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Research Article

Agronomic and Economic Performance of Bread Wheat (*Triticum aestivum L.*) Varieties in Response to N-Fertilizer Rate at Lemu-Bilbilo District, Southeastern Ethiopia

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Abstract

Managing N inputs in wheat production systems is a main issue to achieve maximum profitable production, and decreasing environmental impact. To this effect, the experiment was conducted on farmer's field during the 2017 main cropping season at Lemu-Bilbilo district of Arsi zone, southeastern Ethiopia to determine the response of different rates of N fertilizer and its influence on yield and yield components of bread wheat varieties. Factorial combinations of two bread wheat varieties (Lemu and Wane) and five N- rates (0, 46, 92,138 and 184 kg N ha^{-1}) were used in a Randomized Complete Block Design with three replications. The variety Lemu had higher values for effective tillers per plant, spike length, plant height, and number of grains spike^{-1}, grain and straw yields. On the other hand, Wane variety exhibited greater values for thousand grain weights, and short phenological periods. Application of N significantly prolonged number of days to heading and maturity and grain filling period. Effective tillers, plant height, spike length, straw yield, harvest index and thousand grain weight were consistently increased in response to N rates. The interaction effect of N and variety were significant on days to heading and grain yield. The longest days to heading and the highest grain yield were obtained from 184 kg N ha $^{-1}$ for both varieties. The highest net benefit was obtained from the application of 184 kg N ha^{-1} followed by application of 138 kg N ha^{-1}, 92 kg N ha^{-1} and 46 kg N ha^{-1}. Application of 46, 92,138 and 184 kg N ha^{-1} gave marginal rate of return of 769%, 367%, 326% and 445%, which are well above the minimum acceptable rate of return. Therefore, application of 92 to 184 kg ha^{-1} of N with Lemu bread wheat variety were proved to be productive and superior both in grain yield as well as economic advantage and recommended for wheat production in study area.

Keywords: Grain Yield; Bread Wheat Varieties; Nitrogen Fertilizer; Marginal Rate of Return

Introduction

Wheat (*Triticum aestivum L.*) is one of the major staple crops in terms of both production and consumption in Ethiopia [1]. It is a highly marketable commodity and it is consumed heavily in different forms. Wheat and wheat products make up to 14 percent of the overall calories intake of an average household [2]. Central-Eastern Oromia falls within the agro-ecological zones of the Ethiopian highlands and of the Rift Valley that is characterized by a bi-modal rainfall pattern with mean average rainfall of 900 - 1000 millimeters per year. Temperature variation is low, ranging between 15 - 22 °C throughout the year [3]. Wheat productivity in Central-Eastern Oromia has increased steadily over the past years, reaching yields as high as 3.6 tonnes per hectare, well above the national average which stands at 2.53 tonnes per hectare [4]. The zones producing the largest wheat surplus in Ethiopia are Bale, Arsi and West Arsi in Central-Eastern Oromia, and East Gojjam in Amhara regional state. These four zones generate more than two-thirds of the total wheat surplus across zones [5].

Despite its potential, Ethiopia remains a net importer of wheat. Ethiopia is experiencing a huge gap between production (4.5 million tonnes in 2016) and consumption levels (5.4 million tonnes in 2016), which results in import dependence. For instance, in 2016 the Ethiopian Grain Trade Enterprise imported 750 thousand tonnes from Russia and Argentina and 300 thousand tonnes through food aid, resulting in 1.05 million tonnes of imported wheat. It is conditioned by diverse factors of which climate, genetics, and crop management are the most relevant [6]; attributed to low levels of chemical fertilizer usage, limited knowledge on time and rate of fertilizer application, complete removal of crop residues from farmlands, imbalanced use of mineral fertilizers and inappropriate method of their application that culminated in low efficiency [7,8].

There are two main species of wheat in Ethiopia: bread wheat (*Triticum aestivum*) and durum wheat (*Triticum turgidum durum*) [9]. Both are cultivated in Central-Eastern Oromia, which is among the most productive areas of the country. Bread wheat accounts for slightly more than half of the area planted and are generally grown in the highland and semi-highland areas. Durum wheat covers about 40 percent of the cultivated area, but reliable information is limited [10]. Wheat consumption is higher in urban than rural areas due to high population growth, changes in lifestyle, and the rising prices for tef [11]. Poor agronomic and soil management, inadequate level of technology generation and dissemination are the most significant constraints to increased wheat production in the highlands and mid highlands of Ethiopia [12, 13]. Wheat is mainly grown in the highlands of Ethiopia, which lie between 6°N and 16°N and between 35°E and 42°E, at altitudes ranging from 1,500 to 2,800 m above sea level and with mean minimum temperatures of 6°C to 11°C [14]. Of the current total wheat production area, about 75% is located in the Arsi, Bale, and Shewa wheat belts [15].

Wheat productivity of these areas in terms of yield per unit area of land is very low due to poor agronomic and soil management practices. As a result of this, the Ethiopian government is forced to import wheat every year because of higher demand than supply [16]. To increase and sustain wheat production and to narrow down the gap between supply and demand, adoption of proper soil fertility managements is of paramount importance. Low soil fertility, especially nitrogen (N) deficiency, is one of the major constraints limiting wheat production in Ethiopian highlands [1]. Nevertheless, fertilizers are applied by less than 45% of farmers, on about 40% of the cultivated land for crop production, most likely below-optimal dosage levels are applied [17].Nitrogen is often the most deficient of all the plant nutrients. Wheat is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization [18]. The increase of agricultural food production worldwide over the past four decades has been associated with a 7-fold increase in the use of N fertilizers [19]. Hence, application of nitrogen fertilizer at the right rate and time is vital for the enhancement of soil fertility and crop productivity. Therefore, the experiment was conducted to determine the response of different rates of nitrogen fertilizer rates on yield and yield components of bread wheat varieties at Lemu Bilbilo district.

Materials and Methods

Description of the Study Areas

Field experiment was conducted at Lemu-Bilbilo district of Arsi Administrative Zone, Oromia Regional State, Ethiopia during the 2017 main crop season (Figure 1). Lemu Bilbilo district is located at 235 km away from Addis Ababa to southeast direction. The geographical location of the experimental field is 7° 32’ 41’’ N and 39° 15’ 17’’ E, respectively. The experimental site is situated at 2796 m above sea level. The average mean minimum and maximum temperature are 7.9 and 18.6**°C** respectively. It receives mean annual rainfall of 1020 mm with pseudo bi-modal distribution and maximum (202 mm) occurs in August (KARC, unpublished). Wheat, malt and food barley, faba bean and field pea are the most common crops cultivated in study site. Pre-experiment soil analyses result revealed that the soil was silty clay in texture, medium in total N, slightly acidic in reaction and medium in organic matter content as shown in Table 1.

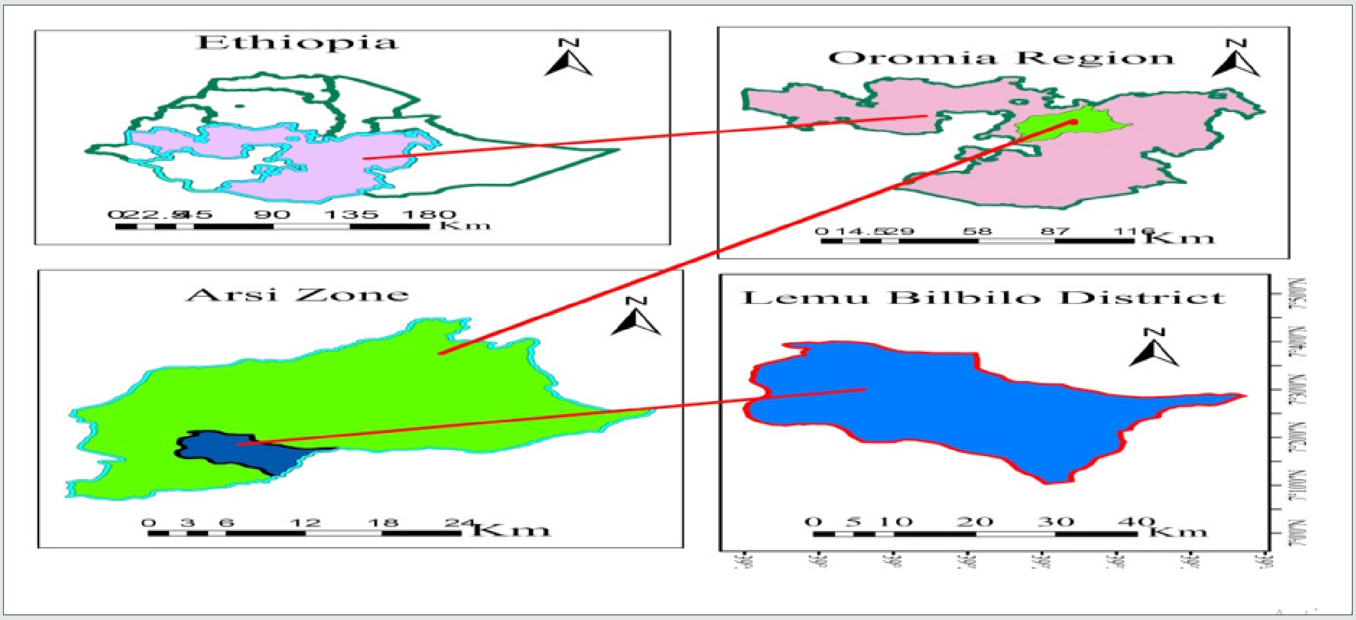

Figure 1: Location map of the study area.

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Table 1: Pre-planting physicochemical characteristics of soil (0-20 cm depth) for the experimental site.

Soil parameters	Value	Rating	Reference
pH(1:2.5 Water)	5.6	Moderately acidic	[28]
Available Phosphorus(mg kg^{-1})	16.7	High	[30]
Organic carbon (%)	3.5	Medium	[30]
Total Nitrogen (%)	0.15	Low	[30]
Sand (%)	9.1	Silty clay	Textural Class
Silt (%)	40.4		
Clay (%)	50.5		
Bulk Density (g cm^{-3})	1.2	Low	[31]

Treatments and Experimental Design

Factorial combination of two improved bread wheat varieties (Lemu and Wane) and five rates of nitrogen (0, 46, 92, 138 and 184 kg ha^{-1}) were used in the experiment and arranged in a randomized complete block design with three replications. Following the history of preceding production season, farmland that was covered with wheat or barley in the preceding year was selected for planting. Plot size was 4 m and 2.6 m with 20 cm spacing. The net harvestable plot size of the experiment was 3.20 m long and 2 m wide with 16 central rows. The spacing between plots and replications were 1 and 1.5 m, respectively. Lemu and Wane were released from KARC during 2016 for its adaptation in the highlands and mid to high land agro-ecologies of southeastern Ethiopia. Both bread wheat varieties were planted in rows using a manual row marker at the recommended grain rate of 125 kg ha^{-1}. Urea (46% N) was used as source of N in triple application (1/3 at planting, tillering and flowering stages of development). Basal application of triple super phosphate (TSP) was used as source of phosphorous (P) at the rate of 100 kg ha^{-1} at planting. Other agronomic practices were properly carried out as per the recommendations of the areas.

Soil Sampling and Analysis

Pre planting, 15 random surface soil samples (0-20 cm) were collected from the experimental site in zigzag walk and bulked to make one representative composite soil sample. The composite soil sample was air-dried, ground and passed through a 2 mm sieve size and analyzed for texture, pH, organic carbon, total nitrogen and available P. For determinations of total nitrogen and organic carbon, a 0.5 mm sieve was used. Soil texture was determined using the Bouyoucos hydrometer method [20]. The pH of the soil was measured in the supernatant suspension of a 1:2.5 soil to water ratio using a pH meter by potentiometer method [21]. Organic carbon was determined by wet oxidation method as described by [22]. Available P was determined by [23] method. Total nitrogen was determined using Kjedahl method as described by [24].

Pre plowing, three undisturbed soil samples were taken by using the core sampler from three randomly selected places of the experimental site. During sampling, the three cylinders were carefully separated, the soil sample flush with each end of the cylinder was carefully trimmed and sealed on each end and transported to soil laboratory. The soil samples were dried in an oven at 105 °C for 24 hours. The weight of the oven dry sample was weighed. Finally, the bulk density (g cm^{-3}) of the soil was calculated from weight of oven dry soil core (g) and volume of soil core (cm^{3}) [25].

Data collected

Data on the phenological, growths, yield and yield components parameters were taken from the 16 central rows of harvestable areas of the experimental plots as follows:

a) **Days to Heading**: Numbers of days from date of sowing to the stage where 50% of the spikes have fully emerged were recorded.

b) **Days to Maturity:** Number of days from date of sowing to the stage where 90% of the plants in the plot reached physiological maturity was recorded.

c) **Days to Grain Filling:** It was obtained by the number of days to maturity minus the number of days to heading.

d) **Number of Effective Tillers:** It was recorded from randomly selected 10 plants in each experimental plot at physiological maturity.

e) **Plant Height (cm):** It was measured from the ground level to the tip of spike excluding the awn at physiological maturity.

f) **Spike Length (cm):** It was the length of the spike from the node where the spike emerges to the tip of the spike, excluding the awn.

g) Grains per spike: It was taken from ten randomly selected spikes per net plot at harvest and averaged per plant basis.

h) **Above Ground Dry Bio-Mass Yields (kg ha^{-1}):** It was obtained from plants harvested at maturity from 16 central rows of each plot and sun dried it for 72 hrs. and then the data was converted to kg per hectare.

i) **Grain Yield (kg ha^{-1}):** Was harvested from 16 central rows that were considered for dry biomass yield were threshed to

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determine grain yield after adjusting the moisture content of the grains 12.5%. Finally, yield per plot was converted to per hectare and the average yield was reported in kg ha^{-1}.

j) **Thousand Grain Weight (g):** It was the weight of 1000 grains determined by carefully counting the grains harvest of each experimental plot by grain counter and weighing them using sensitive balance.

k) **Straw Yield (kg ha^{-1}):** It was measured by subtracting the grain yield from the total above ground biomass yield (after threshing).

l) **Harvest Index (HI %):** It was the ratio of dried grain weight to the dried total above ground biomass weight per plot multiplied by100.

Data Analysis

The collected data of crop phenology, growth, yield and yield components were subjected to analysis of variance using the General Linear Model procedure of R computer software version 4.0.1[26]. Whenever treatment effects were significant, the mean differences were separated using the least significant difference (LSD) at 5% level of significance [27].

Economic Analysis

The economic analysis was performed whenever significant difference was observed for mean grain yields with respect to the applied N rates as per the procedures of [28]. Accordingly, those factors with significant effect were considered for partial budget analysis, dominance and marginal analysis. The average grain yield was adjusted downward by 10% to make it more representative with average grain yield obtained from farmers' field. Then, gross yield benefit (total revenue) was obtained by multiplying the adjusted yield by the price of grain. The mean market price of wheat was obtained by assessing the market price during 2017 cropping season. Total variable cost (TVC) equals to fertilizer cost Birr ha-1 plus fertilizer application and transport cost in Birr. Net revenue (NR) was obtained by subtracting TVC from total revenue (TR). Finally, marginal rate of return (MRR) in percentage was calculated as the change in net revenue (NR) divided by the change in total variable cost (TVC) multiplied by hundred.

Results and Discussion

Selected Physicochemical Properties of Soils of the Experimental Site

The results of the soil physic-chemical characteristics analysis at the study site revealed that, the soil texture distribution of the experimental site was silty clay (Table 1). The soil reaction of the experimental site is moderately acidic [28] rating. This indicates that the soil of experimental site is suitable for optimum growth and yield of most crops. It was found that, plant nutrients are most available at pH varying from 5.5 to 7 [29]. Organic carbon (3.5%) and total nitrogen contents (0.15%) were low in this study site, while available P level (16.7 mg kg^{-1} of soil) was high [30]. The low availability of total N at experimental site indicates maximizing N- application at the study area is critical to maximize wheat production. The bulk density of the soils of the experimental site was (1.2 g cm^{-3}) which is found in low range as [31].

Effects of Nitrogen Rate and Variety on Crop Phenology

Days to heading

Days to heading was significantly affected by N, varieties and their interactions (Figure 2). Days to heading showed an increasing tendency with rising N rates for both varieties at experimental site (Figure 2). Short number of days to heading was recorded from plots without nitrogen fertilization while the longest days to heading was recorded for plots that received 184 kg N ha^{-1}. The same with this result, [32] reported that days to heading were significantly delayed when N fertilizer was applied at the highest rate for wheat and barley production compared to the lowest rate. This could be due to the fact that higher N rates enhance more vegetative growth and larger photosynthesis than reproductive parts. This result is consistent with other studies that reported increased days to heading of wheat with increasing nitrogen fertilizer rates [33].

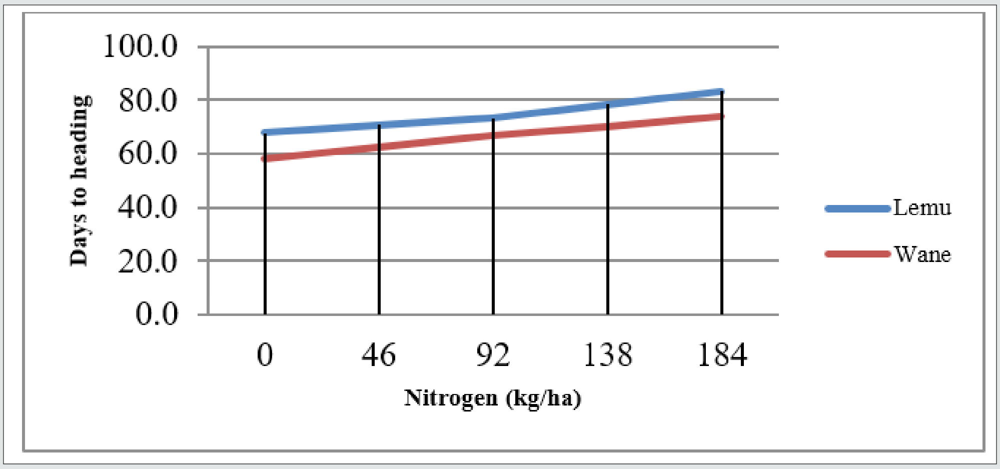

Figure 2: Interaction effect of N and variety on number of days to heading of bread wheat.

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Spike length

Spike length was significantly influenced by the main effects of N rate, and variety but their interactions showed non-significant (Table 2). It is evident from the results that the spike length was markedly higher (7.6 cm) in variety Lemu than variety Wane (7.2 cm), and differences between these values were statistically significant; suggesting that variety Lemu is genetically superior to Wane for spike length character. In line with this result it was reported that the length of spike plays a vital role in wheat towards the grains spike-1 and finally the yield [40]. This result was in agreement with those of [41] who reported that individual genotypes responded differently to spike length for different varieties of wheat. The spike length was consistently increased with increasing N rates (Table 2). In agreement with this result it was reported that increasing N application increased spike length [42].

Table 2: Main effect of variety and N- rate on days to maturity, days to grain filling, number of effective tillers plant-1, plant height and spike length of bread wheat.

Treatments	Days to maturity	Days to grain filling	Effective tellers plant^{-1}	Plant height(cm)	Spike length (cm)
Variety					
Lemu	148.5^{a}	73.8^{a}	4.9^{a}	97.7^{a}	7.6^{a}
Wane	137.8^{b}	71.5^{b}	4.1^{b}	94.7^{b}	7.2^{b}
LSD (%)	1.0	1.1	0.2	0.8	0.2
N rates (kg ha^{-1})					
0	133.7^{e}	70.7^{c}	3.1^{e}	92.7^{d}	6.2^{e}
46	138.7^{d}	72.0^{bc}	4.0^{d}	95.0^{c}	6.6^{d}
92	143.5^{c}	73.3^{ab}	4.6^{c}	96.8^{b}	7.4^{c}
138	148.3^{b}	74.2^{a}	5.1^{b}	97.8^{ab}	8.0^{b}
184	151.5^{a}	73.0^{ab}	5.5^{a}	98.8^{a}	8.8^{a}
LSD (5%)	1.5	1.8	0.3	1.3	0.3
CV (%)	1.0	2.0	5.4	1.1	3.4

Number of Effective Tillers

Number of effective tillers were highly ($p<0.001$) significantly influenced by N rates and varieties, but their interaction was non-significant. Corresponding to this growth parameter, variety Lemu had better performance than variety Wane (Tables 2). The response of the crop in terms of number of effective tillers was consistently increased with increasing N rates and the highest number of effective tillers was recorded from 184 kg N ha^{-1} (Table 2). The lowest numbers of effective tillers were recorded from the control plots; which might be due to the role of N in accelerating vegetative growth of plants. The results were in agreement with that of [43] who reported that increasing in the number of effective tillers with nitrogen fertilization. The findings of other researches also showed that numbers of effective tillers was significantly increased by increasing N fertilization levels [44, 45].

Effects of Nitrogen Rate and Variety on Yield and Yield Components

Number of grains per spike

The analysis of variance showed significant difference ($P<0.01$) on number of grains per spike due to the main effects of variety and rates of N, but their interactions were non- significant (Table 3). Higher number of grains per spike (48.3) was recorded in variety Lemu than Wane (48.5) at experimental site (Table 3). Lower number of grains spike^{-1} was recorded in control plot than fertilized plots. Number of grain spike^{-1} was consistently increased with increasing N rates and the highest values of grain spike-1 was obtained from 184 kg N ha^{-1} which was statistically at par with that of 138 kg N ha^{-1}. The results were in conformity with that of [46] who stated that increasing N level significantly increased number of grain spike-1. Also, other authors reported that increasing N level increased grain spike^{-1} [47].

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Thousand Grain weight

The results revealed that the main effect of varieties and N rates showed highly significant ($p<0.001$) difference with respect to thousand grain weight, but not for their interactions (Table 4). Variety Wane exceeded variety Lemu by 4.9% in thousand grain weight at experimental site (Table 3). This could be due to the late maturity of variety Lemu which might have suffered from unfavorable environmental condition lately in the growing season. Previous finding showed that 100-grain weight exhibited highly significant difference in wheat genotypes [48]. On the other hand, thousand grain weight was increased with increasing N rates, while did not show significant difference between 46 and 92 kg ha^{-1} N rates in thousand grain weight at experimental site. The result was the same to [49] who reported number of grains spike^{-1} and 1000 grain weight were significantly enhanced by increasing nitrogen levels.

Table 3: Main effect of variety and N- rate on grains per spike, straw yield, harvest index and thousand grain weight of bread wheat.

Treatments	Grains spike^{-1}	Straw yield (kg ha^{-1})	Harvest index (%)	Thousand grain weight (g)
Variety				
Lemu	48.3	7409.5	45.5	41.0b
Wane	48.5	7329.5	45.7	43.0a
LSD (5%)	NS	NS	NS	9.1
N rates (kg ha^{-1})				
0	37.2^{d}	6991.8^{b}	35.5^{d}	38.0^{d}
46	41.7^{c}	7196.8^{b}	47.0^{c}	41.5^{c}
92	50.5^{b}	7451.3^{ab}	47.5^{bc}	42.2^{c}
138	55.1^{a}	7472.0^{ab}	48.8^{ab}	43.7^{b}
184	57.7^{a}	7735.5^{a}	49.3^{a}	46.5^{a}
LSD (5%)	3.9	485.4	1.8	1.4
CV (%)	6.6	5.4	3.2	2.8

Grain yield

The results revealed that main effect of varieties and N rates as well as their interactions showed highly significant ($p<0.001$) difference with respect to grain yield (Figure 3). The highest and the lowest grain yield were obtained at the N rate of 184 kg ha-1 and control, respectively for both varieties (Figure 3). Relatively Lemu variety was more productive than Wane at experimental site. The relative advantage in grain yield of Lemu over Wane variety might be largely attributed to its higher number of grains per spike, number of effective tillers and spike length. This result is in agreement with [48] who reported a notably superior performance of between bread wheat varieties. This could be due to its longest spike length, which plays a vital role in wheat on the number of grains per spike and finally the yield [40]. Nitrogen fertilizer applied at rate of 184 kg ha^{-1} had 40.2 % and 37.0 % more grain yield improvement than control for Lemu and Wane varieties, respectively (Figure 3).

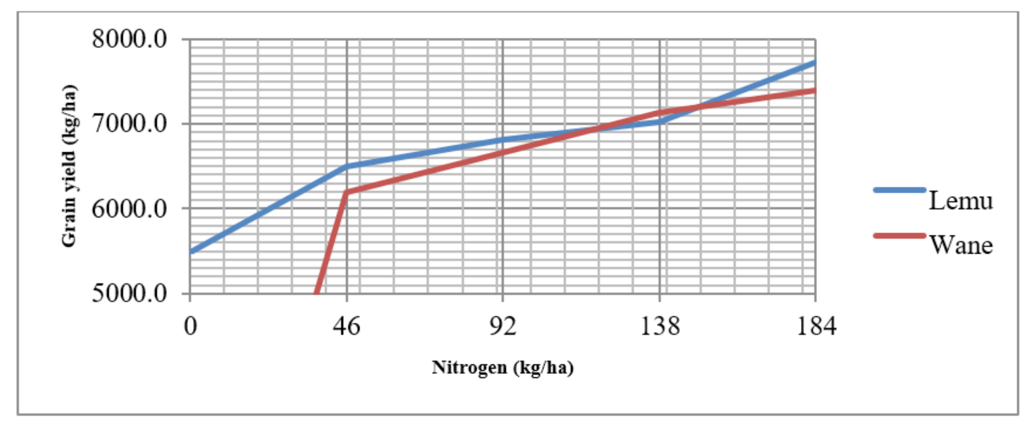

Figure 3: Interaction effect of nitrogen and variety on grain yield of bread wheat.

In line with the result of this study, [44] reported that increasing rate of nitrogen fertilization increased grain yield of wheat. On the other hand, grain yield of both Lemu and Wane variety did show a consistent increasing trend with increasing N rates. With greater N input, higher grain yield was realized in parallel with an increase in photosynthetic area [50]. The most efficient production in both varieties associated with the highest N applications defined nitrogen use efficiency as grain production per unit of N supplied (i.e. available N for the plant during the growth period, including initial inorganic N in the soil, applied N fertilizer, and mineralized N from organic N during this period) [51]. This result corresponds with the findings of other researchers [52,53] who reported increasing of nitrogen fertilization rate increased significantly the average grain yield of bread wheat if compared to control.

Straw yield

The analysis of variance indicated that the main effect of N fertilizer rate exhibited highly ($p<0.001$) differential responses in straw yield whereas the main effect of varieties and the interaction effect of varieties and N rates didn't show significant (Table 3). Straw yield increased with increasing N rates, whereby the lowest and highest straws yield were obtained from control plots (6991.8 kg ha^{-1}) and from plots that received 184 kg N ha^{-1} (7735.5 kg ha^{-1}), respectively (Table 3). This might be due to N increases vegetative growth of plants, especially at higher doses. Besides, the significant increase in plant height, spike length and number of fertile tillers by N rate contributed to the significant increase in straw yield. In agreement with this result, [33] and [44] reported that wheat straw yield increased with increasing N rates.

Harvest index

Harvest Index (HI) was highly ($p<0.01$) significantly influenced by N rate, but the main effect of varieties and the interaction between the two factors were non-significant at experimental site. With increasing N rates from 0 to 184 kg N ha^{-1}, there was increasing trends of HI (Table 3). It might be due to grain harvest index was used to indicate the physiological adaptations of crops to soil N availability, as it expressed by the allocation of biomass to grain in relation to the whole aboveground plant. A mean harvest index of about 50% with a positive trend due to increasing N rate was previously reported in Ethiopia [53]. In contrast, [54] reported that rates and sources of N did not affect harvest index of wheat.

Economic Analysis of Nitrogen Rates

The result of Partial budget analysis of the experimental site was presented in Table 4. The identification of a recommendation is based on a change from one treatment to another if the marginal rate of return of that change is greater than the minimum rate of return (100%). It can be determined that the highest net benefit of ETB 66,740 ha^{-1} was obtained from the application of 184 kg N ha^{-1} followed by application of 138 kg N ha^{-1} (ETB 62,603 ha^{-1}), 92 kg N ha^{-1} (ETB 59,890 ha^{-1}) and 46 kg N ha^{-1} (ETB 56,690 ha^{-1}) (Table 4). Higher marginal rate of return of 769% was obtained with application of 46 kg N ha^{-1} followed by 184, 92 and 138 kg N ha^{-1} with marginal rate of return of 445,367 and 326%, respectively (Table 4). The value to cost ratio was ranged from 3.6 to 3.9 profits per unit of investment. Therefore, applications of 92 to 184 kg N ha^{-1} were economically feasible and recommended for bread wheat production in Lemu bilbilo district of Arsi zone.

Table 4: Partial budget analysis of bread wheat as influenced by N fertilizer rates at study site.

Nitrogen rate (kg ha^{-1})	Average yield (kg ha^{-1})	Adjusted yield (kg ha^{-1})	Total gross benefit (ETB ha^{-1})	Total variable cost (ETB ha^{-1})	Net benefit (ETB)	Benefit to cost ratio	MRR (%)
0	5422	4880	61000	13335	47665	3.6	
46	6344	5710	71375	14685	56690	3.9	769
92	6736	6062	75775	15885	59890	3.8	367
138	7083	6375	79687.5	17085	62603	3.7	326
184	7558	6802	85025	18285	66740	3.6	445

ETB=Ethiopian Birr; Cost of grain = 15 Birr kg^{-1}; Urea = 1350 Birr 100 kg$^{-1;}$ TSP = 1250 Birr 100 kg^{-1}; Field Sales price = 12.5 Birr kg^{-1}; MRR= Marginal Rate of Return

Summary and Conclusions

The results of the experiment revealed that days to maturity, days to grain filling, plant height, number of effective tillers, number of seeds per spike, thousand seed weight, and straw yield were significantly affected by main effects of variety and N fertilizer rate, whereas days to heading and grain yield were influenced by the main effects of variety, N rate as well as their interactions. Straw yield and harvest index were highly and significantly affected by N fertilizer rate only. Corresponding to all studied parameters, variety Lemu had better performance than variety Wane at study site. Grain yield of both varieties were nearly consistently increased with increasing N rate and the highest grain yields were recorded at of 184 kg N ha^{-1}. Partial budget analysis indicated that N rate of 92 to 184 kg N ha^{-1} were greater than the minimum rate of return and economically beneficial. Generally, based on considered agronomic parameters of bread wheat and grain yield, net benefit, MRR, N rates of 92 to 184 kg N ha^{-1} could be recommended for Lemu bread wheat variety production in the study area and similar agro ecologies considering farmers income. However, since this study was lead only at one location for single cropping season it is advisable to conduct further research across locations, soil type, and over seasons to make reliable and acceptable recommendations.

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References

1. Zemichael B, Dechassa N, Abay F (2017) Yield and Nutrient Use Efficiency of Bread Wheat (*Triticum Aestivum L.*) as Influenced by Time and Rate of Nitrogen Application in Enderta, Tigray, Northern Ethiopia. Open Agriculture 2(1):611-624.
2. Brasesco F, Asgedom D, Sommacal V, Casari G (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. Addis Ababa FAO. pp 108.
3. Anaye AA, Erkalo KT (2020) Comparative Analysis of Technical Efficiency of Wheat Production in Row Planting and Broadcasting Methods: Empirical Evidence from Southern Ethiopia. African Journal of Science, Technology, Innovation and Development.
4. Dabi A, Mekbib F, Desalegn T (2019) Genetic variability studies on bread wheat (*Triticum aestivum L.*) genotypes. Journal of Plant Breeding and Crop Science 11(2): 41-54.
5. Gebreselassie S, Haile M, Kalkuhl M (2017) The wheat sector in Ethiopia: Current status and key challenges for future value chain development.
6. Deressa TT, Hassan RM (2009) Economic impact of climate change on crop production in Ethiopia: Evidence from cross-section measures. Journal of African economies 18(4): 529-554.
7. Shah A S, Shah S M, Mohammad W, Shafi M, Nawaz H, et al. (2010) Effect of integrated use of organic and inorganic nitrogen sources on wheat yield. Sarhad J Agric 26(4): 559-563.
8. Agegnehu G, Vanbeek C, Bird MI (2014) Influence of integrated soil fertility management in wheat and tef productivity and soil chemical properties in the highland tropical environment. Journal of soil science and plant nutrition 14(3): 532-545.
9. Alamerew S, Chebotar S, Huang X, Roder M, Borner A (2004) Genetic diversity in Ethiopian hexaploid and tetraploid wheat germplasm assessed by microsatellite markers. Genetic Resources and Crop Evolution 51(5): 559-567.
10. Bishaw Z, Alemu D (2017) Farmers perceptions on improved bread wheat varieties and formal grain supply in Ethiopia. International Journal of Plant Production 11(1):117-130.
11. Abu T (2013) Ethiopia: Grain and feed annual. GAIN Report Number: ET–1301. Agronomy Journals 54: 464-465.
12. Teklu E, Hailemariam T (2009) Agronomic and Economic Efficiency of Manure and Urea Fertilizers Use on Vertisols in Ethiopian Highlands. Agricultural Science in China 8(3): 352-360.
13. Demeke M, Marcantonio DiF (2013) Analysis of incentives and disincentives for wheat in Ethiopia. Technical notes series, MAFAP, FAO, Rome.
14. Hailu GM (1991) Wheat Productions and Research in Ethiopia. Addis Ababa, Ethiopia: Institute of Agricultural Research.
15. Abate GT, de Brauw A, Minot N, Tanguy B (2015) The impact of the use of new technologies on farmers' wheat yield in Ethiopia: Evidence from a randomized controlled trial 49(4): 409-412.
16. Habte Z, Legesse B, Haji J, Jeleta M (2016) Supply analysis in wheat industry: contributions of value chain analysis in Ethiopia: Cases from Arsi and East Shewa Zones in Oromia National and Regional State. In Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists 23-26.
17. Dercon S, Hill RV (2009) Growth from agriculture in Ethiopia. Identifying key Constraints. Paper prepared as part of a study on agriculture and growth in Ethiopia. DFID, UK.
18. Hawkesford MJ (2014) Reducing the reliance on nitrogen fertilizer for wheat production. Journal of cereal science 59(3): 276-283.
19. Hirel B, Le Gouis J, Ney B, Gallais A (2007) The challenge of improving nitrogen use efficiency in crop plants: toward a more central role for genetic variability and quantitative genetics within integrated approaches. Journal of Experimental Botany 58(9): 2369-2387.
20. Bouyoucos GJ (1962) Hydrometer method improvement for making particle size analysis of soils. Agronomy Journal 54: 179-186.
21. Page AL, Miller RH, Keeney DR (1982) Methods of Soil Analysis. American Society of Agronomy.
22. Walkley A, Black IA (1934) An examination of the Degtjareff method for determining soil organic matter and proposed chromic acid titration method. Soil Science 37(1): 29- 38.
23. Olsen SR (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture.
24. Bremner JM (1996) Nitrogen - Total, Methods of soil analysis: Part 3-Chemical Methods 1085-121.
25. George E, Rolf S, John R (2013) Methods of soil, plant, and water analysis: A manual for the West Asia and North Africa region (3rd Edn.). ICARDA (International Center for Agricultural Research in the Dry Areas).
26. Huang NE (2014) Hilbert-Huang transform and its applications. World Scientific.
27. Gomez KA, Gomez AA (1984) Statistical analysis for agricultural research. John Willy and Sons.
28. (2010) Natural Resource Conservation Service, Agricultural Department, editors. Keys to soil taxonomy. Government printing office.
29. CLDB (Canada land development branch) (2001) Crop fertilization guide. New Nouveau Brunswick, Canada.
30. Landon JR (1991) Booker Tropical Soil Manual, Longman Scientifc and Technical Essex, UK.
31. Hazelton P, Murphy B (2007) Interpreting soil test results: What do all the numbers mean? 2nd Edition. CSIRO Publishing 20.
32. Getachew Fisseha (2004) Soil characterization and bread wheat (*Triticum aestivum L.)* response to N and P fertilizatoin. MSc Thesis, Alemaya University, Alemaya, Ethiopia.
33. Abebe B, Manchore M (2016) Effect of the rate of N fertilizer application on growth and yield of wheat (*triticum aestivum l.)* at chencha, southern ethiopia. International Journal of Plant, Animal and Environmental Sciences 6(3): 168-175.
34. Bergene T, Balcha A (2016) Effect of Nitrogen Rates and Varieties on Grain Yield and Nitrogen Use Efficiency of Bread Wheat (*Triticum*

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DOI: 10.32474/CIACR.2021.09.000320

aestivum L.). Greener Journal of Plant Breeding and Crop Science 4(4): 81-86.

35. 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.
36. Sofonyas Dargie (2016) Response of bread wheat (*Triticum Aestivum L.)* to application of slow releasing nitrogen fertilizer in Tigray, Northern Ethiopia, a thesis (M.Sc.), The School of Graduate Studies, Alemaya University, and Ethiopia.
37. 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, Ethiopia. American Journal of Life Sciences 2(5): 260-266.
38. Shiferaw B, Kassie M, Jaleta M, Yirga C (2014) Adoption of improved wheat varieties and impacts on household food security in Ethiopia 44: 272-284.
39. Hussain I, Khan MA, Khan EA (2006) Bread wheat varieties as influenced by different nitrogen levels. Journal of Zhejiang University Science B 7(1): 70-78.
40. Shahzad MA, Wasi-ud-Din ST, Sahi MM, Khan Ehsanullah, Ahmad M (2007) Effect of sowing dates and grain treatment on grain yield and quality of wheat *(Triticum aestivum L.)*. Pak J Agri Sci 34(4): 581-583.
41. Otteson BN, M Mergoum, JK Ransom (2008) Graining rate and nitrogen management on milling and baking quality of hard red spring wheat genotypes. Crop Science 48: 749-755.
42. Noureldin NA, HS Saudy, F Ashmawy, HM Saed (2013) Grain yield response index of bread wheat cultivars as influenced by nitrogen levels. Annals of Agricultural Science 58(2): 147-152.
43. Abdullatif M, Asmat UM, Sattar A (2010) Response of growth and yield of wheat to NPK fertilizer. Science international (lahore) 24(2): 185-189.
44. 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.
45. Abdollahi Gharekand J, Hashemi Majd K (2012) Effects of fall nitrogen rates on rainfed bread wheat yield and yield components in drought condition. International Research Journal of Applied and Basic Science 3(11): 2195-2204.
46. Asif M, A Ali, ME Safdar, M Maqsood, S Hussain, M Arif (2009) Growth and yield of wheat as influenced by different levels of irrigation and nitrogen. International Journal of Agriculture and Applied Sciences 1: 25-28.
47. Iqbal J, K Hayat, S Hussain (2012) Effect of sowing dates and nitrogen levels on yield and yield components of wheat (*Triticum aestivum L.)* Pakistan Journal of Nutrition 11(7): 531-536.
48. Ali SHS, Ahmad NS, Ahmad MM, Ahmad DA (2018) Performance of Bread Wheat (*Triticum aestivum L.*) Varieties under Rainfed Condition of Sulaimani.
49. Tayebeh A, Abbas A, Seyed AK (2011) Wheat yield and grain protein response to nitrogen amount and timing. AJCS 5(3): 330-336.
50. Chen W, Zhang J, Deng X (2019) The spike weight contribution of the photosynthetic area above the upper internode in a winter wheat under different nitrogen and mulching regimes. The Crop Journal 7(1): 89-100.
51. Semenov MA, PD Jamieson, P Martre (2007) Deconvoluting nitrogen use efficiency in wheat: A simulation study. Eur J Agron 26(3): 283-294.
52. Sieling K, Christen O (2015) Crop rotation effects on yield of oilgrain rape, wheat and barley and residual effects on the subsequent wheat. Archives of Agronomy and Soil Science 61(11): 1531-1549.
53. Gaile Z, Litke L, Ruža A (2018) Effect of nitrogen fertilization on winter wheat yield and yield quality. Agronomy Research 16(2): 500-509.
54. Taye Bekele, Yesuf Assen, Sahlemedhin Sertsu, Amanuel Gorfu, Mohammed Hassena, et al. (2002) Optimizing fertilizer use in Ethiopia: Correlation of soil analysis with fertilizer response in Hetosa Wereda, Arsi Zone. Addis Ababa: Sasakawa-Global.
55. Marcelo Curitiba Espindula, Valterley Soares Rocha, Moacil Alves de Souza, Marcela Campanharo, Guilherme de Sousa Paula (2013) Rates of urea with or without urease inhibitor for topdressing wheat. Chilean journal of agricultural research 73(2).

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