Agricultural and Biological Sciences Journal
Vol. 6, No. 2, 2020, pp. 60-71
http://www.aiscience.org/journal/absj
ISSN: 2381-7178 (Print); ISSN: 2381-7186 (Online)

Effects of Variety and Fertilizer Rate on Yield of Bread Wheat (*Triticum aestivum*, L) Varieties in East Wollega Zone, Western Ethiopia

Lemi Aga Duressa[1], Negash Geleta Ayana[2, *]

[1]Agronomy, Gida Ayana District Agricultural Development Office, Ayana, Ethiopia
[2]Durum Wheat Breeding Program, Ethiopian Institute of Agricultural Research, Debre Zeit Agricultural Research Center, Debre Zeit, Ethiopia

Abstract

An experiment was conducted to determine the effect of variety, fertilizer rate and their interaction on yield and yield components and to determine the economic feasibility of application of fertilizer and varieties for optimum yield of bread wheat. The experiment consisted of four levels of NPSZnB/Urea fertilizers (0/0, 75/75, 100/100, and 125/125 kg ha^{-1}) and four bread wheat varieties (Liben, Ogolcho, Hulluka and Senate) combined factorially and laid out in Randomized Complete Block Design with three replications. Soil samples for the experimental site were taken before planting for physicochemical analysis using the standard methods. Agronomic data were collected and analyzed using GLM procedure of SAS (Version 9.0, 2004 USA) and means difference were tested for the significance with least significant difference (LSD) method at 0.05 probability level. Partial budget analysis was carried out for grain yield to determine the optimum use of inputs. The results for soil physico chemical analysis before sowing showed that texturally high in sand, moderate in silt and clay in content, with pH of 5.42, organic carbon content of 3.219%, moderate total N (0.277%) and low total P (1.294%), medium CEC of 16.978 meq/100g soil. The results of analysis of variance for agronomic traits showed that the main effect of variety and fertilizer rate applications were significant for all parameters except for number of productive tillers due to the effect of variety. The interaction effect of variety by fertilizer rate application was highly significant for all parameters except for days to 50% emergence and days to 50% heading. Grain filling period and days to 90% maturity were delayed with increased rates of fertilizer for all varieties. The highest mean plant height, spike length, number of grains per spike, and harvest index were 90.46 cm, 8.73 cm, 53.46, 5.28 t ha^{-1}, and 54.33% respectively for Ogolcho at 100/100 kg ha^{-1} NPSZnB/Urea application, while the highest biomass yield was 10.20 t ha^{-1} for Ogolcho at 125/125 kg ha^{-1} NPSZnB/Urea application and the highest mean thousand kernel weight was 49 g for Ogolcho and Liben at 100/100 kg ha^{-1} NPSZnB/Urea application. The lowest grain yield (0.89 t ha^{-1}) was recorded from Liben with no fertilizer (control). The results of economic analysis showed that the maximum net benefit (Birr. 50,904.35 ha^{-1}) was obtained due to the use of the variety Ogolcho and application of 100 /100 kg ha^{-1} NPSZnB/Urea. In conclusion, the results of the study showed that application of 100 /100 NPSZnB/Urea kg ha^{-1} with the variety Ogolcho enhanced yield of bread wheat with acceptable economic benefit.

Keywords

Bread Wheat, Economic Analysis, Fertilizer Rate, Varieties, Yield

Received: July 3, 2019 / Accepted: February 13, 2020 / Published online: March 9, 2020

@ 2019 The Authors. Published by American Institute of Science. This Open Access article is under the CC BY license.
http://creativecommons.org/licenses/by/4.0/

* Corresponding author
E-mail address: ayananegash@yahoo.com (N. G. Ayana)

1. Introduction

Wheat (*Triticum* spp.*)* belongs to the grass family, *Poaceae*. Bread wheat (*Triticum aestivum) and* durum wheat (*Triticum durum)* and emmer wheat (*Triticum dicoccum)* are economically important in Ethiopia [1]. Most of the wheat grown throughout the world is hexaploid which is commonly referred to bread wheat and this includes the vast majority of varieties with great diversity in agro-ecological adaptation and utilization [2]. Wheat is one of the world's most important staple food crops, providing 20% of humanity's dietary energy supply and serving as the main source of protein in developing nations [3] and it is a staple food for about one third of the world's population [4]. Ethiopia is one of the largest producers of wheat in sub-Saharan Africa with an estimated area of 1.70 million ha and wheat ranks fourth in cereals after tef (*Eragrostis tef*), maize (*Zea mays*) and sorghum (*Sorghum bicolor*) in area coverage and in total production, and which was surpassed by maize in productivity (2.74 t ha^{-1}) [5].

Wheat grows in Ethiopian at altitudes ranging from 1500 to 3000 m.a.s.l. [6], and it is produced exclusively under rain fed conditions. However, the most suitable areas, falls between 1900 and 2700 masl; and currently, production under irrigation in lowland plains are under trial. The relatively low yield of wheat in Ethiopia may be partially attributed to the low level of adoption of improved varieties and improved management techniques [7]. Moreover, multifaceted biotic and abiotic factors are responsible for the low yield of wheat in the country. Soil degradation and depletion of soil nutrients are among the major factors threatening sustainable cereal production in the Ethiopian highlands and wheat production in the country is adversely affected by low soil fertility and suboptimal use of mineral fertilizers in addition to diseases, weeds, erratic rainfall distribution in lower altitude zones and water logging in the Vertisols areas [8]. Low availability of nitrogen (N) and phosphorus (P) has been reported to be the major constraint to wheat production in Ethiopia [9]. In sustainable wheat production the efficiency of fertilization could be increased by using variety-specific fertilization [10]. Comparative study by [11] on varietal differences and N fertilization on wheat grain yield and quality showed significant variations among the varieties for all the agronomic traits.

Phosphorous has a lower mobility than any other nutrients and it does not remain in a free state for long in which it is slowly available to plants and plants deficient in phosphorus have stunted growth and its deficiency in wheat caused reduced tillering, reduced leaf area and increased susceptibility to diseases, and delayed maturity [12]. Improvement in total number of tillers with P application might be due to the role of P in emerging radical and seminal roots during seedling establishment in wheat [13] and number of tillers is enhanced in wheat with increased P application. The same authors reported readily availability of P during early season which saved the plants from early stresses and its higher uptake at higher levels resulted into enhanced number of grains per spike and 1000-grain weight due to its involvement in grain formation and development.

Sulfur (S) is one of the essential nutrients for plant growth and it accumulates 0.2 to 0.5% in plant tissue on dry matter basis; and it is required in similar amount as that of Phosphorus [14]. Without adequate S, crops cannot reach their full potential in terms of yield or protein content [15]; and it is required for the synthesis of S containing amino acids such as cystine, cysteine and methionine. Sulfur deficiency results in stunted growth, reduced plant height, tillers, spikelets and delayed maturity in plants and sulfur deficient plants have also less resistance under stress conditions [16]. Due to its synergistic effect, the efficiency of NPK, and Zn is enhanced which results in increased crop productivity. Application of S fertilizer is a feasible technique to suppress the uptake of undesired toxic elements (Na and Cl) because of the antagonistic relationship, thus its application is useful not only for increasing crop production and quality of the produce but also improves soil conditions for healthy crop growth [15]. Wheat requires a relatively high amount of supplemental S due to incompatibility of conditions with its period of most rapid growth, when the rate of S release from soil organic matter is quite slow [17]. According to [18] elemental S and sulphate fertilizers application increased wheat grain yield by 36%. Sulfur application increased the grain S content at high N rather than at low N treatment [19].

Zinc (Zn) is one of the eight trace elements among Fe, Cu, Mn, Cl, B, Mo and Ni which are essential for the normal healthy growth and reproduction of crop plants; and plays a key role in various plant metabolism processes such as the development of cell wall, respiration, carbohydrate metabolism and gene regulation [20]. Zinc has been found useful in improving yield and yield components of wheat [21] and adequately applied zinc has been shown to improve the water use efficiency of wheat plants [22]. Zn is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory co-factor of a large number of enzymes in many important biochemical pathways and essential for the normal healthy growth [23]. The main factors which affect the amount of zinc in soil are pH, carbonate content, organic matter, soil texture and interaction between zinc and other microelements, such as iron [24] and zinc fertilizers are used in the prevention of Zn deficiency and in the bio fortification of cereal grains.

Boron (B) is an essential micronutrient for plants, and plant requirements for this nutrient are lower than the requirements for all other nutrients except molybdenum and copper. It is the only non-metal among the micronutrients and also the only micronutrient present over a wide pH range as a neutral molecule rather than an ion [25]. Boron is required for normal development of reproductive tissues and deficiency results in low grain set and poor seed quality. Even the cereals (like wheat and rice) with small B requirement can suffer from impaired seed set due to B shortage at a critical growth stage [26]. Boron is involved in N and P metabolism, in plants poorly supplied with B, NO_3^- N accumulated in the roots, leaves, and stems, showing that NO_3^- reduction and amino acid synthesis were inhibited. Boron is mainly associated with cell wall pectin, and physical characteristics of the growing cell wall were altered under B deficiency. Boron uptake by plants is controlled by the B level in soil solution rather than the total B content in soil [27]. Plants absorb boron in the form H_3BO_3, and it moves to plant root mainly by mass flow and diffusion. In B-deficient soils, use of appropriate source is fundamental to improve crop yields and B use efficiency. Boron fertilizers can be applied as broadcast, band, or foliar [28]. Hence, to improve the productivity of wheat in nutrient deficient soils, determination for optimum use of fertilizer rate for different varieties are paramount important. Though, bread wheat is majorly produced in mid to highlands of East wollega, Gida Ayana district, there was no recommendation for fertilizer rate for improved varieties so far. Hence, the objectives of the study were to determine the effect of variety, fertilizer rate application, and their interactions on yield and yield components of bread wheat and to analyze the economic feasibility of fertilizer rates and variety application for optimum yield of bread wheat.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted in Gida Ayana district of East Wollega Zone, western Ethiopia during 2018 main cropping season. The experimental site is located at 09° 49' 361''N latitude and 036° 38' 472''E longitudes and at altitude of 2191 meter above sea level (masl) (Figure 1). The average annual rainfall is 1329 mm and the average minimum and maximum air temperature of the area is 16.7°C and 22.4°C, respectively.

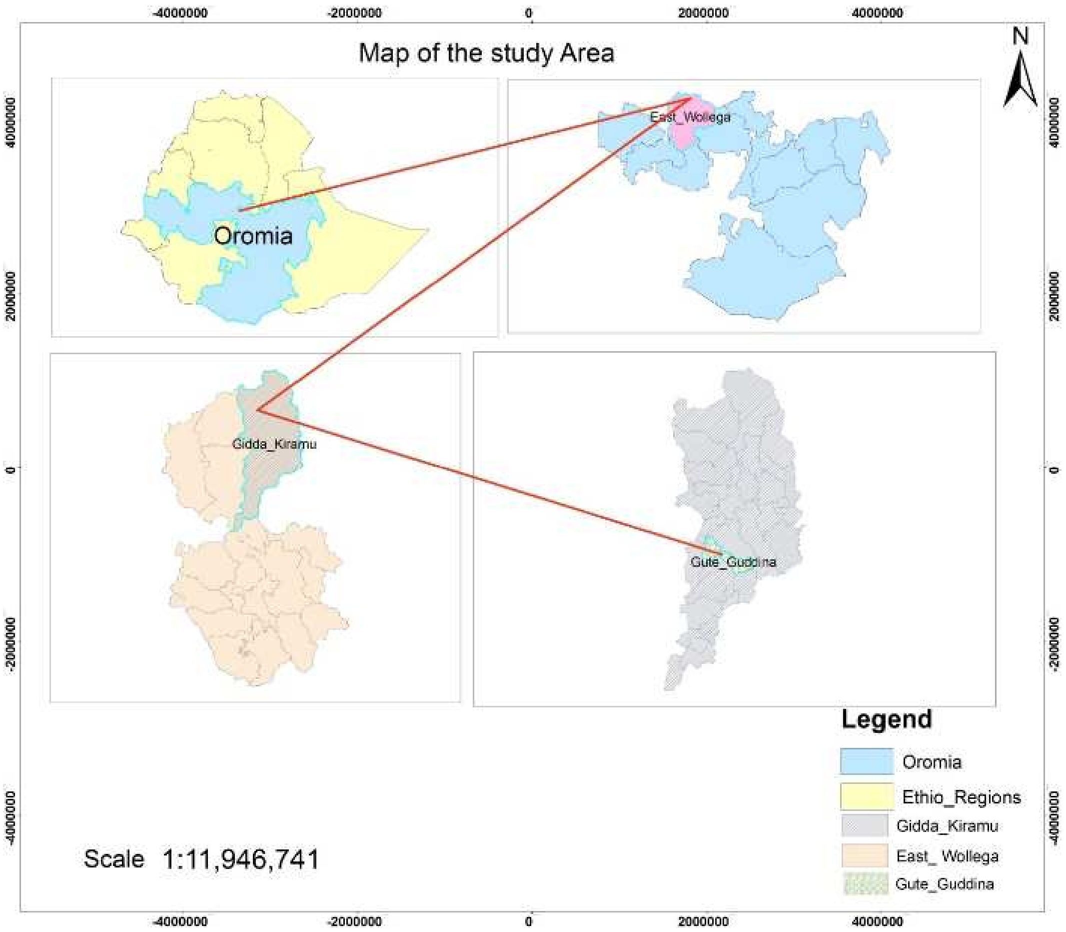

Figure 1. Map of the study area.

2.2. Experimental Materials and Design

Four bread wheat varieties viz. Liban (ETBW5653), Ogolcho (ETBW5520), Senate (14F/HAR1685), and Hulluka (ETBW 5496) and four different fertilizer rates ($R_{1=}$ 0/0 kg NPSZnB/Urea; R_2=75kg NPSZnB / 75kg URrea, R_3= 100kg NPSZnB / 100kg Urea and $R_{4=}$ 125 kg NPSZnB / 125kg UREA) were combined factorially and laid out in Randomized Complete Block Design with three replications. The size of each plot was 4 m x 3 m (12 m^2) and the distance between adjacent plots and blocks was kept at 0.5 m and 1 m apart, respectively. Each plot consisted of 15 rows of 4m length and the rows are spaced at 20 cm apart. The blended fertilizer (Nitrogen, phosphorus, Sulphur, zinc and boron fertilizer) was applied in the form of NPSZnB at different rates at planting and the urea was applied half at planting and the rest half at tillering stage. All other management practices such as weeding; insect pests and diseases management were applied uniformly as needed.

2.3. Data and Data Collection

2.3.1. Physico-chemical Property of Soil of the Study Area

Before sowing, soil samples were taken randomly from 10 plots at the depth of 0-30 cm in a zigzag pattern to make one composite surface soil sample of the experimental field. The prepared soil samples were composited to one sample and air dried, crushed in a mortar and sieved through a 2 mm sieve. From this mixture, a sample weighing 1 kg was put into a plastic bag. Then the composite soil sample was analyzed for the determination of soil texture, soil pH, organic carbon, total nitrogen, available phosphorus and cation exchange capacity (CEC) analysis using standard laboratory procedures at Nekemte Regional Soil Testing Laboratory, Ethiopia.

2.3.2. Agronomic Data

Data were collected for days to 50% emergency, days to 50% heading, days to 90% physiological maturity, days to grain filling period, plant height (cm), number of productive tillers per plant, spike length (cm), number of spikelet's per spike, number of kernels per spike, thousand kernels weight (g), biomass yield (t ha^{-1}), grain yield (t ha^{-1}) and harvest Index (%).

2.3.3. Data Analysis

The data obtained from the field were subjected to analysis of variance (ANOVA) using SAS, general linear model procedures and mean separation was done by least significant difference (LSD) test. Partial budget analysis was done to identify the economic feasibility of the treatments for yield; and on-farm experimental plots were adjusted downward by 10% *i.e.*, for management and for plot size difference, to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment [29].

3. Results and Discussion

3.1. Soil Physico-chemical Properties of the Experimental Site Before Planting

Texturally, the soil in the experimental site is high in sand, moderate in silt and clay in content (Table 1). The soil texture (sand, silt and clay in the soil) indicates the degree of weathering, aeration, nutrient and water holding capacity of the soil. The pH and organic carbon content of the experimental site was 5.42 and 3.219% which were moderately acidic and high respectively [30]. The analysis of soil samples indicated moderate level of total N (0.277%) at experimental site. According to [31] N content < 0.1% was rated as very low, 0.1-0.2% has poor, 0.2-0.3% as moderate, 0.3-0.4% has high and greater than 0.4% is very high. The analysis for P indicated low level of total P (1.294%) at experimental site, indicating that the nutrient is limiting factor for wheat production in the study area. According to the rating of [32], the available P is very low at < 3 (ppm), low at 4-7 (ppm), medium for 8-11 (ppm) and high > 12 (ppm). Cation Exchange Capacity (CEC) is an important parameter of soil, because it gives an indication of the type of clay minerals present in the soil, soil texture, organic matter content of the soil and its capacity to retain nutrients against leaching [33]. The CEC of the soil of the study area was 16.978 meq/100g soil which was stated as medium according to the rating of [34], which indicates its better capacity to retain the cations, top soils having CEC> 40 meq/100g soil are rated as very high and 25-40 meq/100g soil as high. Those top soils with 15-25, 5-15 and < 5 meq/100g soil are classified as medium, low and very low respectively.

Table 1. Physio- chemical properties of the soil in experimental site before planting.

Physio-chemical properties	Content	Rating / classification	References
Soil texture:			
Sand (%)	45	High	[34]
Silt (%)	27	Moderate	[34]
Clay (%)	28	Moderate	[34]
Textural class	-	Sandy clay Loam	[30]
pH (1:2.5 H_2O)	5.42	Moderately acidic	[30]
Organic carbon (%)	3.219	High	[30]
Total N (%)	0.277	Moderate	[31]
Available K (ppm)	16.070	High	[31]
CEC (Meq/100gm soil)	16.978	Medium	[33]
Available P (ppm)	1.294	Very low	[32]
Organic matter (%)	5.549	High	

Note: CEC=Cation exchange capacity

3.2. Effect of Variety and Fertilizer Rate on Yield and Yield Components of Bread Wheat Varieties

3.2.1. Analysis of Variance

The results indicated that the effect of variety were significant (P<0.05) for all parameters except for number of productive tillers per plant. This indicates that the four bread wheat varieties differed significantly for all agronomic parameters due to their genetic background (Table 2). Similarly, the effect of fertilizer rate were significant (P<0.05) for all parameters considered indicating the application of fertilizer could increase the vegetative, yield and yield components of the wheat varieties. In addition the interaction effect of variety by fertilizer rate were significant (P<0.05) for all parameters considered except for days to 50% emergence and days to 50% heading.

3.2.2. Effect of Variety on Days to 50% Emergence and Days to 50% Heading

The results showed that the mean days to 50% emergence was earlier for Ogolcho (3.75) as compared to the others (Table 3). The variety Ogolcho has fast sprouting property as compared to the other varieties which could be controlled by genetic background. As stated by [35], tetraploid wheat landrace varieties differed in days to germination and varieties with fast and uniform germination are suited for malt preparation from West Shewa, Ethiopia. The highest mean for days to heading was 71.50 days for Ogolcho and the lowest mean 57.50 days for Senate.

Table 2. Mean square values affected by variety, fertilizer rate and variety by fertilizer interaction of bread wheat.

Traits	Sources of variation				
	Rep (DF=2)	Variety (V) (DF=3)	Fertilizer (FR) (DF=3)	V x FR (DF=9)	Error (DF=38)
Days to 50% emergence	0.43	1.07**	12.13**	0.33ns	0.19
Days to 50% heading	0.27	449.86**	57.91**	0.73ns	1.04
Grain filling period	0.58	126.13**	10.36**	7.08**	0.85
Days to 90% maturity	1.56	1013.72**	95.38**	6.55**	1.58
Plant height (cm)	3.21	192.26**	3520.72**	43.89**	3.73
#of productive tillers per plant	0.023	0.006ns	11.46**	0.05**	0.01
Spike length (cm)	0.42	2.10**	30.82**	0.73**	0.18
#of spikelets per spike	3.02	177.60**	3147.67**	12.76**	2.96
#of grains per spike	4.10	186.37**	3117.68**	12.33**	3.15
Biomass yield (t ha^{-1})	5.23	1234.97**	11347.58**	425.13**	1.63
Thousand kernel weight (g)	1.08	5.90**	110.40**	3.18**	0.77
Grain yield (t ha^{-1})	4.06	170.61**	3703.49**	17.58**	0.85
Harvest index (%)	2.77	4.88*	118.50**	11.87**	1.37

** = high significant *= significant ns= non-significant; DF= degrees of freedom; V.= Variety, FR =Fertilizer rate.

3.2.3. Effect of Fertilizer Rate on Days to 50% Emergence and Days to 50% Heading

The results indicated that the lowest mean value for days to emergence was 3.08 days at 125/125 kg ha^{-1} NPSZnB/Urea application while the highest was 5.33 days at 0/0 kgha-1 NPSZnB/Urea (control) application (Table 4). As application of fertilizer rate increases the mean days to 50% emergence decreases significantly. While the mean days to 50% heading increases as the rate of fertilizer increases and the highest mean value was 66.08 days at 125/125 kg ha^{-1} NPSZnB/Urea application while the lowest mean was 61.0 days for control treatment. This indicated that as the rate of fertilizer increases the vegetative growth is encouraged and heading days are delayed. The present study is in line with the findings of [36] who reported that the most prolonged duration to heading (66.08 day) was recorded with the application of 138 kg N ha^{-1} compared to 46, 69, 92 and 115 kg N ha^{-1}. [37] reported that the duration of heading of wheat was delayed in response to increasing N levels.

Table 3. Effect of variety on days to 50% emergence and days to 50% heading of bread wheat Varieties.

Variety	Days to 50% emergence	Days to 50% heading
Liben	4.25a	64.67b
Ogolcho	3.75b	71.50a
Hulluka	4.42a	60.17c
Senate	4.33a	57.50d
Mean	4.19	63.46
CV (%)	10.49	1.61

Means followed by the same letters in the column are not significantly different at P=0.05 alpha level.

Table 4. Effect of fertilizer rate application on days to 50% emergence and days to 50% heading of bread wheat Varieties.

Fertilizer rate (NPSZnB/Urea)	Days to 50% emergence*	Days to 50% heading
0/0 kg ha^{-1}	5.33a	61.0d
75/75 kg ha^{-1}	4.67b	62.50c
100/100 kg ha^{-1}	3.67c	64.25b
125/125 kg ha^{-1}	3.08d	66.08a
Mean	4.19	63.46
CV (%)	10.49	1.61

*Means followed by the same letters in the column are not significantly different at P=0.05 alpha level.

3.2.4. The Interaction Effect of Variety by Fertilizer Rate on Mean Values of Agronomic Traits

(i). Grain Filling Period and Days to 90% Maturity

The results showed that the highest mean values for grain filling period was 67.66 days for the variety Ogolcho at the fertilizer rate of 100/100 Kg ha^{-1} NPSZnB/Urea while the lowest mean grain filling period was 56 days for the variety Senate at the fertilizer rate of 75/75 kg ha^{-1} NPSZnB/Urea (Table 5). Similarly, the highest days to 90% maturity was 149.66 days for the variety Ogolcho at the fertilizer rate 100/100 kg ha^{-1} NPSZnB/Urea while the lowest mean days to 90% maturity was 113 days for the variety Senate at the fertilizer rate of 75/75 kg ha^{-1} NPSZnB/Urea. This shows that the application of different rate of fertilizer on different varieties had different effect which could be realized that by increasing the fertilizer rate up to 100/100 kg ha^{-1} NPSZnB/Urea prolongs grain filling period and days to 90% maturity in all varieties while the different varieties have different maturity periods also showing Liben and Ogolcho are late variety types while Hulluka and Senate are relatively early types.

The delay in grain filling period might also be due to high nutrients in blended NPSZnB and UREA application. The prolonged time period required by the plants to reach grain filling at higher rate of nitrogen may be attributed to the increase in leaf area duration, increased vegetative growth and increased light use efficiency. [38] also reported application of nitrogen at higher dose promotes vegetative and lush growth thereby delaying grain filling period. According to [39] grain filling period was significantly increased with increasing N fertilizer rate till reached its maximum value for wheat plant received 120 kg N ha^{-1}. The present results are corroborated by [40] who reported grain filling period is highly variety dependent. The delay in maturity of bread wheat plants in response to the increasing NPSZnB and UREA applications might be because of the fact that increased rate of nitrogen, which delays physiological maturity by promoting vigorous vegetative growth and development of the plants. N fertilization at the rate of 92 kg N ha^{-1} significantly ($P \leq 0.01$) delayed physiological maturity of bread wheat [41]. Similar results were reported by [42] who reported that higher fertilizer levels resulted in delayed leaf senescence, sustained leaf photosynthesis and extended days to maturity.

Table 5. The interaction effect of variety by fertilizer rate on mean values of grain filling period and days to 90% physiological maturity of bread wheat.

Variety	Grain filling period*				Days to 90% maturity			
	Fertilizer (NPSZnB/Urea kgha-1)				Fertilizer (NPSZnB/Urea kgha-1)			
	0/0	75/75	100/100	125/125	0/0	75/75	100/100	125/125
Liben	64.33b	61.66d	62.33cd	63.00bcd	126.66ef	124.66f	128.33de	130.33cd
Ogolcho	62.66cd	63.00bcd	67.66a	63.66bc	131.66c	134.00b	139.66a	137.66a
Hulluka	57.00f	57.33f	57.00f	59.33e	114.33jk	116.33ij	118.33hi	122.33g
Senate	59.00e	56.00f	59.33e	59.33e	114.33jk	113.00k	117.00i	119.33h
Mean	60.79				124.25			
CV (%)	1.50				1.01			

*Means followed by the same letter for each trait are not statistically different from each other at 5% significant level.

(ii). Plant Height and Number of Productive Tillers per Plant

The results showed that the highest mean plant height was obtained for the variety Ogolcho (90.46 cm) at the fertilizer rate of 100/100 kg ha^{-1} NPSZnB/urea while the lowest mean plant height was obtained for the variety Senate (45.26 cm) for control treatment (Table 6). This indicated that with increasing dose of fertilizer rate up to 100/100 kg ha^{-1} NPSZnB/Urea, mean plant height increased significantly. Generally, increasing NPSZnB fertilizer supplemented with nitrogen rates led to increases in plant height. The increased plant height at the highest level of NPSZnB and UREA fertilizer could be attributed to the increasingly adequate supply of nitrogen, phosphorus and Sulphur nutrients, which helped, in high vegetative growth and development of plant. This result is in agreement with that of [43] who reported that increasing nitrogen rates increased the wheat plant height; and [44] reported that the beneficial role of N and P in cell division and elongation as well as the root growth and dry matter content of wheat plants. [45] also reported significant increments in the height of wheat plants in response to increasing the rates of P fertilizer.

The present result is also in line with the findings of [46] who reported increase in the number of productive tillers produced in response to the increased rates of N and P fertilizers may be attributed to the synergic roles in enhancing productive tillers production by the plant. Similarly, [47] also reported that application of N at the rate of 160 kg ha^{-1} produced higher number of productive tillers per unit area as compared to the nil N (no N) treatment.

Table 6. The interaction effect of variety by fertilizer rate on mean values of plant height and number of productive tillers per plant of bread wheat.

Variety	Plant height (cm)*				Number of productive tillers per plant			
	Fertilizer rate (NPSZnB/Urea kgha-1)				Fertilizer rate (NPSZnB/Urea kgha-1)			
	0/0	75/75	100/100	125/125	0/0	75/75	100/100	125/125
Liben	50.60^{h}	63.96^{fg}	79.90^{de}	85.60^{bc}	0.00^{e}	0.56^{c}	1.96^{ab}	1.83^{ab}
Ogolcho	52.26^{h}	79.03^{e}	90.46^{a}	86.73^{b}	0.00^{e}	0.56^{c}	2.03^{a}	1.90^{ab}
Hulluka	47.10^{i}	61.83^{g}	79.80^{de}	82.53^{cd}	0.00^{e}	0.33^{d}	2.00^{ab}	2.03^{a}
Senate	45.26^{i}	65.53^{f}	81.26^{de}	90.60^{a}	0.26^{d}	0.33^{d}	1.80^{b}	1.86^{ab}
Mean	71.4				1.09			
CV (%)	2.60				12.37			

*Means followed by the same letter are not statistically different from each other at 5% significant level under each parameter

(iii). Spike Length and Number of Spikelets per Spike of Bread Wheat

The results showed that the highest mean value for spike length was 8.73 cm for Ogolcho at 100/100 kg ha^{-1} NPSZnB/Urea application while the lowest was 3.56 cm for the variety Liben and Senate at zero application of NPSZnB/Urea (Table 7). This shows that increasing application of fertilizer increased spike length and thereby increases productivity of wheat. Generally, all four varieties had minimum spike length at zero application of NPSZnB/Urea and they are statistically in par. The present results are in line with the result of [4] who reported that with increasing fertilizers rate of organic and inorganic application to wheat the spike length increased. According to [48, 49] with increasing the level of fertilizer application both macro and micro nutrient increase the spike length due to the application of those nutrients.

With regard to number of spikelets per spike the highest mean value was 53.56 for Ogolcho at 100/100 kg ha^{-1} NPSZnB/Urea application and it was statistically in par with the application of 125/125 kg ha^{-1} NPSZnB/Urea; and for the variety Liben at 100/100 kg ha^{-1} and 125/125 kg ha^{-1} NPSZnB/Urea respectively. The lowest mean value for number of spikelets per spike was 13.36 for Hulluka for control treatment and it was statistically in par with Liben and Senate for control treatment. The highest number of spikelet per spike is four fold of the fewest and generally the number of spikelets per spike of a wheat increases with increases in fertilizer rate up to a certain level for all varieties.

Table 7. The interaction effect of variety by fertilizer rate on mean values of plant height and number of spikelets per spike of bread wheat.

Var.	Spike length (cm)*				Number of spikelets per spike			
	Fertilizer rate (NPSZnB/Urea kg ha^{-1})				Fertilizer rate (NPSZnB/Urea kg ha^{-1})			
	0/0	75/75	100/100	125/125	0/0	75/75	100/100	125/125
Liben	3.56^{f}	5.90^{cd}	6.76^{b}	6.63^{bc}	14.267^{h}	40.10^{c}	52.26^{a}	51.53^{a}
Ogolcho	3.86^{f}	3.86^{d}	8.73^{a}	6.86^{b}	17.36^{g}	40.10^{c}	53.56^{a}	51.93^{a}
Hulluka	3.63^{f}	4.86^{e}	6.50^{bcd}	6.50^{bcd}	13.36^{h}	32.40^{e}	47.03^{b}	45.96^{b}
Senate	3.56^{f}	4.70^{e}	7.13^{b}	6.56^{bc}	13.76^{h}	26.76^{f}	45.96^{b}	42.20^{c}
Mean	5.72				36.55			
CV (%)	7.74				4.71			

*Means followed by the same letter are not statistically different from each other at 5% significant level

Table 8. The interaction effect of variety by fertilizer rate on mean values of number of grains per spike of bread wheat.

Variety	Number of grains per spike*			
	Fertilizer rate (NPSZnB/Urea kgha-1)			
	0/0	75/75	100/100	125/125
Liben	14.26^{i}	36.36^{i}	52.1^{a}	51.46^{a}
Ogolcho	17.26^{h}	40.00^{d}	53.46^{a}	51.83^{a}
Hulluka	13.20^{i}	32.30^{f}	46.90^{b}	45.83^{b}
Senate	13.70^{i}	26.73^{g}	44.90^{bc}	42.13^{cd}
Mean	36.40			
CV (%)	4.92			

*Means followed by the same letter are not statistically different from each other at 5% significant level.

(iv). Number of Grains per Spike of Bread Wheat

The results showed that mean number of grains per spike was highest (53.46) for Ogolcho at 100/100 kg ha^{-1} NPSZnB/Urea application which was statically in par at 125/125 kg ha^{-1} NPSZnB/Urea; and for Liben at 100/100 kg ha^{-1} and 125/125 kg ha^{-1} NPSZnB/Urea application respectively (Table 8). The mean number of grains per spike was lowest (13.20) for Hulluka for control treatment and it was statistically in par with Liben and Senate at control treatment. Generally the number of grains per spike of a wheat increases with increase in fertilizer rate up to a certain level for all varieties. This result is supported by the result of [46] who reported marked increases in number of kernels per spike of wheat as a result of applying N and P fertilizers in a combination. [15] reported that nitrogen and sulphur supply can also beneficially influence the numbers of kernels per spike.

(v). Biomass Yield and Grain Yield of Bread Wheat

The results showed that mean biomass yield was highest for Ogolcho (10.20 t ha^{-1}) at 125/125 kg ha^{-1} NPSZnB/Urea application. The lowest mean biomaass yield was observed for Liben (2.0 t ha^{-1}) for control treatment and it was statistically in par with the mean values for Hulluka (2.10 t ha^{-1}) for control treatment (Table 9). Generally the biomass yield t ha^{-1} of a wheat increases with increase in fertilizer rate up to a certain level for all varieties. The possible reason for this response could be due to adequate supply of fertilizer application and their assimilation in meristematic tissue which might have played an important role in tillering and overall plant growth. The present results are similar to the research findings of [50] who reported that as fertilizer rate increased, the biological yield also increased. According to [51, 52] the highest aboveground dry biomass was obtained for the highest application rates of N levels. [53] also pointed out that the increase in biomass yield as a result of increment in fertilizer rates explained that wheat plant used N to produce more biomass. The highest grain yield in the present study was obtained for Ogolcho (5.28 t ha^{-1}) at 100/100 kgha-1 NPSZnB/Urea application while the lowest was for Liben (0.89 t ha^{-1}) for control treatment and it was statistically in par with mean grain yield for Senate (1.01 t ha^{-1}) at zero application of fertilizer.

Table 9. The interaction effect of variety by fertilizer rate on mean values of biomass yield and grain yield of bread wheat.

Variety	Biomass yield (tha^{-1})*				Grain yield (tha^{-1})			
	Fertilizer rate (NPSZnB/Urea $kgha^{-1}$)				Fertilizer rate (NPSZnB/Urea $kgha^{-1}$)			
	0/0	75/75	100/100	125/125	0/0	75/75	100/100	125/125
Liben	2.00l	2.00l	9.70b	9.70b	0.89j	2.97g	5.06b	4.79c
Ogolcho	2.50j	6.43f	9.70b	10.20a	1.17i	3.06g	5.28a	4.87c
Hulluka	2.10kl	5.33g	4.40i	8.00e	0.93j	2.03h	4.16ef	4.05f
Senate	2.27k	4.70h	8.97c	8.37d	1.01ij	2.18h	4.32de	4.37d
Mean	6.29				3.20			
CV (%)	2.16				3.21			

*Means followed by the same letter are not statistically different from each other at 5% significant level.

Generally the grain yield of a wheat increases with increase in fertilizer rate up to a certain level for all varieties. The present results are in line with the findings of many researchers [36, 40, 50] who reported that significant increases in grain yields of bread wheat with increasing application levels of fertilizer. The result also agreed with the findings of [54] who reported that combined application of N with S fertilizers increases the net photosynthetic rate in crop plants, which in turn increases their grain yield of the plants.

(vi). Harvest Index and Thousand Kernel Weight

The highest mean harvest index was obtained for Ogolcho (54.33%) at 100/100 kg ha^{-1} NPSZnB/Urea application and which was statistically in par with the mean harvest index of Liben (53%) at 100/100 kg ha^{-1} NPSZnB/Urea application. The lowest mean harvest index (43.66%) was for Hulluka and Senate for control treatment and this was statistically in par with the mean harvest index for Liben (44%) and Ogolcho (45.66%) for control treatment (Table 10). Generally the harvest index of a wheat increases with increase in fertilizer rate up to a certain level for all varieties. The result of the study agree with the findings of [55] who reported higher harvest index under higher level of nitrogen and phosphorus than application of lower levels of the fertilizers in maize plant. The results are in harmony with [56, 57] who reported that application of NPK increased yield components of wheat especially on harvest index and grain yield.

The highest mean thousand kernel weight was 49 g for Liben and Ogolcho at 100/100 kg ha^{-1} NPSZnB/Urea application and this was statically in par with the mean thousand kernel weight for Liben (48 g) and Senate (48.33 g) at 125/125 kg ha^{-1} NPSZnB/Urea application. The lowest mean thousand kernel weight was observed for Liben (41 g), Hulluka (41 g) and Senate (41 g) for control treatment and it was statically in par with the thousand kernel weight for Ogolcho (42 g) for control treatment. Generally thousand kernel weight of a wheat increases with increase in fertilizer rate up to a certain level for all varieties. The present results are in line with [57] who reported that increase in application of fertilizer rate had a positive impact on yield component of wheat especially on thousand kernel weight. This result is also in harmony with [58] which states when applying both micro and macro nutrients and when N –level application increase there is a positive impact on yield components of wheat crop especially on thousand kernel weight. But, [2] reported a non-significant effect of N application rate on thousand kernels weight.

Table 10. The interaction effect of variety by fertilizer rate on mean values of Harvest index and thousand kernel weight of bread wheat.

Variety	Harvest index (%)				thousand kernel weight (g)			
	Fertilizer rate (NPSZnB/Urea kgha^{-1})				Fertilizer rate (NPSZnB/Urea kgha^{-1})			
	0/0	75/75	100/100	125/125	0/0	75/75	100/100	125/125
Liben	44.00^{ij}	46.66^{fgh}	53.00^{ab}	48.66^{def}	41.0^{f}	48.00^{abc}	49.00^{a}	48.00^{abc}
Ogolcho	45.66^{hij}	47.33^{fgh}	54.33^{a}	47.66^{efgh}	42.33^{f}	45.33^{de}	49.00^{a}	46.66^{cd}
Hulluka	43.66^{j}	46.00^{ghi}	49.66^{de}	50.33^{cd}	41.33^{f}	44.66^{e}	47.33^{bc}	48.33^{ab}
Senate	43.66^{j}	46.00^{ghi}	48.00^{efg}	52.00^{bc}	41.00^{f}	44.00^{e}	47.00^{bc}	47.33
Mean	47.91				45.64			
CV (%)	2.52				1.94			

Means followed by the same letter are not statistically different from each other at 5% significant level

3.3. Partial Budget Analysis for Grain Yield

The partial budget analysis showed that the maximum net benefit (Birr 50,904.35 ha^{-1}) was obtained from 100/100 kg blended NPSZnB/ Urea ha^{-1} fertilizer application, for the variety Ogolcho, whereas the lowest net benefit among the treatments (i.e., with the fertilizer rate 75 /75 kg NPSZnB/Urea with variety Liben) gave a net benefit (Birr 28,167.84 ha^{-1}), but the net benefit of control treatment (Birr 9,124.58 ha^{-1}) was the least (Table 11). This had resulted in a net benefit advantage of (Birr 22,736.51 and Birr 41,779.77 ha^{-1}) over the 75/75 kg NPSZnB/Urea and control treatment, respectively. In line with these result [36, 46] indicated that the estimated net income for mineral fertilizer is attractive as compared to growing wheat without application of fertilizer. In conclusion, the net benefit obtained by the use of improved bread wheat (Ogolcho) with fertilizer rate of 100/100 kg NPSZnB ha^{-1} / Urea ha^{-1} were found to be the most profitable and can be recommended for farmers in study area and other areas with similar agro-ecological conditions.

Table 11. Economic feasibility analysis for the interaction effect of variety by fertilizer rate application for grain yield of bread wheat.

Variety.	NPSZnB/ Urea (kgha^{-1})	Yield (tha^{-1})	Adju. yield (tha^{-1})	Gross ben. (Birr ha^{-1})	Total var. cost (Birr ha^{-1})	Net ben. (Birr ha^{-1})	MRR%
Liben	0/0	0.89	0.80	9,124.58	-	9,124.58	D
Liben	75/75	2.97	2.70	30,856.84	2,689.00	28,167.84	708
Liben	100/100	5.06	4.56	52,040.94	3,397.75	48,643.19	2888
Liben	125/125	4.79	4.31	49,208.78	4,107.18	45,101.60	D
Ogolcho	0/0	1.17	1.05	12,013.84	-	12,013.84	D
Ogolcho	75/75	3.06	2.76	31,484.94	2,689.00	28,795.94	624
Ogolcho	100/100	5.28	4.75	54,302.10	3,397.75	50,904.35	3119
Ogolcho	125/125	4.87	4.38	50,042.44	4,107.18	45,935.26	D
Hulluka	0/0	0.93	0.84	9,558.54	-	9,558.54	D
Hulluka	75/75	2.05	1.84	21,035.64	2,689.00	18,346.64	326
Hulluka	100/100	4.16	3.74	42,756.48	3,397.75	39,358.73	2964
Hulluka	125/125	4.05	3.42	41,591.64	4,107.18	37,484.46	D
Senate	0/0	1.01	0.91	10,403.62	-	10,403.62	D
Senate	75/75	2.18	1.96	22,428.88	2,689.00	19,739.88	347
Senate	100/100	4.32	3.89	44,412.38	3,397.75	41,014.63	3001
Senate	125/125	4.37	3.93	44,92628	4,107.18	40,819.10	D

D=dominated, MRR=marginal rate of return

4. Summary and Conclusion

Common Wheat (*Triticum. aestivum*.L.) is important food crop in Ethiopia. However, low yield in this cereal crop may be partially attributed to the low level of adoption of improved varieties and improved management techniques. Therefore, an experiment was conducted to determine the effects of improved variety, fertilizer rate and their interaction on yield components and yield of bread wheat; and to estimate the economic feasibility of variety by fertilizer rate application for optimum yield of bread wheat. Prior to sowing or fertilizer applications soil samples were taken and analyzed for physico-chemical contents of the experimental site. And the results showed that texturally high in sand, moderate in silt and clay in content, with pH of 5.42, organic carbon content of 3.219%, moderate total N (0.277%) and low total P (1.294%), medium CEC of 16.978 (meq/100g soil).

Significant differences have been observed among the wheat varieties which could be due to their differences in genotypes. Similarly, application of different rates of NPSZnB/Urea had significant effect on all agronomic traits of wheat. Moreover, the variety x fertilizer rate interaction had significant effect on all agronomic traits except for days to 50% emergence and days to 50% heading. Days to grain filling period and days to 90% maturity were delayed with increased rates of fertilizer for all varieties. The longest plant height (90.46 cm) and spike length (8.73 cm) were obtained for Ogolcho at the fertilizer rate of 100/100 kg ha^{-1} NPSZnB/urea. Generally, plant height and spike length of wheat were increased with increased in fertilizer rate for all varieties. Highest number of grains per spike (53.46) and the highest mean biomass yield (1.02 tha^{-1}) were obtained for Ogolcho variety at 100 kg NPSZnB/100 kg UREA application The highest grain yield (5.283 tha^{-1}.) and the highest harvest index (54.33%) were recorded from Ogolcho at 100 kg NPSZnB/100 kg UREA. And the highest mean thousand seed weight (49g) was recorded from Liben and Ogolcho at 100 kg NPSZnB/100 kg Urea. Further, analysis for economic feasibility of fertilizer application at different rates on different varieties was carried out for on farm. The results of the partial budget analysis showed that the maximum net benefit (Birr 50,904.35 ha^{-1}) was obtained from 100/100 kg NPSZnB/Urea ha^{-1} fertilizer application, using the variety Ogolcho. Therefore, the net positive benefit obtained with application of 100/100 kg NPSZnB ha^{-1}/ Urea ha^{-1} to bread wheat (Ogolcho) are economically profitable and it can be recommended for farmers in study area and other areas with similar agro-ecological conditions.

Acknowledgements

The first author thanks Gida Ayana District Agricultural Office, western Ethiopia, for providing the experimental plot and financial support for the experiment; and Wollega University for admitting him for postgraduate in agronomy program and providing the facilities during the thesis work.

References

[1] Ministry of Agriculture and Natural resources (MoANR) (2016). Crop Variety Register. Issue No. 19. Addis Ababa, Ethiopia

[2] Gooding, M. J. and Davies, W. P. (1997). Wheat Production and Utilization System, Quality and Environment. CAB international, USA. 355P.

[3] Braun H. J., Atlin G. and Payne, T. (2010). Multi-location testing as a tool to identify plant response to global climate change, pp. 71-91. In: Reynolds, M. P. (Ed), Climate Change and Crop Production. CABI, London, UK.

[4] Hussain, I., Khan, M. A. and Khan, E. A. (2006). Bread wheat varieties as influenced by different nitrogen levels. Journal of Zhejiang University of Science, 7 (1): 70-78.

[5] Central Statistical Agency (2018). Agricultural Sample Survey 2017/2018 (2010 EC), Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season). V. I., Statistical Bulletin No. 586, Addis Ababa, Ethiopia.

[6] Bekele G, Amanuel G. and Getinet G. (1994). Wheat Production and Research in Ethiopia: Constraints and Sustainability. In: Tanner, D. G. (Ed.), Developing Sustainable Wheat Production Systems. The Eighth Regional Wheat Workshop for Eastern, Central and Southern Africa. Addis Ababa, Ethiopia: CIMMYT.

[7] Kotu, B., Verkuijl, H., Mwangi, W. and Tanner, D. G. (2000). Adoption of Improved Wheat Technologies in Adaba and Dodola Woreda of The Bale Highlands, Ethiopia. Mexico, D. F. CIMMYT and the Ethiopian Agricultural Research Organization (EARO).

[8] Amanuel G., Kuhne, R. F., Tanner, D. G. and Vlek, P. L. G. (2002). Recovery of 15- N labeled urea applied to wheat in the Ethiopian highlands as affected by P fertilization. Journal of Agronomy and Crop Science*,* 189: 30-38.

[9] Asnakew W., Tekalign M., Mengsha B. and Tefera A. (2001). Soil fertility management studies in Ethiopia. pp. 138-172. In: Hailu G, Tanner, D. G. and Mengsitu H. (Eds.), Wheat Research in Ethiopia: Historical Perspective. IAR/CIMMYT, Addis Ababa, Ethiopia.

[10] Filipov H and Dachev, Z. (1999). Varietal differentiation of wheat according to the effect of nitrogenous nutrition of the yield of grain. Agricultural Academy Sofia. 36 (1): 11-14.

[11] Arega G, Wondimu, B., Kebede, T. and Legesse, A. (2013). Varietal differences and effect of nitrogen fertilization on durum wheat (*Triticum turgidum var.* durum) grain yield and pasta making quality traits. International Journal of Agronomy and Plant Production*,* 4 (10): 2460-2468.

[12] Marschner, H. (1995). Mineral Nutrition of Higher Plants. Second Edition. London: Academic Press. 889 pp.

[13] Cook RJ., and Veseth, R. (1991). Wheat Health Management, APS Pres, 152. pp.

[14] Ali, R., Khan, M. J. and Khattak, R. A. (2008). Response of rice to different sources of Sulfur (S) at various levels and its residual effect on wheat in rice-wheat cropping system. Soil Environment 27 (1): 131-137.

[15] Zhao, F. J., Salmon, S. E. Withers, P. J. A. Monaghan, J. M. Evans, E. J. Shewry P. R. and McGrath S. P. (1999). Variation in the bread making quality and mineralogical properties of wheat in relation to sulfur nutrition under field conditions. Journal of Cereal Science 30 (1): 19-31.

[16] Dobermann, A., and Fairhurst, T. (2000). Economics of Fertilizer Use. In 'Rice: Nutrient Disorders & Nutrient Management'. 1st Edition. Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC), and International Rice Research Institute (IRRI), 40-117.

[17] Johnson, J. W. (1999). Most asked agronomic questions. In: Johnson, J. W. and Hudak, C. (Eds.), Ohio State University Extension Bulletin E-760-88. Columbus, OH: The Ohio State University.

[18] 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 (1/2): 139– 147.

[19] Blake-Kalff, M. M. A., Hawkesford, M. J. Zhao F. J. and McGrath S. P. (2000). Diagnosing sulfur deficiency in field-grown oilseed rape (*Brassica napus* L.) and wheat (*Triticum aestivum* L.). Plant and Soil, 225 (1-2): 95-107.

[20] Cakmak, I. (2008). Enrichment of cereal grains with zinc: Agronomic or genetic bio fortification. Plant science, 302: 1-17.

[21] Singh, Y. P. (2004). Effect of nitrogen and zinc on wheat irrigated with alkali water. Annals of Agricultural Research, 25: 233–236.

[22] Bagci, S. A., Ekiz, H., Yilmaz, A. and Cakmak, I. (2007). Effect of zinc deficiency and drought on grain yield of field-grown wheat cultivars in Central Anatolia. Journal of Agronomy and Crop Science, 193: 198–206.

[23] Grotz, N. and Guerinot, M.. L. (2006). Molecular aspects of Cu, Fe and Zn homeostasis in plants. Biochimica et Biophysica Acta., 1763: 595–608.

[24] Bukvic, G., Antunovic, M., Popovic, S. and Rastija, M. (2003). Effect of P and Zn fertilization on biomass yield and its uptake by maize (Zea mays L.). Journal of Plant, Soil and Environment, 49: 505-510.

[25] Epstein, E., and Bloom, A. J. (2005). Mineral Nutrition of Plants: Principles and Perspectives, 2nd. Ed. Sinauer Associates, Sunderland pp 17–39.

[26] Shorrocks, V. M. (1997). The occurrence and correction of boron deficiency. Plant Soil, 193: 121–148.

[27] Yermiyahu, U., R. Keren, and Y. Chen. 2001. Effect of composted organic matter on boron uptake by plants. Soil Sci. Soc. Amer. J. 65: 1436–1441.

[28] Fageria, N. K., Barbosa Filho, M. P., Moreira, A. and Guimarães, C. M. (2009). Foliar fertilization of crop plants. Journal of Plant Nutrition, 32: 6, 1044-1064, DOI: 10.1080/01904160902872826.

[29] CIMMYT. (1988). From Agronomic Data to Farmer Recommendations: An Economic Training Manual. Completely Revised Edition, Mexico D. F.

[30] Tekalign Tadesse (1991). Soil, Plant, Water, Fertilizer, Animal Manure and Compost Analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa.

[31] Landon, J. R. (1991). Booker Tropical Soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics," Booker Tate Ltd., England.

[32] Tisdale, S. L., Nelson, W. L., Beaton, J. D. and Havlin, J. L. (2002). Soil and fertilizer potassium. pp. 230-265. In: Soil Fertility and Fertilizers (5th Ed.) Prentice Hall, India, New Delhi.

[33] Heluf Gebrekidan and Wakene Negassa (2006). Inmpact of Land use and management practices on Chemical properties of some soils of Bako area, Western Ethiopia. Ethiopian Journal of Natural Resources, 8 (2): 177-197.

[34] Hazelton, P. and Murphy, B. (2007). Interpreting Soil Test Results: What Do All the Numbers Mean? 2nd Edition. CSIRO Publishing. 152pp.

[35] Geleta, N. and Grausgruber, H. (2013). Homemade products and socio-cultural values of wheat seed production in Ambo and Dandi districts of West Central Ethiopia. *Science, Technology and Arts Research Journal*, 2 (4): 62-70. www.starjournal.org.

[36] Yohannes E. (2014). Yield Response of Bread Wheat to Rate and Time of Nitrogen Fertilizer Application at Meta District of Eastern Hararghe Zone of Oromia Regional State, Eastern Ethiopia. MSc Thesis, Alemaya University, Alemaya Ethiopia.

[37] Ayoub, M., Guertin, S., Lussier S. and Smith, D. L. (1994). Timing and levels of nitrogen fertility effects on spring wheat. *Crop Science Journal,* 34: 748-750.

[38] Gupta R. P, and Sharma, V. P. (2000). Effect of Different Spacing and Levels of Nitrogen for Production of Export Quality Onion Bulbs Planted on Raised Bed. News Letter,- National Horticultural Research and Development Foundation, India, 20: 1-4.

[39] El-Habbal M. S, Ashmawy F, Saoudi H. S, Abbas I. K. (2010). Effect of nitrogen fertilizer rates on yield, yield components and grain quality measurements of some wheat cultivars using SPAD-Meter. *Egypt J. Agric. Res*. 88, 211-223.

[40] Pržulj, N. and Momcilovic, V. (2011). Characterization of vegetative and grain filling periods of winter wheat by stepwise regression procedure II. grain filling period. Genetika, 43 (3): 549 -558.

[41] Getachew F. (2004). Soil Characterization and Bread Wheat Response to Nitrogen and Phosphorus Fertilization on Nitosol at Ayehu Research Substation in North western Ethiopia. MSc Thesis Presented to The School of Graduate Studies of Alemaya University, Ethiopia.

[42] Frederick, J. R. and Camberato, J. J. (1995). Water and nitrogen effects on winter wheat in the south eastern coastal plain: II- Physiological responses. Agron. J., 4: 241-248.

[43] Khan M. A., Hussain, I. and Baloch, S. (2000). Wheat yield potential current status and future strategies. *Pakistan Journal of Biological Science*, 3: 82-86.

[44] Marschner, H. (1997). Sulfur supply, plant growth, and plant composition. In: Mineral Nutrition of Higher Plants, Academic Press, and Cambridge. 261-265.

[45] Schefe, C. R., Patti, A. F., Clune, T. S. and Jackson, W. R. (2008). Organic amendment addition enhances phosphate fertilizer uptake and wheat growth in an acid soil, *Australian Journal of Soil Research*, 46: 686–693.

[46] Firehiwot G. (2014). Yield Response to Bread Wheat *(Triticum aestivum* L.*)* to Applied Levels of Inorganic N and P Fertilizers at Haramaya, Eastern Hararghe Zone of Oromia Regional State, Eastern Ethiopia. MSc Thesis, Alemaya University, Alemaya Ethiopia.

[47] Ejaz H., Alishah, W., Shed, A. A., Hayat, F. and Bakht, J. (2002). Yield and yield components of wheat as affected by different planting dates, seed rates and nitrogen levels. *Asian Journal of Plant Science*, 1 (5): 502-506.

[48] Rahmatullah, K., Raza, G. A., Hussain G. A., and Sharif, Z. M. (2007). Effect of phosphorus application rain fed wheat growing in the Mediterranean region. *Field Crops Research*, 71: 113-122.

[49] Amjed, A., Syed, W., Asif, M., Aziz, M., Ahmad, A. and Khalid, S. (2011). Effect of nitrogen on growth yield and yield components of wheat: *Sci: Int., Lahore* 23 (4): 331-332.

[50] Minale L., Alemayehu A. and Tilahun T. (2005). The response of bread wheat to nitrogen and phosphorous fertilizer at different agro-ecologies of North Western Ethiopia. Pp. 315-319.

[51] Ali, H., Shakeel, A., Hina, A. and Hassan, F. H. (2005). Impact of nitrogen application on growth and productivity of wheat (*Triticum aestivum* L.). *Journal of Agricultural Science,* 3: 216-218.

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

[53] Ehdaie B. and Waines, J. G. (2001). Sowing date and nitrogen rate effects on dry matter and nitrogen partitioning in bread and durum wheat. Field Crops Research, 73: 47-61.

[54] Ahmad A., and Abdin, M. Z. (2000). Photosynthesis and its physiological variables in the leaves of Brassica genotypes as influenced by S fertilization. *Physiology Platarum*, 110: 144-149.

[55] Sharer M. S., Ayub, M. Nadeem, M. A. and Ahmad, N. (2003). Effect of different nitrogen and phosphorus on growth and grain yield of maize. *Asian Journal of Plant Sciences*, 2 (3): 347-349.

[56] Yosef, T. S. (2013). Effect of nitrogen and phosphorus fertilizer on spikelet structure and yield in rice *(Oryza sativa L)*. *International Journal of Agriculture and Crop Sciences*: 5 (11): 1204-1208.

[57] Arshad M, Khalid, A., Mahmood, M. H. and Zahir, Z. A. (2004). Potential of nitrogen and L-tryptophan enriched compost for improving growth and yield of hybrid maize. *Pak J Agric Sci*. 41: 16-24.

[58] Shuaib K, Muhammad A, Muhammad A. A, Ahmad S, Ghulam A, Muhammad R. (2009). Effect of phosphorus on the yield and yield components of wheat variety. INQLAB-91 under rainfed conditions. *Sarhad Journal of Agriculture*, 25 (1): 21-24.