cde}
Mean	6.37		
LSD	1.86		
CV	11.0		
P value	***		

Means in columns and rows followed by the same letters are not significantly different at 5% level of significance; LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of variation

3.3 Plant height

The result showed that, the main effect of fertilizer and variety had significant (p <0.001) effect on plant height. Variety Ogolcho had the tallest plant height of 92.75 *cm*, whereas, variety kekeba had the shortest plant height of 81.88 *cm* (Figure 1). In case of fertilizer rates, plant height was reduced at the lowest fertilizer rates. Whereas the highest plant height (89.74 *cm*) was recorded from 150 *kg* NPSB ha^{-1} fertilizer rate (Figure 2).

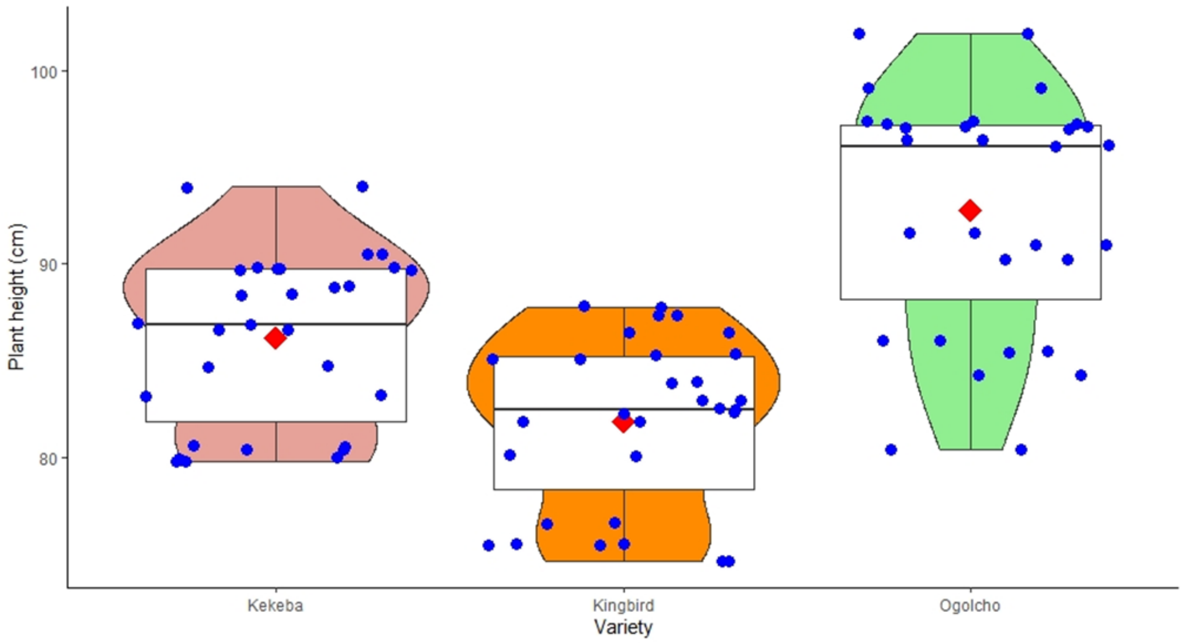

Figure 1. Response of plant height to different wheat varieties

This could be due to the adequate soil fertility resources in the soil required by the wheat crop for growth and development. These results supported by the findings of Khan *et al*. (2010) who reported that increasing the level of nitrogen increased the plant height. Application of the highest dose of phosphorus contributed to maximum dry matter and physiological attributes towards the yield attributes in wheat and therefore, helped in achieving highest number of grains per spike, 1000 grain weight and ultimately yield of wheat (Alam & Jahan, 2013). Non-significant variation for plant height among bread wheat varieties was reported by (Fano & Tadeos, 2017).

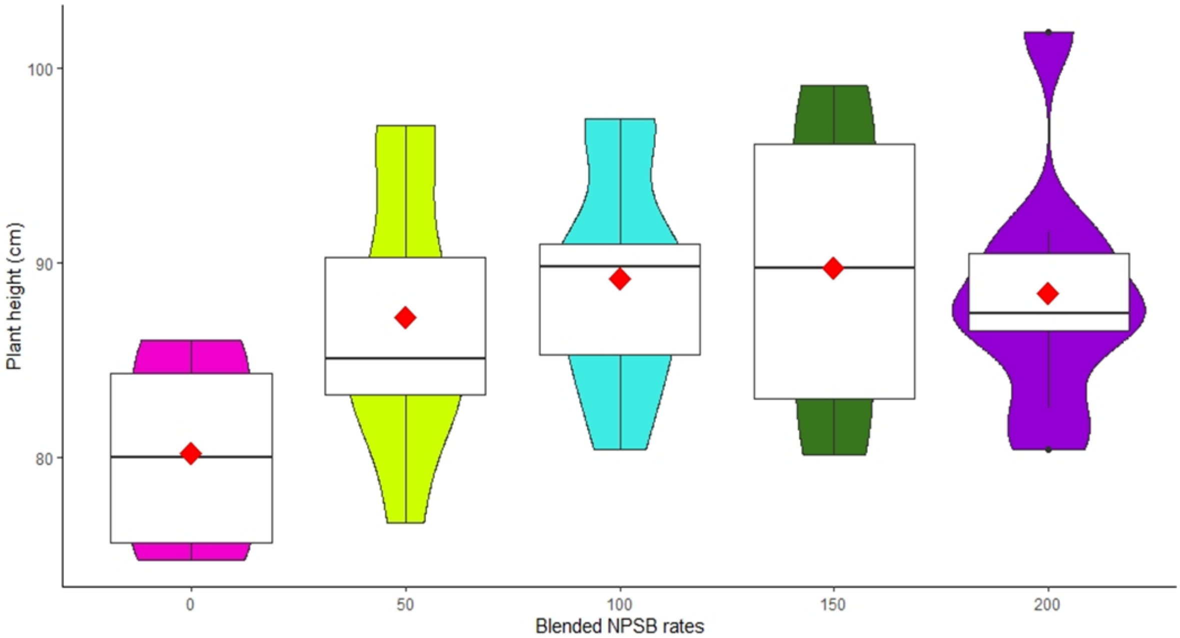

Figure 2. Main effects of blended NPSB fertilizer on plant height

3.4 Number of total tillers and productive tillers

The analysis of variance indicated that the main effect of fertilizer rate had highly significant (p <0.01) effects on the number of total and effective tillers per plant. However, main effect of variety and the interaction effect of variety and fertilizer rates were not significant (Table 5). Application of 200 kg NPSB ha^{-1} resulted into maximum number of total and effective tillers of 476.1 and 451.7 per m^2, respectively and no fertilized treatment resulted into minimum number of total and effective tillers of 240 and 218.9 per m^2, respectively (Table 5). In line with this result, Hameed *et al*. (2003) observed that increasing nitrogen application significantly increased the number of tillers m^{-2}. Jaenisch *et al*. (2022) also found a significant increase in the number of total tillers per plant with the increase of NPK level from 0 to150 $kg\ ha^{-1}$. Muhammad *et al*. (2009) reported that the significant variations on number of tillers per plant with the increased level of phosphorus application and the maximum numbers of tillers per plant (6.67) were found in the 80 $kg\ P\ ha^{-1}$.

3.5 Number of kernels per spike

The result revealed that fertilizer rates showed highly significant (p <0.01) effect with respect to the number of kernels per spike. While, the main effect of varieties and the interaction between the two factors were not significant to the number of kernels per spike. Variety Ogolcho had the highest number of kernels per spike (47.28) while lowest number of kernels per spike (41.97) recorded in variety kingbird (Table 5). The difference among varieties might be due genetic differences among the varieties. In agreement with this result Knezevic *et al*. (2015) reported that highly significant differences among the tested cultivars for number of kernels per spike with largest impact belongs to the genetic variability

(63.92%). Similarly, Akmal *et al.* (2000) observed significant differences among the wheat varieties for number of grains per spike. In contrast to this result, Hussain *et al* .(2002) reported non- significant difference among wheat cultivars for number of grains per spike in response to *NPK* fertilizer treatments which on an average varied only from 43.9 to 44.25. The effect of fertilizer also showed that the highest number of kernels per spike (50.43) was recorded from NPSB fertilizer rate of 150 $kg\ ha^{-1}$ (Table 5). Such response can be attributed to the adequate nitrogen availability which might facilitate the tillering ability of the plants, resulting in a greater spike population. The current study is in agreement with Jaenisch *et al.* (2022) who observed that number of grains per spike was significantly increased with each increment of NPK fertilizer. Geleto *et al.* (1995) also reported higher number of spikes per unit area at 120 $kg\ N\ ha^{-1}$ fertilized plots than the control.

3.6 Thousand kernels weight (TKW)

The result revealed that fertilizer rate and the varieties showed highly significant (p <0.01) effect on the thousand kernels weight and the interaction effect was not significant. Variety Kekeba had the highest thousand kernels weight (40.28 g) whereas variety Kingbird had the lowest thousand kernels weight (37.91 g) (Table 5). This might be due to good grain filling period and favorable environmental condition increases the thousand seed weights differ among the varieties. The reason is due to genetic variability in the parameter among the varieties. In line with this result the significant variation with the highest 42.96 g and lowest 39.58 g thousand seed weight among the varieties was reported by Shirinzadeh *et al.* (2018).

Table 5. Main effects of variety and blended fertilizer on number of total and productive tillers, Number of kernels per spike and straw yield of bread wheat

Treatments	Number of total tillers/m^2	No. of productive tillers/m^2	Number of kernels per spike	Thousand kernels weight	Straw yield ($kg\ ha^{-1}$)
Variety					
Ogolcho	329.0^{ns}	302.0^{ns}	47.28^{a}	38.76^{b}	5259^{b}
Kekeba	315.0^{ns}	297.7^{ns}	45.66^{a}	40.28^{a}	5244^{b}
Kingbird	355.3^{ns}	329.0^{ns}	41.97^{b}	37.91^{b}	6264^{a}
NPSB Fertilizer ($kg\ ha^{-1}$)					
0	240.0^{d}	218.9^{c}	32.46^{c}	36.97^{c}	3033^{c}
50	277.2^{cd}	250.6^{c}	43.52^{b}	39.03^{ab}	4269^{b}
100	340.0^{b}	310.6^{b}	48.81^{ab}	38.68^{b}	6293^{a}
150	332.2^{bc}	316.1^{b}	50.43^{a}	40.7^{a}	7130^{a}
200	476.1^{a}	451.7^{a}	49.62^{a}	39.53^{ab}	7222^{a}
LSD	58.19	54.38	2.88	1.67	1126.6
CV	5.80	8.00	13.60	4.40	20.9
P value	**	**	**	**	*

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; NS= non-significant, means in column followed by the same letter are not significantly different at 5% levels of Significance

The effect of fertilizer rate showed that the highest thousand kernels weight (40.7 g) was recorded from NPSB fertilizer rate of 150 $kg\ ha^{-1}$ while the lowest thousand kernels weight (36.97 g) was obtained with no fertilizer application (Table 5). This may be due to the provision of balanced nutrients application have enhanced accumulation of assimilate in the grains and thus resulting in heavier grains of wheat. This could also be due to adequate and better nutrition of the plants resulted in good grain filling and development of better seed size. The fact that higher amount of nitrogen application resulted in higher percentage of weight gain in grain filling stage in kernels and there by thousand kernel weight increased (Kauser *et al.*, 1993). Makowska *et al.* (2008) also reported that 1000 kernels weight increased with the increase in nitrogen rate up to 100 $kg\ ha^{-1}$. In similar to this result, Bereket *et al.* (2014) also reported that increasing N rate from 92 $kg\ N\ ha^{-1}$ to 138 $kg\ N\ ha^{-1}$ decreased thousand kernels weight of bread wheat by about 3.7%.

3.7 Grain yield ($kg\ ha^{-1}$)

The analysis of variance showed that the main effects of blended NPSB fertilizer and variety and their interactions significantly ($P < 0.01$) affected the grain yield of bread wheat Thus, the highest grain yield (6500 $kg\ ha^{-1}$) was obtained at the rates of 200 kg NPSB ha^{-1} for Ogolcho whereas, the lowest grain yield (2330 $kg\ ha^{-1}$) was recorded at 0 fertilizer application in combination with Kekeba (Table 6). The increase in grain yield at increasing NPSB rate might have resulted from improved root growth and increased uptake of nutrients and better growth favored due to the synergetic effects of both nutrients which enhanced yield components and yield. In agreement with this result, Haile *et al.* (2012) found that increasing N rate from 0 to 120 $kg\ N\ ha^{-1}$ increased grain yield of bread wheat. Bereket *et al.* (2014) also reported that increasing P rate from 46 to 69 $kg\ P_2O_5\ ha^{-1}$ increased grain yield of bread wheat by about 6.8%. Similarly, Guja *et al.* (2020) reported that application of nutrients like K, S, Zn, Mg and B used in experiments significantly increased grain yield and yield component of bread wheat as compare to the control (no fertilizer).

Table 6. Mean grain yield ($kg\ ha^{-1}$) of bread wheat as influenced by the interaction of blended NPSB fertilizer and variety

Blended NPSB ($kg\ ha^{-1}$)	**Variety**		
	Ogolcho	**Kekeba**	**Kingbird**
0	2444^{g}	2330^{g}	3078^{fg}
50	2650^{g}	4444^{de}	4039^{e}
10	4167^{de}	4178^{de}	5833^{abc}
150	5000^{cd}	3889^{ef}	5556^{bc}
200	6500^{a}	6222^{ab}	5944^{ab}
LSD	915		
CV	12.4		
P value	***		

Means in columns and rows followed by the same letters are not significantly different at 5% level of significance;
LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of variation

3.8 Straw yield

The result showed highly significant (p <0.01) difference among the varieties of wheat and the fertilizer rate and the interaction between the two factors were not significant. Variety Kingbird had the highest straw yield (8056 $kg\ ha^{-1}$) whereas variety Kekeba had the lowest straw yield (2611 $kg\ ha^{-1}$) (Table 5). This might be due to differences in genetic make-up of the varieties. Similarly, Ghafari *et al.* (2017) and Gul *et al.* (2012) found that straw yield of wheat significantly varied among the varieties. The result showed that an increase in straw yield when fertilizer rate increased from the lowest to the highest rate. The highest straw yield of 7222 $kg\ ha^{-1}$ was obtained at the highest NPSB rate of 200 $kg\ ha^{-1}$ whereas the lowest straw yields of 3033 $kg\ ha^{-1}$ was from the control (Table 5). The significant increase in straw yield in response to the highest rate of blended NPSB might be attributed to the synergistic roles of the nutrients that enhanced growth and development of the crop. The result is consistent with that of Nasser (2009) who reported increased straw yield of wheat with increase in NP fertilizers rates up to 90/45 $kg\ ha^{-1}$. Bereket *et al.* (2014) also reported that the highest straw yield was recorded at the highest nitrogen rate of 69 $kg\ N\ ha^{-1}$. On top of this, Gul *et al.*, (2012) reported that higher nitrogen application (160 $kg\ ha^{-1}$) has more contribution in higher straw yield production (9098.65 kg ha-1) as compared to control treatment (5302.97 $kg\ ha^{-1}$).

3.9 Aboveground biomass yield ($kg\ ha^{-1}$)

Analysis of variance showed that the main effects of variety, fertilizer rates and the interaction effect of variety and fertilizers had a highly significant effect (p <0.01) on aboveground dry biomass yield. Variety Ogolcho produced the highest aboveground dry biomass yield (15389 $kg\ ha^{-1}$) treated with 200 $kg\ ha^{-1}$ NPSB while the lowest above ground dry biomass yield (5056 $kg\ ha^{-1}$) was produced from variety Kekeba at 0 level application of the fertilizer (Table 7). This result agrees with that of Dawit *et al.*, (2015) who reported that increasing N from 0 to 184 $kg\ ha^{-1}$ and P from 0 to 138 $kg\ ha^{-1}$ increased the aboveground dry biomass yield of wheat by about 70.1% and 40.6%, respectively. Similarly, Workineh *et al.*, (2015) reported that the highest biomass yield (11890 kg ha-1) of wheat was observed with 138/115 $kg\ N/P_2O_5\ ha^{-1}$ while the lowest (9780 $kg\ ha^{-1}$) was recorded with 46/46 $kg\ N/P_2O_5\ ha^{-1}$. Likewise, Melesse Harfe (2017) reported that increasing the N/P fertilizer rate from 46/20 $kg\ N/P_2O_5\ ha^{-1}$ to 69/30 $kg\ N/P_2O_5\ ha^{-1}$ for wheat biomass yield was increased from 10417 $kg\ ha^{-1}$ to 11233 $kg\ ha^{-1}$. The increase in aboveground dry biomass at the highest rates of NPSB might have resulted from improved root growth and increased uptake of nutrients favoring better growth and delayed senescence of leaves of the crop due to synergetic effect of the nutrients. In conformity with this result, Jasemi *et al.*, (2017) reported vegetative growth and biological yield has much dependence to consumption of chemical fertilizers, application of the fertilizers led to increasing biological yield of wheat. Similarly, Bekalu and Mamo, (2016) also reported that increasing N rates from 23 to 69 $kg\ ha^{-1}$ increased aboveground dry biomass of wheat by about 22.6%. Likewise, Wakene *et al.* (2014) stated that supply of P_2O_5 at rate of 69 $kg\ ha^{-1}$ in wheat found to be adequate to produce maximum aboveground dry biomass. Yasir *et al.* (2015) also reported the maximum aboveground dry biomass of wheat have obtained with application of 140 $kg\ N\ ha^{-1}$ at sowing and 20 $kg\ S\ ha^{-1}$ at anthesis.

Table 7. Mean Above ground biomass ($kg\ ha^{-1}$) of bread wheat as influenced by the interaction of blended NPSB fertilizer and variety

Blended NPSB ($kg\ ha^{-1}$)	**Variety**		
	Ogolcho	**Kekeba**	**Kingbird**
0	5208^{ij}	5056^{j}	6689^{hij}
50	7122^{ghi}	8611^{fg}	8206^{gh}
100	8669^{fg}	10844^{de}	13611^{abc}
150	11944^{cde}	10278^{ef}	13611^{abc}
200	15389^{a}	12611^{bcd}	14278^{ab}
LSD	1919.3		
CV	11.3		
p value	**		

Means in columns and rows followed by the same letters are not significantly different at 5% level of significance; LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of variation

3.10 Partial Budget Analysis

The partial budget analysis showed that highest net benefit of (72, 495) $Birr\ ha^{-1}$ was obtained for variety Ogolcho that received 200 kg NPSB ha^{-1} (Table 8). However, the lowest net benefits of 27,651 $Birr\ ha^{-1}$ was obtained from the unfertilized treatment with the variety Kekeba. The variety Ogolcho gave economic benefit of 72,495 $Birr\ ha^{-1}$ with marginal rate of return of 2711.9% at 200 kg NPSB ha^{-1} fertilizer rate. Therefore, on economic grounds, application of 200 kg NPSB ha^{-1} with variety Ogolcho would be best and economical for production of bread wheat in the study area and other areas with similar agro-ecological conditions. In line with this result, (Bekalu & Mamo, 2016) reported that N application at 69 $kg\ ha^{-1}$ is effective in attaining higher grain yield and economic benefit of wheat in southern part of Ethiopia.

Table 8. Marginal rate of return analysis for response of bread wheat varieties to blended NPSB fertilizers in Hulbareg District, Southern Ethiopia

Treatments		Wheat yield ($kg\ ha^{-1}$)			Income ($ETB\ ha^{-1}$)					2MRR (%)
Variety	NPSB	UGY	AGY	SY	Grain	Straw	GFB	TVC	NB	
Ogolcho	0	2444	2199.6	2611	27495	1305.5	28800.5	0	28800.5	D
Ogolcho	50	2650	2385	4472	29812.5	2236	32048.5	2550	29498.5	72.45
Ogolcho	100	4167	3750.3	4502	46878.75	2251	49129.75	3160	45969.75	2700
Ogolcho	150	5000	4500	6944	56250	3472	59722	3770	55952	1636.4
Ogolcho	200	6500	5850	7500	73125	3750	76875	4380	72495	2711.9
Kekeba	0	2330	2097	2878	26212	1439	27651.5	0	27651.5	D
Kekeba	50	4444	3999	4167	49995	2083.5	52078.5	2550	49528.5	812.9
Kekeba	100	4178	3760	6667	47002.5	3333.5	50336	3160	47176	D
Kekeba	150	3889	3500.1	6389	43751.25	3194.5	46945.75	3770	43175.75	D
Kekeba	200	6222	5599.8	6389	69997.5	3194.5	73192	4380	68812	4202
Kingbird	0	3078	2770.2	3611	34627.5	1805.5	36433	0	36433	D
Kingbird	50	4039	3635.1	4167	45438.75	2083.5	47522.25	2550	44972.25	334.9
Kingbird	100	5833	5249.7	7711	65621.25	3855.5	69476.75	3160	66316.75	3499
Kingbird	150	5556	5000.4	8056	62505	4028	66533	3770	62763	D
Kingbird	200	5944	5349.6	7778	66870	3889	70759	4380	66379	592.8

Where, AGY= adjusted grain yield; SY = Straw yield; GFB = gross field benefit; TVC= total variable costs; NB = net benefit, MRR = marginal rate of return; $ETB\ ha^{-1}$= Ethiopian Birr per hectare; D = dominated treatments. Cost of bread wheat seed= 16.00 $ETB\ kg^{-1}$; Cost of NPSB= 12.20 kg^{-1}; Cost of Urea =10.40 $ETB\ kg^{-1}$; Labour cost for NPSB application = 7 persons ha^{-1}, each 60 ETB day−1; Labour cost for urea top dress fertilizer application at tillering = 8 person ha^{-1}, each 60 ETB day^{-1}. Market price of bread wheat grain =12.5 $Birr\ kg\ ha^{-1}$ and straw=0.5 $Birr\ kg^{-1}$ in Hulbareg town at harvesting time in December 2019.

4 Conclusion

For the last four to five decades, Ethiopian agriculture depended solely on imported fertilizer products; only urea and Di-ammonium phosphate (DAP), as sources of *N* and *P*, respectively. However, recently it is perceived that the production of such high protein cereals like wheat can be limited by the deficiency of *S* and other nutrients. Thus, addition of nutrients such *N*, *P*, *S* and *B* to low fertile soil is important to increase yield, yield components and quality of wheat whether it is for consumption or industrial purpose. Therefore, from the result of present study that the application of the 200 $kg\ ha^{-1}$ blended NPSB fertilizer in addition to 46 $kg\ N\ ha^{-1}$ with variety Ogolcho can be recommended to farmers for production of wheat in the study area and other areas with similar agro-ecology.

Acknowledgments

This study is financially supported by Haramaya University.

Authors' Contributions

*** and *** designed the experiment and collected the data. *** analyzed the data and interpreted the results. *** prepared the manuscript. *** and *** revised and edited the manuscript. All authors read and approved the final version of the manuscript.

Conflict of Interest

The authors declares that there is no conflict of interest.

Data Availability

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

References

Akmal MS, Shah M, & Asim M. (2000). Yield performance in three commercial wheat varieties due to flag leaf area. *Pakistan J. Biol. Sci.*, 3(12):2072-2074.

Alam, M. S. & Jahan, I. (2013). Yield and yield components of wheat as affected by phosphorus fertilization. *Rajshahi University Journal of Life and Earth and Agricultural Sciences*, 41:21-27.

Asnakew, W., Tarekegn, M., Mengesha, B. & Tefera, A. (1991). Soil fertility management studies on wheat in Ethiopia. Wheat Research in Ethiopia: A Historical Perspective. Addis Ababa, *IAR/CIMMYT*: 137-172.

Assefa Workineh, Yemane Nega & Dawit Habte (2015). Planting density and nitrogen and phosphorus fertilization effect on different bread wheat (*Triticum aestivum* L.) genotypes in South Tigray, Ethiopia. *World Journal of Medicine and Medical Science Research* Vol. 3 (2): 020-028.

ATA (Agriculture Transformation Agency) (2014). Wheat Sector Development Strategy working document.

Bekalu Abebe & Mamo Manchore (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 Sciences*, 6(3): 168-175.

Bereket Haileselassie, Dawit Habte, Mehretab Haileselassie & Gebremedhin Gebremeskel (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. https://doi.org/10.11648/j.aff.20140303.18

Brian N. Otteson, Mohamed Mergoum & J. K. R. (2007). Seeding rate and nitrogen management effects on spring wheat yield and yield components. *Agronomy Journal*, 99(6):1615-1621.

Chapman, H. D. (1965). Cation exchange capacity by ammonium saturation. 891-901. In: Black, C.A., L.E. Ensminger and F.E. Clark (ed.), Method of soil analysis. American Society of Agronomy, Madison Wisconsin, USA.

CIMMYT (Centro International de Mejoramiento de Maiz y Trigo /International Maize and Wheat Improvement Center) (1988). From agronomic data to farmer recommendation: An Economic work Book. Mexico, D.F.: CIMMYT.

Clayton, W.D., Govaerts, R., Harman, K.T., Williamson, H. & Vorontsova, M. (2015). World Checklist of Poaceae. (Royal Botanic Gardens, Kew) Accessed on 5 Jul 2022.

CSA (Central Statistical Agency) (2019). Agricultural sample survey Report on area and production for major crops. Central Statistical Agency, Ethiopia

Curtis, B.C. (2002). *Wheat in the World*. In: Bread Wheat: Improvement and Production, Curtis, B.C., S. Rajaram and H.G. Macpherson (Eds.) Food and Agriculture Organization of the United Nations, Rome, Italy, ISBN-13: 9789251048092, pp: 1-18.

Dawit Hapte, Kasu Tadese, Wubengeda Admasu, Tadese Dessalegn & Asrat Mekonen (2015). Agronomic and Economic Evaluation of the *N* and *P* Response of Bread Wheat Grown in Moist and Humid Mid highland Vertisols Areas of Arsi Zone, Ethiopia. *African Journal of Agricultural Research*, 10 (3):89-99

Demeke, M. D: Marcantonio, F. (2013). Analysis of incentives and disincentives for Wheat in Ethiopia. Techical notes series, MAFAP, FAO, and Rome.

Dewis J, Freitas P. (1975). Physical and chemical methods of soil and tissue analysis. FAO Bulletin No. 10. Rome. pp. 275.

EthioSIS (Ethiopia Soil Information System). (2014). Soil fertility status and fertilizerrecommendation atlas for Tigray regional state, Ethiopia.

EthioSIS (Ethiopian Soil Information System). (2013). Soil analysis report. Agricultural Transformation Agency (Unpublished)

Fano Dargo and Tadeos Shiferaw (2017). Participatory Varietal Selection of Bread Wheat Cultivars (*Triticum aestivum* L.) for Moisture Stress Environment of Somali Regional State of Ethiopia. *Journal of Biology, Agriculture and Healthcare*: 7(5):58-67.

FAO (Food and Agriculture Organization) (2014). Food Balance Sheets. Rome, Italy.

FAO (Food and Agriculture Organization) (2019). Strategic analysis and intervention plan for wheat and wheat products in the Agro-Commodities Procurement Zone of the pilot Integrated Agro-Industrial Park in Central Eastern Oromia, Ethiopia. FAO, Addis Ababa

Geleto, T., Tanner, D.G., Mamo, T. *et al.* (1995). Response of rainfed bread and durum wheat to source, level and timing of nitrogen fertilizer on two Ethiopian Vertisols: II. *N* uptake, recovery and efficiency. Fertilizer Research 44: 195–204. https://doi.org/10.1007/BF00750926

Ghafari, H., Gorji, M., Arabkhedri, M., Ali, GR., Heidari, A. & Akhavan, S. (2017). Identification and prioritization of critical erosion areas based on onsite and offsite effects. Catena. 156:1-9. https://doi.org/10.1016/j.catena.2017.03.014

Guja U., Abreham K., Mekuria T. & Tsegaye H. (2020). Evaluation of different blended fertilizer types and rates for better production of bread wheat (*Triticum aestivum* L.) at Adiyo District, South Westhern Ethiopia. *Agricultural and Veterinary Sciences* 8(1): 12-18.

Gul, H., Said, A., Saeed, B., Ahmad, I. & Ali, K. (2012). Response of yield and yield components of wheat towards foliar spray of nitrogen, potassium and zinc. *ARPN J Agric Biol Sci* 6:23–25

Haile Deressa, Nigussie Dechasa & Amsalu Ayana (2012). Nitrogen use efficiency of bread wheat: Effects of nitrogen rate and time of application. *Journal of Soil Science and Plant Nutrition*, 12 (3): 389-409.

Hailu Gebremariam (1991). Wheat production and research in Ethiopia. pp. 1-15. In: Hailu G.M., Tanner, D.G., Mengistu, H. (eds.). Wheat Research in Ethiopia: A Historical Perspective. IAR/CIMMYT, Addis Ababa, Ethiopia.

Hameed, E., W.A. Shah, A.A. Shad, J. Bakht & T. Muhammad (2003). Effect of different planting dates seed rate and nitrogen levels on wheat. *Asian J. Plant Sci*., 2(6):467-474.

Hamzeh Mohmmed. Rawashdeh & Florin Sala (2013). The effect of foliar application of iron and boron on early growth parameters of wheat (*Triticum aestivum* L.). *Research Journal of Agricultural Science*, 45(1):21-26.

Haun, J. R. (1973). Visual quantification of wheat development. *Agronomy. J*. 65:116–119.

Havlin, J.L., Beaton J.D., Tsdale, S.L. & Nelson W.L. (1999). Soil fertility and fertilizer: an introduction to nutrient management Prentice Hall, New York, 499p.

Hillette Hailu, Tekalign Mamo, R. Keskinen, E. Karltun, Heluf Gebrekidan & Taye Bekele (2015). Soil fertility status and wheat nutrient content in Vertisol cropping systems of central highlands of Ethiopia. *Agriculture and Food Secure* 4:19-23.

Horneck, D. A., Sullivan, D. M., Owen, J. S. & Hart, J. M. (2011). Soil Test Interpretation Guide. EC 1478. Revised July 2011, Oregon State University Extension Service.

Hussain M. Iftikhar, Shah Shamshad H., Hussain Sajjad & Iqbal Khalid. (2002). Growth, Yield and Quality response of three Wheat (*Triticum aestivum* L.) varieties to different levels of *N*, *P* and *K*. *International Journal of Agriculture and Biology*, 4(3):362-364.

Jaenisch R. B., Munaro B. L., Jagadish K. V. & Lollato P. R. (2022). Modulation of Wheat Yield Components in Response to Management Intensification to Reduce Yield Gaps. *Front. Plant Sci.*, https://doi.org/10.3389/fpls.2022.772232

Jasemi M., Valizadeh L., Zamanzadeh V. & Keogh B. (2017). A Concept Analysis of Holistic Care by Hybrid Model. *Indian J Palliat Care*, 23:71-80.

Jemal Abdulkerim, Tamado Tana & Firdissa Eticha (2015). Response of Bread Wheat (*Triticum aestivum* L.)Varieties to Seeding Rates at Kulumsa, South Eastern Ethiopia. *Asian Journal of Plant Sciences,* 14: 50- 58.

Kausar, K., M. Akbar, E. Rasul & A.N. Ahmad (1993). Physiological responses of nitrogen, phosphorus and potassium on growth and yield of wheat. *Pakistan J. Agric. Res*., 14: 2-3.

Khan, M. B. Lone, M.I., Ullah R. & Kaleem S. (2010). Effect of different phosphatic fertilizers on growth attributes of wheat (*Triticum aestivum* L.). *Journal of American Science*, 6(12):1256-1262.

Knezevic D., Radosavac A. & Zelenika M. (2015). Variability of grain weight per spike in wheat grown in different ecological conditions. *Acta Agriculturae Serbica*, 39: 85-951

Landon JR. (1991). Booker tropical soil manual: a handbook for soil survey and agricultural land evaluation in the tropics and sub-tropics. *Longman Scientifc and Technical, Essex* , p 474

Legesse Amsalu (2004). Response of tef [*Eragrostis tef* (Zucc.) Trotter] to applied nitrogen and phosphorus in Sirinka, North Eastern Ethiopia. MSc. Thesis, Haromaya University. 68p.

Luo, J., Su, F., Chen, D., Shiloh, A. & Gu, W. (2000). Deacetylation of p53 modulates its effect on cell growth and apoptosis. *Nature*, 408: 377–381.

Makowska A., Obuchowski W., Sulewska H., Koziara W., Paschke H. (2008). Effect of nitrogen fertilization of durum wheat varieties on some characteristics important for pasta production. *Acta Sci. Pol., Technol. Aliment*. 7(1): 29-39.

Manna, M. C., Swarup, A., Wanjari, R. H., Mishra, B. & Shahi, D. K. (2007). Long-term fertilization, manure and liming effects on soil organic matter and crop yields. *Soil & Tillage Research*, 94, 397–409.

Marschner, H. (1995). Functions of Mineral Nutrients: Micronutrients. In: Mineral Nutrition of Higher Plants, 2^{nd} Edition, Academic Press, London, 313-404.

Martens, D.C. & Westermann, D.T. (1991). Fertilizer Applications for Correcting Micronutrient Deficiencies. Soil Science Society of America, 677 S. Segoe Rd., 50 Madison, WI 53711, USA. Micronutrients in Agriculture. 2^{nd} ed. SSSA Hook Series, no. 4.pp. 549-553.

Mathpal, B., Srivastava, P. C., Shankhdhar, D. & Shankhdhar, S. C. (2015). Zinc enrichment in wheat genotypes under various methods of zinc application. *Plant Soil & Environment*, 61, 171–175.

Melesse Harfe (2017). Response of bread wheat (*Triticum aestivum* L.) varieties to *N* and *P* fertilizer rates in Ofla district, Southern Tigray, Ethiopia. *African Journal of Agricultural Science*, 12(19): 1646-1660. https://doi.org/10.5897/AJAR2015.10545

Mengel, K. & Kirby, E.A. (1996). Principles of plant nutrition. *Panima Publishing Corporation*, New Delhi, India.

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

Motsara., M. R. & Roy, R. N. (2008). Guide to laboratory establishment for plant nutrient analysis. FAO Fertilizer and Plant Nutrition Bulletin 19. Rome, Italy.

Muhammad Tahir, Asif Tanveer, Tajamal Hussain Shah, Naeem Fiaz & Allah Wasaya (2009). Yield Response of Wheat (*Triticum aestivum* L.) to Boron Application at Different Growth Stages. Pakistan journal of life and social science, 7(1):39-42.

Nadian, H., Najarzadegan, R., AlamiSaeid, K., Gharineh, M.H. & Siadat, A. (2010). Effects of boron and sulfur application on yield and yield components of *Brassica napus* L. in a calcareous soil. *World Applied Science Journal*, 11: 89–95.

Nasser, M. E. A. W. (2009). Effect of partial or complete replacement of cottonseed meal by jojoba meal on gas production, rumen fermentation and produced amylase and carboxymethylecellulase activity, *in vitro*. *Livest. Res. Rural Dev.*, 21 (5) Article No.79

Olsen, S. R., Cole, C. V., Watanabe, F. S. & Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular, Vol 939 (p. 19). Washington, DC: US Department of Agriculture.

Rai, B., Thandapani, V. & Chandrababu R. (2012). Physio-morphological and biochemical characterization of selected recombinant inbred lines of rice for drought resistance. *Indian Journal of Plant Physiology*, 17(2):189-193.

Shirinzadeh, A., Abad, S. H., Nourmohammadi, G., Haravan, M. E. & Madani, H. (2018). Yield Gap Associated with Crop Management in Wheat (Case Study: Ardabil Province-ParsabadMoghan). *Egypt. J. Agron.*, 40(3): 223 -236.

Tekalign Tadesse (1991). Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa.

Teklu Erkossa & Teklewold Hailemariam (2009). Agronomic and economic efficiency of manure and urea fertilizers use on vertisols in Ethiopian Highlands. *Agricultural Sciences in China*, 8(3):352-360.

Temesgen Godebo, Fanuel Laekemariam & Gobeze Loha (2021). Nutrient uptake, use efficiency and productivity of bread wheat (*Triticum aestivum* L.) as affected by nitrogen and potassium fertilizer in Keddida Gamela Woreda, Southern Ethiopia. *Environ Syst Res.*, 10:12

USDA (United States Department of Agriculture) (2022). Wheat Outlook: https://www.nass.usda.gov/Newsroom/2022/05-12-2022.php accessed on 03 July 2022.

Wakene Tigre Walelign Worku & Wassie Haile (2017). Effects of Nitrogen and Phosphorus Fertilizer Levels on Growth and Development of Barley (*Hordeum vulgare* L.) at Bore District, Southern Oromia, Ethiopia. *American Journal of Life Sciences*, 2(2):260-266. https://doi.org/10.11648/j.ajls.20140205.12.

Wakene Tigre, Walelign Worku & Wassie Haile (2014). Effects of nitrogen and phosphorus fertilizer levels on growth and development of barley (*Hordeum vulgare* L.) at Bore District, Southern Oromia, and Ethiopia. *American Journal of Life Sciences*, 2(5): 260-266.

Walkley, A.J. & Black, I.A. (1934). Estimation of soil organic carbon by the chromic acid titration method. Soil Science, 37:29-38.

Weil R. R. and Brady N. C. (2017). The Nature and Properties of Soils.15th edition. Pearson/Prentice Hall, USA.

Yasir Hayat, Zahid Hussain, Shad Khan Khalil1, Zafar Hayat Khan, Ikramullah, Muhammad Ali, Tariq Shah & Farooq Shah (2015). Effects of Nitrogen and Foliar Sulphur Applications on the Growth and Yield of Two Wheat Varieties Grown in Northern Pakistan. *ARPN Journal of Agricultural and Biological Science*, 10(4):139-145.

Yong L. D., Fam D. S. & Lum Shawn (2011). Reel Conservation: Can Big Screen Animations Save Tropical Biodiversity? Tropical Conservation Science 4(3):244-253. https://doi.org/10.1177/194008291100400302