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Effects of Blended NPS Fertilizer Rates on Yield and Quality Attributes of Bread Wheat (Triticum aestivum L.) Varieties

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ABSTRACT
Wheat is one of the cereal crops dominating the food habit and dietary practices of Ethiopia. However, its yield and quality is low due suboptimum fertilizer application by smallholder farmers. Thus, an experiment was undertaken to determine effects of various levels of blended NPS fertilizer on yield and quality attributes of bread wheat varieties. Factorial combinations of three bread wheat varieties (Hidase, Ogolcho, Liben) and six levels of blended NPS fertilizer (0, 50, 100, 150, 200, 250 kg NPS ha^{-1}) were laid out in a randomized complete block design in three replications. The study result showed that wheat varieties had significant ($P<0.05$) effects on plant height, biomass yield, grain yield, harvesting index, number of seed spike^{-1} and thousand seed weight. Higher plant height (118 cm) was obtained from Ogolcho variety, and higher biomass yield, grain yield, harvest index and thousand seed weight of wheat were obtained from Hidase and Ogolcho varieties as compared to Liben variety. Also, application of NPS fertilizer rates significantly ($P<0.05$) affected the mean date of heading and plant height of wheat varieties. Interaction effects of wheat varieties and blended NPS fertilizer rates significantly affected biomass yield, grain yield and protein content of wheat. Significantly higher mean grain yield (7667 kg ha^{-1}) was obtained from Hidase and Ogolcho varieties at an application of 250 kg NPS ha^{-1} which improved by 28% as compared to the lowest yield obtained from Liben variety at an application of 100 kg NPS ha^{-1}. Highest (14.52%) and lowest (11.16%) grain protein contents were obtained from Hidase and Ogolcho varieties at an application of 50 kg NPS ha^{-1}, respectively. Significantly, higher and positive correlation coefficient was observed between grain yields and dry biomass yield (0.81) and plant height of wheat (0.61). Wheat production at an application of NPS from 50 to 200 kg ha^{-1} levels gave better net profit and marginal rate of return for the area even though the growth and yield attributes of wheat were increased up to 250 kg NPS ha^{-1}. Thus, it can be concluded that an application of NPS fertilizer at 200 kg ha^{-1} gave higher grain yield and profitable for wheat production in the study area.
Keywords: NPS Fertilizer, grain yield, protein contents, wheat varieties
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1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is very important food grain in the world and grows worldwide according to its genotypic adaptability (Hossain *et al*., 2015). Wheat is the second after rice as a source of calories in the diets of consumers in developing countries and is first as a source of protein (Braun *et al*., 2010). It is the staple food for more than 35% of world population (Jing and Chang, 2003; Hussain *et al*., 2006). Wheat is one of the major cereals of choice in Ethiopia, dominating the food habit and dietary practices and known to be a major source of energy and protein for the highland population (Abera, 1991). Wheat is a major crop in Ethiopia and grows in the highlands of southeastern, central and northwestern agro-ecological zones (Debebe *et al.,* 2000). According to CSA (2015) the area under wheat production in Ethiopia is about 13.25% (1,663,837.58 hectares) of the total grain crop area. However, its national average yield is about 2.5 tons per hectare (CSA, 2015). This is low yield as compared to the global average of 4 tons per hectare (FAO, 2009). Despite its higher yield potential, average yield of different varieties of wheat in Ethiopia is much less than that of most of the countries of the world. To meet the increasing demand of food grains for quickly growing population of the country, it is desired to have a higher yield per unit area. The major constraint of wheat production in Ethiopia includes environmental factors, soil fertility, and shortage of improved varieties, diseases, pests and fertilizer utilization. Varieties have different responses across environments and years resulting in significant genotype environment interaction (Debebe *et al*., 2000). The vital factor for the harvesting suitable environment in grain yield is the genetic potential of the crops (Nadeem, 2001).

The introduction of new varieties with their high yielding potential and wide range of adaptability is an important factor responsible for enhancing wheat production (Alam *et al*., 2006). Different varieties respond differently to varying environment and hence differ in their yield and quality. Cultivars differed significantly due to difference in number of tillers m^{-2} (Jan *et al*., 2003; Irfan *et al.*, 2005), number of grain $spike^{-1}$ (Akmal *et al*., 2000) and grain yield (Nadeem, 2001). Amsal *et al.* (1999) released cultivars of wheat are highly responsive to improved management practices and require higher rates of nutrient application which is true for released varieties of wheat (Tanner *et al.,* 1993).

Fertilizer application is responsible for wheat yield and quality improvement. Teklu *et al*. (2000) found both grain and straw yield of wheat varieties increased significantly up to the maximum N (115 kg N ha^{-1}) applied at Chaffe Donsa and 69 kg N ha^{-1} at Akaki District; this showed that wheat varieties responded differently to N application rates at various locations. Teklu *et al*. (2000) also stated the new high yielding cultivars have a higher nutrient requirement because of their yield potential increment. In Ethiopia, urea and diammonium phosphate were common fertilizer, however, recently it is perceived that the production of wheat and legumes can be limited by the deficiency of Sulphur and other nutrients, major prone areas of S deficiency are the central highlands (Assefa *et al*., 2015). They found that, the grain yield and yield components of wheat showed significant ($P<0.001$) response among treatments with N, S and P applied. Recently acquired soil inventory data from Ethiopian Soil Information System also revealed that in addition to nitrogen and phosphorus, sulfur, born and zinc deficiencies are widespread in Ethiopian soils; while, some soils are also deficient in potassium, copper, manganese and iron, which all potentially holdback crop productivity due to continued utilization of N and P nutrients as per the blanket recommendation reported by Ethiopian Soil Information System (2013).

Farmers in Munessa district apply N and P in the form of urea and DAP at sub-optimal blanket rates mostly only once at the time of sowing, and this limits the potential productivity of cereal crops (Bekele *et al*., 2000). In general, blanket recommendations, regardless of considering the physical and chemical properties of the soil do not lead to increase the crop productivity in the country. Currently, in addition to nitrogen and phosphorus, Ethiopian soil lacks about five nutrients (K, S, Cu, Zn, B) as studied by Ethiopian Soil Information System (2013). Thus, compound fertilizer (NPS) and three blended fertilizers (NPSB, NPSZnB, NPSZn) plus or minus potash fertilizer are needed to address the key nutrient deficiencies in the tested soils in Ethiopia (ATA, 2014). Fertilizers containing sulphur, potassium, and micronutrients like zinc gave increased crop yields (Bereket *et al*., 2011). So far there is no information on the differential newly blended fertilizer responses to high yielding newly released bread wheat varieties by increasing rates of N on Andosols in the Munessa district. The varieties potentials to produce maximum yield remain unknown under the changed location and environment. Hence, the yield potential of improved wheat varieties require optimum amount and types of fertilizers, and this made to deal with different NPS fertilizer levels is needed to investigate and explore the varieties potentials in maximizing wheat yields and qualities in the area and to identify better yielding wheat varieties for the area. Thus, the objective of this study was initiated to investigate the effects of NPS fertilizer rates on yield and yield components and quality attributes of bread wheat varieties.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study area, Munessa districts is found in Arsi Zone, Oromia National Regional State of Ethiopia. It lies between 70 latitudes and 38^0 41' 55" E to 40 areas. According to climatic zones of classification, Munessa districts can be classified as midland of 1500-2300 and highland of 2300-3200 m.a.s.l. zones (Teshome, 1996). The soils are mainly Andosols (Lemenih, 2004). The mean annual rainfall was 1200 mm with bimodal rainfall pattern with a short rainy season from March to May and a long rainy season from July to September. The mean relative humidity was 87%; mean minimum, maximum and average temperature was 6, 15 and 10^oc, respectively. The district is characterized by mixed farming system where crop and livestock production are the main activities, where crops play the dominant role in terms of contribution to farmers' income.

2.2. Soil Sampling and Analysis

The collected soil sample both before planting and after crop harvested was analyzed for the selected physico-chemical properties mainly total N, available P, organic carbon, Soil pH, cation exchange capacity and textural analysis using standard laboratory procedures at Kulumsa Agricultural Research Center Laboratory. Total nitrogen was determined following Kjeldahl procedure as described by Bremner and Mulvaney (1982). The available phosphorus was determined following Bray-II procedure as described by Bray and Kurtz (1945). Soil organic matter was determined following wet digestion methods as described by Walkley (1947) and FAO (1974). Soil pH was measured potentiometrically using digital pH meter in the supernatant suspension of 1:2.5H_2O, 0.01M $CaCl_2$ and 0.1M KCl as described by McLean (1982). Cation exchange capacity (CEC) of the soil and exchangeable bases was determined by saturating soil with neutral 1M NH_4OAc (ammonium acetate) and the adsorbed NH^{4+} displaced by using 1M KCl and then determined by Kjeldahl distillation method for estimation of CEC of soil (Rhoades, 1982). Available SO_4 was determined using turbid metric method

(Tabatabai, 1982). Hydrometer method was used to determine the particle size distribution following the procedure of FAO (1974).

2.3. Treatments and Experimental Design

Factorial combinations of the three improved wheat varieties (Hidase, Ogolcho and Liben obtained from Kulumsa Agricultural Research Center) and six levels of NPS fertilizer rates (0, 50, 100, 150, 200 and 250 kg ha^{-1}) were used as treatments for the experiment which was laid out in randomized complete block design in three replications.

2.4. Experimental Procedures and Crop Management

The field was prepared with conventional methods using oxen plough. Improved seeds of wheat varieties used for planting were drilled in rows at optimum sowing date in the area. The NPS fertilizer rates were calculated and applied per plots once at planting for the area accordingly. Improved agronomic management practices were applied to wheat varieties as per research result recommendations (Hailu, 1991). The plot size was 2 m x 2 m (4 m^2) and the total experimental land was 44.5m x 8m (356m^2) with gross plot land size of 36mx6m (216m^2). Number of row per plot was 10 rows and the distance between plants and plots was 0.2m and 0.5m, respectively. Seed rate of planting was 100 kg ha^{-1}. Finally, wheat varieties were harvested after germination within 134-138 days of maturity.

2.5. Data Collected

Crop phenology and growth parameters like days to heading at 50% of plants headed, days to physiological maturity at 90% plants maturity and plant height(cm) at one week before harvesting were collected. Yield and yield components like spike length(cm) at maturity one week before harvesting, dry biomass(kg), number of seeds per spike at maturity, grain yield(kg ha^{-1}) adjusted to 12% moisture, thousand seed weight(g) and harvest index(%) which was computed as a ratio of grain yield to dry biomass yield multiplied by 100 where collected. Grain quality parameters like hectoliter weight ($kghl^{-1}$) and grain protein content(%) using digestion methods of Micro-Kjeldhal's apparatus (AACC, 2000) formula. The percentage of protein was calculated by multiplying the grain N content with a constant factor of 5.7 (AACC, 2000). Economic analysis such as partial budget, benefit cost ratio and marginal rate of return for wheat grain yield was valued at an average open market price of ETB 1100 per 100 kg for the last 5 years. Labor cost for field operation was ETB 70 per man-day. The yield was adjusted down by 10% to reflect actual production conditions to adjust to the farmers' production status (CIMMYT, 1988). The cost of fertilizer for NPS was ETB 1106.5 per 100 kg with the current market price, respectively.

2.6. Data Analysis

The collected data were analyzed using analysis of variance by SAS software (SAS, 9.0 version; SAS, 2004). Further analysis was carried out as needed by using appropriate statistical procedures outlined by Gomez and Gomez (1984). Significant means were separated by Least Significant Differences at 5% significance levels (Steel and Torrie, 1980) and Duncan's Multiple Range Test at 5% probability level (Duncan, 1955).

3. RESULTS AND DISCUSSION

3.1. Soil Physico-chemical Properties of Experimental Site

The pre-planting soil physicochemical properties of experimental site were analyzed (Table1). The soil texture distribution of the experimental site was clay loam with soil pH of 6.18, available P 17.09 ppm, total nitrogen of 0.20 and organic carbon of 3.35 % along with CEC of 13.68 meq 100g $soil^{-1}$ (Table 1). The soil reaction was slightly acidic, medium in available P, low in nitrogen concentration, high in organic carbon content and medium in CEC as compared to the categorization of Landon (1991) and Msanya *et al*. (2000). The sulphur concentration of the soil was 10.92 ppm (Table 1) which is categorized in medium range as stated in Horneck *et al*. (2011).

Table 1. Soil physicochemical properties of the experimental site

Soil parameters	Value	Rating
PH (1:25)	6.18	Slightly acidic
P(ppm)	17.09	Medium
N (%)	0.20	Low
OC (%)	3.35	High
OM (%)	5.78	High
SO_4-S (ppm)	10.92	Medium
CEC (meq/100 g soil)		
Clay (%)	34.4	
Sandy (%)	34.0	
Silt (%)	31.6	
Texture class	Clay loam	

Data Sources: Laboratory Analysis using London (1991), Msanya *et al*. (2000), Tekalign *et al*. (1991) and Homeck *et al*. (2011) methodology.

Application of NPS fertilizer at different rates to wheat varieties showed significant variation on post-harvest soil physico-chemical properties (Table 2). The pH of the soil was ranged from 5.28 to 5.60 in the plots planted with Hidase variety in the fertilizer range from without external fertilizer application to 250 kg ha^{-1} and in case of Ogolcho variety planted plots the pH was ranged from 5.67 to 5.82 as the applied NPS rates increased up to 250 kg ha^{-1} NPS. However, in plots planted with Liben variety the soil pH was decreased (5.96 to 5.28) as the applied NPS rates increased from 0 to 250 kg ha^{-1} which indicated that there were variations in the pH of soil left after wheat varieties became harvested along the various rates of NPS applied. After the crop was harvested from whole plot, the pH of the soil became decreased as compared to the composite sample in plots planted with Liben, and when we came to Hidasse and Ogolcho varieties, the pH of the soil was increased consecutively from the level of control to 250 kg ha^{-1} fertilizer application to the soil.

The phosphorus contents of the soil on which Ogolocho variety grown was ranged from 14.15 to 24.76 ppm on the plot applied from 50 to 250 kg NPS ha^{-1}. This indicated that application of NPS fertilizer increased the level of P retained in the soil after the crop harvested along the applied fertilizer levels. Almost similar P results were obtained from all plots after harvested except lowest P at 50 kg ha^{-1} and highest at 250 kg ha^{-1} applied to Ogolcho variety. The nitrogen contents of the soil were also increased after Liben wheat variety became harvested ranged from 0.18 to 0.25 % with an application of 200 and 250 kg NPS ha^{-1} and other treatments were at par to each other. Also, the sulphur contents of the soil were increased from 6.62 to 19.32 ppm as the level of NPS became increased from 0 to 100 kg ha^{-1} on the plot planted with Liben variety; the sulphur contents of the plots planted with Hidase and Ogolcho varieties were not improved beyond the sulphur contained in the soil before the crop planted. The carbon and organic matter contents of the soil were ranged from 2.48 to 3.14 % and 4.28 to 5.40 % with an applied 250 and 0 kg NPS ha^{-1}. This indicated that application of NPS fertilizer significantly influenced the soil physico-chemical properties of the soil conversion for utilization by the crop.

Table 2. Interaction effects of varieties and NPS fertilizer rates on post-harvest soil physicochemical properties of the experimental soil

Varieties	NPS ($kgha^{-1}$)	Soil pH (1:25)	Phosphorus (ppm)	Nitrogen (%)	SO_4-S (ppm)	Carbon (%)	Organic Matter (%)
Hidase	0	5.28^{e}	18.85^{abcd}	0.19^{ab}	17.43^{ab}	3.14^{a}	5.40^{a}
	50	5.29^{de}	18.51^{abcd}	0.20^{ab}	16.07^{abc}	2.90^{abc}	5.01^{ab}
	100	5.34^{de}	19.66^{abcd}	0.21^{ab}	11.55^{abc}	2.87^{abc}	4.95^{ab}
	150	5.456^{cde}	16.96^{abcd}	0.19^{ab}	7.46^{bc}	2.88^{abc}	4.96^{ab}
	200	5.53^{bcde}	20.11^{abcd}	0.20^{ab}	10.4^{abc}	2.84^{abc}	4.89^{ab}
	250	5.60^{bcd}	17.37^{bcd}	0.20^{ab}	10.19^{abc}	2.48^{C}	4.28^{b}
Ogolcho	0	5.667^{abc}	18.24^{abcd}	0.19^{ab}	12.18^{abc}	3.14^{a}	5.42^{a}
	50	5.78^{ab}	14.15^{d}	0.19^{ab}	9.45^{abc}	2.80^{abc}	4.83^{ab}
	100	5.82^{ab}	16.32^{bcd}	0.21^{ab}	10.19^{abc}	2.62^{bc}	4.53^{b}
	150	5.81^{ab}	18.06^{abcd}	0.20^{ab}	10.40^{abc}	2.83^{abc}	4.89^{ab}
	200	5.82^{ab}	17.04^{bcd}	0.20^{ab}	16.17^{abc}	2.98^{ab}	5.14^{ab}
	250	5.82^{ab}	24.76^{a}	0.20^{ab}	15.33^{abc}	2.86^{abc}	4.93^{ab}
Liben	0	5.96^{a}	14.40^{cd}	0.19^{ab}	6.62^{c}	2.57^{bc}	4.44^{b}
	50	5.92^{ab}	17.87^{abcd}	0.22^{ab}	13.65^{abc}	2.85^{abc}	4.91^{ab}
	100	5.96^{a}	21.47^{abc}	0.23^{ab}	19.32^{a}	2.58^{bc}	4.45^{b}
	150	5.73^{abc}	23.2^{ab}	0.23^{ab}	18.69^{a}	2.71^{abc}	4.67^{ab}
	200	5.69^{abc}	17.18^{bcd}	0.18^{b}	17.97^{ab}	2.61^{bc}	4.50^{b}
	250	5.28^{e}	17.27^{bcd}	0.25^{a}	16.28^{abc}	2.73^{abc}	4.7^{ab}
Mean		5.89	16.18	0.18	13.30	2.88	4.96
LSD (5%)		0.848	4.151	0.0233	0.5012	8.9667	0.8627
CV (%)		4.601	23.221	17.99	20.64	10.81	10.82

Means followed by the same letter/s in the same column are not significantly different at 5% probability level.

3.2. Effect of Varieties and NPS Fertilizer Rates on Phenology and Growth Parameters

The mean result of date of heading, 90% maturity and plant height of wheat were significantly (P<0.05) differed due main effect of varieties and NPS rates, but not by their interaction and NPS rates on 90% days to maturity (Table 3). Highest days to heading and physiological maturity were obtained on Ogolcho and Liben varieties without significant variation between them and lowest days from Hidase variety. Largest plant height (118cm) was obtained from Ogolcho variety which was differed from Liben and Hidase varieties by 8.50% and 4.24%, respectively, this might be due to varietal differences of wheat varieties on the phenology and growth attributes. This result is similarly reported by Esayas *et al.* (2015) as there were significant differences in days to panicle heading, physiological maturity and plant height among wheat varieties. Similarly, Suleiman *et al.* (2014) reported that significant difference among the three varieties on both days to heading and maturity of the crop. Likewise, Arega *et al.* (2013) reported that there were significant differences in plant height among wheat varieties.

Main effect of NPS fertilizer rates also significantly (P<0.05) affected the mean date of heading and plant height of wheat crop, but not days to maturity (Table 3). The largest mean days to heading (67) was obtained from the control and plant height (115cm) was obtained from plot received 250 kg ha^{-1} without statistical difference from those fertilized with 100 to 200 kg ha^{-1} of NPS and lowest from unfertilized plot. This indicated that application of NPS fertilizer rates had a role in phenology and growth of wheat crop. Similar results were reported by Amsal *et al*. (2000) and Kabir (2009) as there were significant differences in plant height of wheat varieties due to fertilization.

Table 3. Days to 50% heading, physiological maturity and plant height of wheat as influenced by NPS rates and varieties

Treatment	Date to Heading	90% Days of Maturity	Plant Height (cm)
Varieties			
Hidase	63^{b}	134^{b}	113^{b}
Ogolcho	67^{a}	136^{a}	118^{a}
Liben	68^{a}	136^{a}	108^{c}
LSD (5%)	0.99	0.65	2.77
NPS (kg ha^{-1})			
0	67^{a}	136	110^{c}
50	65^{b}	135	110^{bc}
100	65^{b}	136	113^{abc}
150	66^{ab}	135	114^{ab}
200	65^{b}	136	114^{abc}
250	66^{ab}	136	115^{a}
LSD (5%)	1.39	NS	3.92
CV (%)	2.20	0.70	3.60

NS=non-significant difference at 5% probability level, Numbers followed by the same latter in the same column are not significant different at 5% probability level.

3.3. Effect of Varieties and NPS Fertilizer Rates on Yield Components and Yield of Wheat

Spike length, harvest index and thousand seed weight of wheat were significantly (P<0.05) influenced by the main effects of varieties (Table 4). Ogolcho variety gave higher spike length than Hidase and Liben varieties, but significantly higher mean harvest index and thousand seed weight of wheat were obtained from both Hidase and Ogolcho varieties which was improved by 7.9% and 12.5%, respectively as compared to the lowest obtained from Liben variety (Table 4). This indicated that the three varieties of wheat were different in yield components among each other. Similarly, Esayas *et al.* (2015) reported significant differences in number of kernels per spike and thousand kernel weights and harvest index among wheat varieties. Likewise, Guluma *et al*. (2010) reported that significant differences among three varieties of wheat on thousand seeds weight.

However, only thousand seeds weight of wheat was significantly (P<0.05) affected by the main effect of NPS fertilizer rates applied. Higher mean thousand seeds weight of wheat was obtained from application of 50 kg NPS ha^{-1} and the lowest form the wheat crop fertilized with 100 kg NPS ha^{-1}. Similarly, Rashid *et al*. (2016) reported higher 1000 grains weight of wheat was recorded from treatment receiving all N, P, K, S and Zn with FYM.

Table 4. Spike length, harvest index, number of seeds per spike and thousand seed weight of wheat influenced by NPS rates and varieties

Treatments	Spike Length (cm)	Harvest Index (%)	Number of Seeds Spike^{-1}	Thousand Seed Weight (g)
Variety				
Hidase	9^{b}	38^{a}	48^{b}	40^{a}
Ogolcho	11^{a}	38^{a}	51^{b}	39^{a}
Liben	9^{b}	35^{b}	51^{b}	35^{b}
LSD (5%)	0.37	1.76	NS	1.74
NPS (kg ha^{-1})				
0	10	38	51	39^{ab}
50	10	38	51	40^{a}
100	10	36	50	37^{b}
150	10	36	49	38^{ab}
200	10	37	50	38^{ab}
250	10	38	50	38^{ab}
LSD (5%)	NS	NS	NS	2.46
CV (%)	5.50	7.00	7.60	6.70

NS=non-significant difference at 5% probability level; Means followed by the same latter in the same column are not significant different at 5% probability level

Biomass yield of wheat was significantly (P<0.05) affected by the interaction of NPS fertilizer rates application and wheat varieties (Table 5). Higher biomass yield (19750 kg ha^{-1}) was obtained from Ogolcho variety at an application of 250 kg NPS ha^{-1} and lowest biomass yield (15833 kg ha^{-1}) was recorded from Liben variety without external fertilizer application; which improved by 16% and 20% as compared to Hidase and Liben varieties produced without fertilizer application, respectively. However, highest biomass yield obtained from Ogolcho variety was statistically differed only from Hidase and Liben varieties produced without external fertilizer application and Liben variety received 100 kg ha^{-1}. Likewise, Amsal *et al*. (2000) found that the mean biomass yield response to fertilizer application were 76 and 77% on the Vertisol and Nitisol as compared to the unfertilized control. Assefa *et al*. (2015) also observed a synergy between applied fertilizers, particularly N, and S in increasing yield with each level and kind of fertilizer added, as evidenced by the existence of yield advantage at any given fertilizer level. Similarly, Rashid *et al*. (2016) reported higher biological yield of wheat from treatment received all N, P, K, S and Zn with FYM. Biomass yield of wheat significantly increased due to the main effect of nitrogen fertilization and increased grain yield with an increased nitrogen rates (Bereket *et al*., 2014).

Table 5. Interaction effect of varieties and NPS rates on biomass yield of wheat

Varieties	Biomass Yield (kg ha^{-1}) NPS (kg ha^{-1})					
	0	50	100	150	200	250
Hidase	16583^{bc}	18167^{abc}	19083^{ab}	19167^{ab}	19333^{ab}	19000^{ab}
Ogolcho	17083^{abc}	17083^{abc}	18333^{abc}	19167^{ab}	19333^{ab}	19750^{a}
Liben	15833^{c}	17000^{abc}	16833^{bc}	17750^{abc}	18333^{abc}	18000^{abc}
LSD (5%)	2370					
CV (%)	7.89					

Numbers followed by the same letter in the same column are not significant different at 5% probability level

Grain yield of wheat was significantly ($P<0.05$) affected by the interaction effects of varieties and NPS fertilizer rates applied (Table 6). Higher mean grain yield (7667 kg ha^{-1}) was obtained from Hidase and Ogolcho wheat varieties at an application of 250 kg NPS ha^{-1} and lowest from Liben variety without external fertilizer application. Higher grain yield of Hidase, Ogolcho and Liben wheat varieties gave the yield advantage of 19%, 13% and 11% as compared to those produced on the control, respectively (Table 6). Similarly, Amsal *et al*. (2000) found improved grain yield by 163 and 76 %; and 149 and 77 % due to fertilizer application on the Vertisols and Nitisols as compared to the unfertilized control. Assefa *et al*. (2015) found significantly affected grain yield and yield components of wheat due to application of NPS fertilizer. Ali *et al.* (2011) also reported improved grain yield by 58% of bread wheat due to application of nitrogen and phosphorus fertilizer. Similarly, Rashid *et al*. (2016) reported higher grain yield of wheat from those treated by all N, P, K, S and Zn with FYM as compared to unfertilized plot.

Table 6. Interaction effects of varieties and NPS rates on grain yield of wheat

Varieties	Grain yield (kg ha^{-1}) NPS (kg ha^{-1})					
	0	50	100	150	200	250
Hidase	6167^{bcde}	7250^{abc}	7250^{abc}	7000^{abcd}	7250^{abc}	7667^{a}
Ogolcho	6667^{abcde}	6333^{abcde}	6917^{abcd}	7333^{ab}	7250^{abc}	7667^{a}
Liben	5833^{de}	6083^{bcde}	5500^{e}	5917^{cde}	6583^{abcde}	6083^{bcde}
LSD (5%)	1183					
CV (%)	10.63					

Means followed by the same letter in the same column are not significant different at 5% probability level

3.4. Effect of Varieties and NPS Fertilizer Rates on Quality Attributes of Wheat Crop

The hectoliter weight of wheat was significantly ($P<0.05$) varied due to main effect of wheat varieties but not by fertilizer (Table 7). Higher mean hectoliter weight of wheat was obtained from Liben variety as compared to the other two wheat varieties. Thus, hectoliter weight provides a rough estimate of flour yield potential in wheat varieties. Similarly, Dereje (2018) found that main effect of variety exhibited significant difference on hectoliter weight of wheat. Also, Tayyar (2010) and Abboud and Charles (2012) reported higher hectoliter weight values and showed significant differences due wheat genotypes.

Table 7. Effects of varieties and NPS fertilizer rates hectoliter weight of wheat

Varieties	Hectoliter Weight (g)
Hidase	75[b]
Ogolcho	75[b]
Liben	77[a]
LSD (5%)	1.02
NPS (kg ha^{-1})	
0	76
50	76
100	75
150	76
200	76
250	76
LSD (5%)	NS
CV (%)	2.00

NS=non-significant; Numbers followed by the same latter in the same column are not significantly different at 5% probability level.

Grain protein content of wheat was significantly ($P<0.05$) affected by interaction effects of varieties and NPS fertilizer rates (Table 8). Higher grain protein content (14.52%) was obtained from Hidase variety and lowest (11.16%) from Ogolcho variety of wheat at an application of 50 kg NPS ha^{-1} (Table 8). The other results were statistically not significantly differed from each other with the application of different rates of NPS fertilizer on the three wheat varieties. This might be due to the similarities of all wheat varieties with protein concentration. Likewise, Dereje (2018) reported protein contents of wheat genotypes ranged from 12.88 and 15.12% and highest grain protein content of wheat was recorded with an application of 184 kg N ha^{-1}. In contrary, Dereje (2018) found interaction effects of Varieties and N non-significantly affected grain protein contents of wheat. Sial *et al.* (2005) and Karimzadeh *et al.* (2006) found significant differences in grain protein content among the different genotypes of wheat. Also, the result of this study was in contrary to the reports of Bereket *et al.* (2014) and Sofonyas (2016) whereby grain protein content of wheat increased with increased fertilizer rates.

Table 8. Interaction effects of Varieties and NPS fertilizer rates on grain protein of wheat

Varieties	Grain Protein (%) NPS (kg ha^{-1})					
	0	50	100	150	200	250
Hidase	14.25[ab]	14.52[a]	12.84[abc]	12.92[abc]	12.31[abc]	13.31[abc]
Ogolcho	12.68[abc]	11.16[c]	13.10[abc]	12.09[abc]	12.27[abc]	12.93[abc]
Liben	12.49[abc]	12.51[abc]	12.94[abc]	12.58[abc]	11.82[bc]	13.54[abc]
Mean =	**12.97;**	**LSD (%)=**	**2.642;**	**CV (%) =**	**12.45**	

NS=non-significant difference at 5% probability level; means followed by the same latter in the same column are not significantly differed at 5% probability level.

3.5. Correlation of Growth, Yield and Quality Attributes of Wheat due to NPS Fertilizer Application on Different Varieties

Correlation analysis between growth, yield and yield components and quality attributes of wheat revealed that availability of strong and positive associations between some parameters (Table 9). Positively significant associations were observed between yield and yield components of wheat. Significantly, higher and positive correlation coefficient was observed between grain yields and dry biomass yield (0.81) and plant height of wheat (0.61), between harvest index and thousand seed weight (0.73), between dry biomass yield and plant height (0.61). Significantly positive associations were observed between hectoliter weight and days to heading of wheat. This indicated that the higher the number of days to heading the higher would be hectolitre weight of wheat and vice versa. Significantly positive associations between grain protein content with hectoliter weight (0.28), plant height (0.46) and spike length (0.47) of wheat were also obtained. In contrary, Firehiwot (2014) reported that non-significantly positive association between grain protein content with hectoliter weight, plant height and spike length of wheat. Increase in grain protein could increase with hectoliter weight, plant height and spike length of wheat and vise verse. In general, yield and yield components and quality attributes of wheat had positive relationship with grain yield of wheat indicating that the yield components of wheat directly influenced the grain yield and quality of wheat. Similarly, Bereket *et al.* (2014), Esayas (2015) and Dereje (2018) reported similar results with different varieties of wheat.

Table 9. Pearson correlation coefficients of growth and yield components of wheat due to varieties and NPS fertilizer rates

	VT	NPS	DH	NM	PH	SL	DB	SS	GY	TSW	HI	HL	GP
VT			0.76**	0.72*	-0.36*	0.17	-0.31	0.30	-0.50	-0.62	-0.49**	0.38*	0.07
NPS			-0.11	0.03	0.31*	0.063	0.52**	-0.10	0.33*	-0.14	-0.039	-0.038	0.05
DH				0.69**	-0.10	0.44**	-0.16	0.29*	-0.24*	-0.38**	-0.22	0.27	0.13
NM					0.061	0.44**	0.058	0.28*	0.027	-0.11	-0.028	0.49*	0.06
PH						0.54**	0.61**	-0.098	0.61*	0.30	0.33	-0.36	0.46*
SL							0.17	0.145	0.27*	0.19	0.25	0.068	0.47*
DB								-0.067	0.81**	0.30	0.24	-0.03	0.14
SS									-0.02	0.30	0.22	-0.031	0.09
GY										0.11	0.04	0.37	0.19
TSW											0.73**	0.27	0.04
HI												0.23	0.17
HL													0.28*
PP													

VT=varieties, NPS= NPS fertilizer, DH=Days to heading, NM= Days to 90 % maturity, PH= Plant height, SL= Spike length, DB= Dry biomass, SS= Spike length, GY=Grain yield, TSW= thousand seed weight, HI= Harvest index, HL= Hectoliter weight

3.6. Effects of NPS Fertilizer Rates on Economic Profitability of Wheat Varieties

The value to cost ratio for NPS fertilizer was ranged from 11.78 to 57.68 ETB per unit of investment obtained from an application of 250 and 50 NPS kg ha^{-1} (Table 10). This implied that high profitability of wheat due to application of NPS fertilizer rates in that area. Wheat production with application of 200 kg NPS ha^{-1} gave net profit advantage of 32,576 ETB with marginal rate return of 41% followed by 50 kg NPS ha^{-1} gave net benefit of 31,897 with marginal rate return of 198 % (Table 10). The economic analyses confirmed wheat production with application of 50 to 200 kg NPS fertilizer application was profitable in study area. Similarly, Esayas (2015) obtained that application of NPS fertilizer gave economically feasible for all varieties of Durum wheat. Application of 46/20 kg NP ha^{-1} was economically feasible and recommended to achieve sustainable bread wheat production on the sandy soils of Hawzen district (Bereket *et al*., 2014). Also, Assefa *et al*. (2015) obtained higher economic benefit with the application of higher NPS levels 69, 20 and 20, respectively.

Table 10. Effects of NPS fertilizer rates on pooled partial budget analysis of wheat production

NPS (kg ha^{-1})	Grain yield (kg ha^{-1})	Adjusted grain yield (kg ha^{-1})	Gross field benefit (EB ha^{-1})	TCV (EB ha^{-1})	Net benefit (EB ha^{-1})	Value to cost ratio	MRR (%)
0	6222	5600	30800	0	30800		
50	6556	5900	32450	553	31897	57.68	198
100	6556	5900	32450	1106	31344D	28.34	
150	6750	6075	33412.5	1659	31754D	19.14	
200	7028	6325	34787.5	2212	32576	14.73	41
250	7139	6425	35337.5	2765	32573	11.78	

D= dominated, ETB= Ethiopian Birr, TCV= total cost that vary, grain price of wheat=11 ETB kg^{-1}, *Cost of (NPS) =ETB 1106.5 100 kg^{-1}*

Higher net profit of 73,135 ETB ha^{-1} with marginal rate return of 86% with an application of 250 kg NPS ha^{-1} followed by net benefit of 71,222 with marginal rate return of 1839% with application of 50 kg NPS ha^{-1} for Hidase variety was observed (Table 11). Production of Ogolcho variety of wheat with an application of 250 kg NPS ha^{-1} gave net profit advantage of 73,135 ETB ha^{-1} with marginal rate return of 198% followed by 50 kg NPS ha^{-1} gave net benefit of 70,941 ETB ha^{-1} with marginal rate return of 646 % (Table 11). Higher net profit of 62,963 EB ha^{-1} with marginal rate return of 198% with an application of 200 kg NPS ha^{-1} followed by net benefit of 59, 672 ETB ha^{-1} with marginal rate return of 348 % with an application of 50 kg NPS ha^{-1} for Liben wheat variety (Table 11). The value to cost ratio for interaction of varieties with NPS fertilizer was ranged from 27 to 129, to 27 to 112 and 21 to 108 ETB per unit of investment for Hidase, Ogolcho and Liben varieties of wheat with an application of 250 and 50 NPS kg ha^{-1} (Table 11).

Table 11. Interaction effects of varieties and NPS fertilizer rates on economic feasibility of wheat production

Varieties	NPS (kg ha^{-1})	Grain yield (Kg ha^{-1})	Adjusted grain yield (kg ha^{-1})	Gross field benefit (EB ha^{-1})	TCV (EB ha^{-1})	Net benefit (EB ha^{-1})	Value to cost ratio	MRR (%)
Hidase	0	6167	5550	61050	0	61050		
	50	7250	6525	71775	553	71222	128.8	1839
	100	7250	6525	71775	1106	70669 ^{D}	63.9	
	150	7000	6300	69300	1659	67641 ^{D}	40.8	
	200	7250	6525	71775	2212	69563 ^{D}	31.4	
	250	7667	6900	75900	2765	73135	26.5	86
Ogolcho	0	6667	6000	66000	0	66000		
	50	6333	5700	62700	553	62147 ^{D}	112.4	
	100	6917	6225	68475	1106	67369	60.9	124
	150	7333	6600	72600	1659	70941	42.8	646
	200	7250	6525	71775	2212	69563 ^{D}	31.4	
	250	7667	6900	75900	2765	73135	26.5	198
Liben	0	5833	5250	57750	0	57750		
	50	6083	5475	60225	553	59672	107.9	348
	100	5500	4950	54450	1106	53344 ^{D}	48.2	
	150	5917	5325	58575	1659	56916 ^{D}	34.3	
	200	6583	5925	65175	2212	62963	28.5	198
	250	6083	5475	60225	2765	57460^{D}	20.8	

D= dominated, ETB= Ethiopian Birr, TCV= total cost that vary, grain price of wheat=11 ETB kg^{-1}, *Cost of NPS = ETB 1106.5 100 kg^{-1}*

4. CONCLUSION

Application of NPS fertilizer significantly increased yield and yield components; and qualities of wheat varieties in the study area. In conclusion, improved yield and yield components and quality attributes along better economic return of wheat were produced at an application of 200 kg NPS ha^{-1} fertilizer for wheat varieties in that area. However, Hidase and Liben varieties produced better economic return at an application of 50 kg ha^{-1} NPS and Ogolcho variety produced better economic return at an application of 150 kg ha^{-1} NPS in the study areas.

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