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Research Article

Optimizing Wheat Yield: A Comprehensive Study on the Impact of Inorganic Fertilizer Rates and Varietal Selection in Kofele, Ethiopia

Debela Bekele*, Fasil Shimalis, Zenebe Mulatu, Almaz Admasu, Dereje Dobocha, Wogayehu Worku

Ethiopian Institute of Agricultural Research, Kulumsa Agricultural Research Center (EIAR/KARC), Asella, Ethiopia

Abstract

Wheat is one of the globally produced and marketed cereal crops which cover 15% of the total sowing areas of cereal crops in the world. The low productivity of wheat in Ethiopia is mainly attributed to lack of improved agronomic practices. Nitrogen and phosphorus are the major important elements for crop yield. But there is lack of information on optimum fertilizer rate for wheat production in this area (Kofele district of West Arsi zone). Therefore the objective of this research was to determine the optimum nitrogen and phosphorus fertilizer rate for wheat at Kofele district. This experiment was conducted for two consecutive years in 2016 and 2017 main cropping season. The treatment has two factors (three bread wheat varieties:- Digalu, Dendea and Didase and fertilizer rates: - 73kg/ha of nitrogen and 69kg /ha of P_2O_5, 109.5kg/ha of nitrogen and 103.5kg/ha of P_2O_5, 146kg/ha of nitrogen and 138kg/ha of P_2O_5 and 46kg/ha of nitrogen and 181kg/ha of NPS:-19:38:7). The analyzed data indicated that plant height and seeds per spike of bread wheat was highly significantly affected by main effect of variety. Highest plant height (128.33cm) and seeds per spike (42.1) were recorded from variety Dendea. Spike length was significantly affected by main effect of variety. The longest spike length (8.3) was recorded from variety Hidase. Wheat grain yield was significantly affected by interaction effect at ($p<0.05$). Variety Hidase produced the highest grain yield of 6904.4kg/ha at 146kg/ha of nitrogen and 138kg/ha of P_2O_5. Above ground dry weight of wheat was significantly affected by interaction effect. The highest above ground dry weight 18.9 ton/ha of wheat was produced from variety Digalu at 73kg/ha of nitrogen and 69kg/ha of P_2O_5. Therefore, to get the highest benefit farmers should grow variety Hidase by applying 146kg/ha of nitrogen and 138kg/ha of P_2O_5 at this area.

Keywords

Grain Yield, Variety, Bread Wheat, Fertilizer Rate, Plant Height

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important of the cereal crops in the world. Wheat is thought to have first been cultivated in Middle East spreading from Jordan, Palestine, and Lebanon to Syria, Turkey, Iraq, and Iran [2]. This crop is considered as staple food for most of the temperate and sub-tropical regions of the world. The most im-

*Corresponding author: debelabeke@gmail.com (Debela Bekele)

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portant use of wheat is for making bread, biscuits, cookies, chapatti, etc. Industrially, it is used in preparation of starch, gluten, malt, and distilled spirit. Wheat bran is rich in protein and used as valuable livestock feed. From straw corrugated board is prepared.

Wheat is one of the globally produced and marketed cereal crops which cover 15% of the total sowing areas of cereal crops in the world [13]. It is a significant industrial and food grain that is traded internationally and is ranked second in importance among all cereal crops worldwide, after rice [3, 7].

In the marketing year of 2022/2023, the global production volume of wheat amounted to over 781 million metric tons. This represented an increase over the prior marketing year [17]. China, India, and Russia are the three largest wheat producers in the world, accounting for about 41% of the world's total wheat production [8].

Ethiopia is one of the largest wheat producers in terms of total wheat area cultivated and total production [4]. Wheat and wheat products represent 14% of the total calorie intake. Annual wheat production of Ethiopia is estimated to be 5,780,131 t ha^{-1} in 2020/21 cropping season [5]. The national wheat productivity is 2.89 t ha^{-1} [19]. It is minimal in light of certain other nations.

The low productivity of wheat in Ethiopia is attributed to low soil fertility, lack of access to improved varieties, less improved agronomic practices and drought [10, 16].

In Ethiopia, wheat grain is used for preparation of food and local beverages like the traditional staple pancake ("injera"), bread ("dabo"), local beer ("tella"), and several others local food items (i.e., "dabokolo","ganfo", "kinche") and its straw is used for animal feed and roof thatching.

West Arsi zone is the main producer of wheat in Ethiopia [14]. Like other regions of Ethiopia yield of wheat is also low in West Arsi zone. This is mainly due to low management of soil fertility. Nitrogen and phosphorus are the major important elements for crop yield including wheat yield increment. For example phosphorus rates up to 50 kg P_2O_5 ha^{-1} and nitrogen rates up to 120 kg N ha^{-1} significantly increased wheat yield [20] But there is lack of information on optimum fertilizer rate for wheat production in this area (Kofele district of West Arsi zone). Therefore the aim of this research is to determine the optimum nitrogen and phosphorus fertilizer rate for wheat at Kofele district.

2. Material and Methods

2.1. Study Sites Description

This Experiment was conducted for two consecutive years in 2016 and 2017 main cropping season. This experiment was conducted in Oromia regional state Kofele district in Kulumsa Agricultural Research Center (KARC) sub-station compound. This site is located at $07^0 04'27''$N latitude and $38^0 46'45''$E longitude, 2660 meters above sea level. The distance from capital city of Ethioipia (Addis Ababa) is 274 kilometers. The average annual minimum and maximum temperatures are 7.9 and 16.6 ℃, respectively. The area has bimodal rain fall distribution and receives annual rain fall of 1211mm [18]. Soil type of the area is pellic vertisol [11].

2.2. Experimental Design and Treatments

The treatment has two factors (three bread wheat varieties: - Digalu, Dendea and Hidase and fertilizer rates: - 73kg/ha of nitrogen and 69kg /ha of P_2O_5, 109.5kg/ha of nitrogen and 103.5kg/ha of P_2O_5, 146kg/ha of nitrogen and 138kg/ha of P_2O_5 and 46kg/ha of nitrogen and 181kg/ha of NPS:-19:38:7). Variety was assigned to main plot while fertilizer rate was assigned to sub-plot. The experiment was conducted in randomized complete block design with split plot treatment arrangements and replicated three times.

Table 1. *Source of seeds.*

Varieties	Source	Year of release
Digalu	Kulumsa Agricultural Research Center	2005
Dendea	Kulumsa Agricultural Research Center	2010
Hidase	Kulumsa Agricultural Research Center	2012

2.3. Experimental Procedures

The field was ploughed by disc plough and harrowed using tractor before planting. Then it was leveled manually using hand tools. Recommended seed rate of wheat (125kgha^{-1}) was used for this experiment. The crop was planted in row in which the inter row spacing was 20cm and seeds was drilled by hand.

2.4. Growth Parameters and Yield Data Collection

The collected growth parameters were, Yield and yield attributing characteristic, plant height, spikes per 50 centimeter, spike length, seeds per spike, grain yield, above ground dry weight and harvest index (HI). Hectoliter weight (HLW) was recorded as quality parameter.

2.5. Statistical Analysis

The collected data was subjected to analysis of variance (ANOVA) using SAS software 10 [15]. Significant difference among treatment means were assessed using the least significant difference (LSD) at 5% level of probability [9].

3. Results and Discussion

Agronomic Parameters and Yield

The analyzed data indicated that plant height of bread wheat was highly significantly affected by main effect of variety ($p<0.01$). The highest plant height (128.33cm) was recorded from variety Dendea whereas; variety Hidase produced the shortest plant height of 119.25 cm. This result is similar to the finding of [12] who reported that plant height was significantly affected by variety. This is the result of genetic variation among different varieties. But plant height of bread wheat was not significantly affected by fertilizer rate and interaction effect. This indicates that plant height is affected mainly by wheat genetics than fertilizer rate. Similarly, seeds per spike of wheat was highly significantly affected by variety ($p<0.01$) and not significantly affected by fertilizer rate and interaction effect. The highest number of seeds per spike was recorded from variety Dendea, which is 42.1 seeds/spike of wheat. Variety Digalu produced the lowest number of seeds per spike which is 39.2 seeds/spike of wheat. This result is in agreement with [12] who reported that varieties showed significant difference with respect to the number of kernels per spike.

Number of spikes per 50 centimeter was significantly affected by main effect of variety ($p<0.05$). The highest number of spikes per 50 centimeter was recorded from variety Hidase, which is 72.7 but, number of spikes per 50 centimeter was not significantly affected by main effect fertilizer rate and interaction effect.

Similar to that of number of spikes per 50 centimeter, spike length was significantly affected by main effect of variety ($p<0.05$). The highest spike length was recorded from variety Hidase (8.3cm). But, spike length was not significantly affected by main effect fertilizer rate and interaction effect. This is in line with the finding of [1] who reported that spike length was significantly affected by bread wheat variety.

Table 2. *Effect of variety and fertilizer rate on plant height (PH), spikes per 50 centimeter (SP), spike length (SL) and seeds per spike (SS) of wheat at Kofele district.*

Variety	PH (cm)	SP	SL (cm)	SS
Digalu	121.9B	64.3B	6.4B	39.2C
Dendea	128.33A	69.8A	8.2A	42.1A
Hidase	119.25B	72.7A	8.3A	40.8B
LSD	**	*	*	**
Fertilizer Rate		4.9801		
73kg nitrogen and 69kg P_2O_5	122.89	70.022	7.6	40.6
109.5kg of nitrogen and 103.5kg of P_2O_5	122.78	67.467	7.7	40.2
146kg of nitrogen and 138kg of P_2O_5	124.44	67.467	7.6	40.8
46kg of nitrogen and 181kg of NPS	122.56	70.800	7.6	41.2
LSD	ns	ns	ns	ns
CV	4.82	7.80	10.37	4.33

Within each column, means with different letters are significantly different at $p < 0.05$; *(significantly different), ** (highly significantly different).

Wheat grain yield was significantly affected by main effects of variety, fertilizer rate and interaction effect at ($p<0.01$), ($p<0.05$) and ($p<0.05$), respectively. Among varieties variety Hidase gave the highest grain yield which is

5119.4kg/ha. From the fertilizer rates 73kg/ha of nitrogen and 69kg/ha of P_2O_5 gave higher grain yield (6187.2kg/ha) of bread wheat. Variety Hidase produced the highest grain yield of 6904.4kg/ha at 146kg/ha of nitrogen and 138kg/ha of P_2O_5. This may be due to the highest number of spikes in Hidase variety gave per a unit area than other varieties. The lowest grain yield (3178.8kg/ha) was recorded from variety Digalu at 146kg/ha of nitrogen and 138kg/ha of P_2O_5. This could be due to lowest number of seeds in this variety. This study is agreed with the finding of [6]) who reported that grain yield of wheat was significantly affected interaction effect of variety and fertilizer rate. Above ground dry weight of wheat was significantly affected by main effect of fertilizer rate and interaction effect at ($p<0.05$) but, was not significantly affected by variety. The highest above ground dry weight 18869kg /ha of wheat was produced from variety Digalu at 73kg/ha of nitrogen and 69kg/ha of P_2O_5. Harvest index was significantly affected by variety but not significantly affected by fertilizer rate at ($p<0.01$). Variety Hidase and variety Digalu gave the highest (38.6) and lowest (30.5) harvest index, respectively.

Table 3. *Effect of variety and fertilizer rate on grain yield in kilogram (GY), above ground dry weight in kilogram BY), harvest index (HI) and hectoliter weight (HLW) of wheat at Kofele district*

Variety	GY	BY	HI	HLW	
Digalu	4476.1B	14658	30.5C	73.500	
Dendea	5877.2A	16498	35.5B	72.758	
Hidase	6399.3A	16666	38.6A	73.817	
LSD	**	Ns	**	ns	
Fertilizer Rate					
73kg nitrogen and 69kg P_2O_5	6187.2A	17991A	34.781	74.0A	A
109.5kg of nitrogen and 103.5kg of P_2O_5	5358.9B	14657B	36.443	73.4A	
146kg of nitrogen and 138kg of P_2O_5	5013.7B	14798B	36.443	72.0B	
46kg of nitrogen and 181kg of NPS	5777.1AB	16318AB	35.323	73.8A	
LSD	*	*	ns	*	
CV	13.96	14.61	7.34	1.81	

Within each column, means with different letters are significantly different at $p < 0.05$; *(significantly different), ** (highly significantly different).

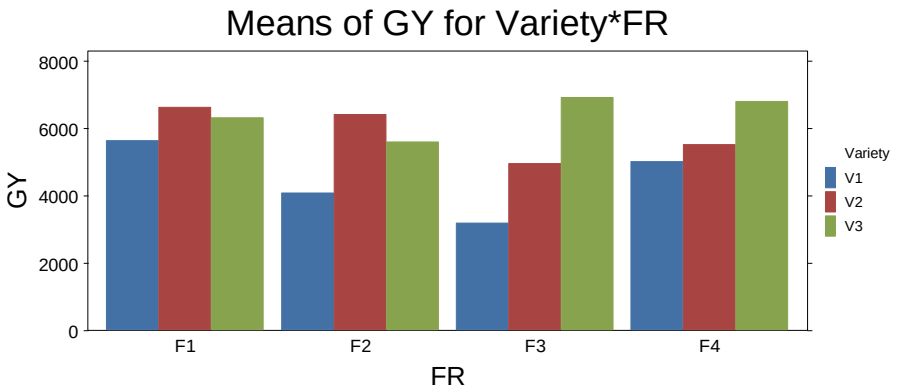

Figure 1. *Interaction effect of varieties and fertilizer rate on grain yield of bread wheat.*

Key: F1=73kg nitrogen and 69kg P_2O_5, F2=109.5kg of nitrogen and 103.5kg of P_2O_5, F3=146kg of nitrogen and 138kg of P_2O_5, F4=46kg of nitrogen and 181kg of NPS, V1= Digalu, V2= Dendea, V3= Hidase

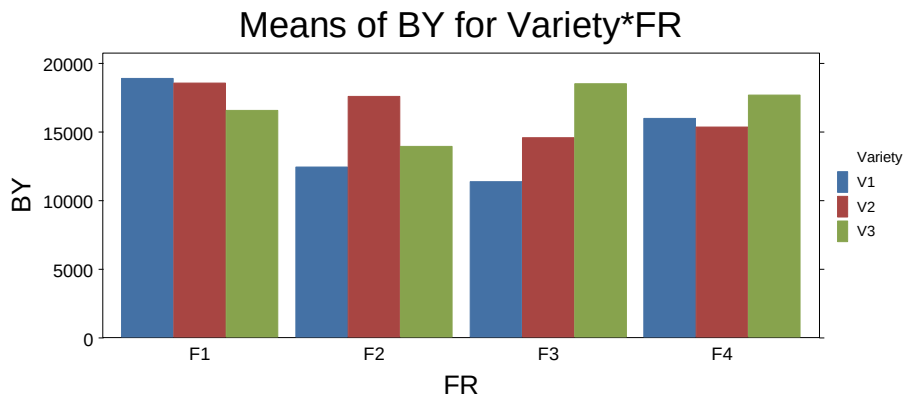

Figure 2. *Interaction effect of varieties and fertilizer rate on above ground dry weight of bread wheat.*

Key: 73kg nitrogen and 69kg P_2O_5, F2=109.5kg of nitrogen and 103.5kg of P_2O_5, F3=146kg of nitrogen and 138kg of P_2O_5, F4=46kg of nitrogen and 181kg of NPS V1= Digalu, V2= Dendea, V3= Hidase

4. Conclusion

The objective of this research is to evaluate nitrogen and phosphorus fertilizer rate for wheat at Kofele district. This Experiment was conducted for two consecutive years in 2016 and 2017 main cropping season in Kofele district in Kulumsa Agricultural Research Center (KARC) sub-station compound. The analyzed data indicated that plant height and seeds per spike were highly significantly affected by main effect of variety while number of spikes per 50 centimeter and spike length were significantly affected by main effect of variety. The highest plant height (128.33cm) and seeds per spike (42.1) were recorded from variety Dendea. But, the highest number of spikes per 50 centimeter (72.7) and highest spike length (8.3) were recorded from variety Hidase. Wheat grain yield was highly significantly affected by main effect of variety and significantly affected by main effects fertilizer rate and interaction effect. Variety Hidase produced the maximum grain yield of 6904.4kg/ha at 146kg/ha of nitrogen and 138kg/ha of P_2O_5. Above ground dry weight of wheat was significantly affected by main effect of fertilizer rate and interaction effect while, harvest index was highly significantly affected by main effects variety only. Accordingly the highest above ground dry weight (18869kg/ha) was produced from variety Digalu at 73kg/ha of nitrogen and 69kg/ha of P_2O_5. Variety Hidase gave the highest (38.6) harvest index. According to this study, growing variety Hidase by applying 146kg/ha of nitrogen and 138kg/ha of P_2O_5 at this area is advantageous than other at this district and similar agro ecological areas.

Conflicts of Interest

The authors declare no conflicts of interest.

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