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Response of Bread Wheat (*Triticum Aestivum* L.) to Seeding Rate and Fertilizer Types on Yield and Yield Components

Birhanu Gebeyehu[1,*]

[1]Mekdela Amba University, Collage of Agriculture and Natural Resource, Department of Plant Sciences, South Wollo, Ethiopia.

Corresponding author:

Birhanu Gebeyehu, Mekdela Amba University, Collage of Agriculture and Natural Resource, Department of Plant Sciences, South Wollo, Ethiopia.

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Abubaker Haroun Mohamed Adam, Department of Crop Science (Agronomy), College of Agriculture, Bahri University- Alkadaru- Khartoum -Sudan.

Abstract

Bread wheat is an economically important crop in Ethiopia. However, its annual productivity is very low due to poor management practices like: inappropriate seeding rate and utilization of different fertilizer types. Therefore, this field experiment was conducted at Tengeha Kebele, Awi Zone to study the response of bread wheat to seeding rate and fertilizer types on growth and yield so as to find economically profitable seeding rate and fertilizer types during the 2017 main cropping season. The field experiment consisted of combinations of six levels of seeding rates (75, 100, 125, 150, 175, and 200) kgha-1 and two fertilizer types blended (NPSB) fertilizer and (DAP) Di-Ammonia Phosphate which was laid out in RCBD with three replications. Bread wheat variety "Kekeba" was used as a planting material. Data of all growth and yield related parameters had been collected and analyzed with SAS version 9.0 software. The ANOVA results showed that most parameters were significantly ($p<0.05$) affected by the main effect of seeding rates and fertilizer types. The maximum grain yield (4166.7 kgha^{-1}) which was also economically feasible was recorded at the seeding rate of 200 kgha-1 combined with NPSB fertilizer types. Based on the agronomic performance and yield result of this study, 200 kgha^{-1} seeding rate and blended fertilizer type were preferable for the study area. However, further study has to be done under different seasons and locations to come up with workable recommendations related to the present study.

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Introduction

Background and Justification

Wheat (*Triticum aestivum* L.) is one of the important grain crops produced worldwide and its production is about 620 million metric tons of wheat was produced from 217 million hectares in the year 2005/06 with an average yield of 2.85 metric tons per hectare. Wheat is grown on larger area than any other crop and its world trade is greater than for all other crops combined. Its world trade is greater than for all other crops combined and it is easily stored and transported [10].

Bread wheat is one of the most important cereals cultivated in Ethiopia. Ethiopia is the second largest wheat producer in Sub-Saharan Africa next to South Africa with the cultivated land of 1.7 million ha which accounts 13.5 percent of the national grain area. Bread wheat in Ethiopia is grown at an altitude range from 1500 to 3000 meter above sea level (m.a.s.l) and latitude and longitude ranges from 6 to 16 0N and from 35 to 42 0E, respectively. The most suitable agro-ecological zones, however, fall between 1900 and 2700 m.a.s.l. The major wheat producing areas in Ethiopia are found in *Arsi, Bale, Shewa, Ilubabor, Western Hareghe, Sidamo, Tigray, Northern Gonder* and *Gojjam*. Total wheat producer farmers in Ethiopia during 2017 cropping season were about 5 million who produced 4.54 million tons of wheat on 1.7 million hectares of land with average productivity of 2.7 ton ha^{-1}, which was accounting for 13.5 percent of the total grain production in the country [2].

Due to a number of constraints such as improper row spacing, soil fertility degradation, soil erosion, occurrence of different pests, in appropriate use of seeding rate and fertilizer types. Seeding rate has a significant influence on the majority of agronomic traits of bread wheat. Bread wheat sowing at the optimum seeding rate with appropriate fertilizer types would significantly enhance the number of grains per spike, the spike length, grain weight per spike and thousand grains weight and then finally produce high grain yield. But, seeding rate above or below the optimum may reduce the yield significantly [11,12]. However, in our country there is limitation of location specific study results, clearly showing the optimum seeding rates and fertilizer types used for bread wheat production in the study area.

Statement of the Problem

Bread wheat is one of the most important crops in Ethiopia. However, the average annual productivity of bread wheat is very low (2.7 ton ha-1) as compared to that of world's average. The low productivity is associated with poor agronomic practices mainly inappropriate seeding rate and improper fertilizer types together with other factors including soil fertility degradation, soil erosion, inappropriate weeding practices and occurrence of different pests. Similar with the national picture, the productivity of bread wheat in *Guangua* district is very low mainly due to inappropriate seeding rate and unbalanced nutrient application.

Indeed, there are different recommendations of seeding rates and fertilizer types recommended by different organizations for bread wheat in the study area. For instances, *Kulumsa* and *Adet* Agricultural Research Centers as well as Bureau of Agriculture recommended 150 $kgha^{-1}$ seeding rate, while Agricultural Transformation Agency (ATA) recommended 90-100 $kgha^{-1}$. Furthermore, farmers in the study area used up to 200 $kgha^{-1}$ regardless of types of fertilizers. These different recommendations create ambiguity between farmers and developmental workers eventually affect the production and productivity of bread wheat. Hence, objective of the present study was to enhance the productivity of bread wheat through optimizing seeding rate and fertilizer types in the study area [4].

Materials And Methods

Description of the Study Area

The study was conducted in 2017 main cropping season on farmer's field at Tengeha Kebele in Guangua district, Awi Zone, Amhara National Regional State.

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Guangua district is located at 200 km far from Bahir Dar, the capital city of the Amhara Region to South western direction and 505 km from Addis Ababa to North western direction. The experimental site is located 45km away from North East of the district town *Chagni* at latitude and longitude of 100 49' 14" N and 360 38' 40" E, respectively. The altitude of the site is 2050 m.a.s.l.

Soils of Guangua district is one of the most ccccdegraded soils in the region, and its soil is very low in soil organic matter content, macro and micro nutrients such as N, P, K, S, B and Zn. Crops grown in the district are maize, finger millet, *teff*, wheat, barley, sorghum, legumes, and oilseeds in the order of importance. The farming system of the area is mixed crop-livestock. Crops grown in the study area are teff, wheat, barely, maize, finger millet, legumes, and oilseeds in the order of importance.

Experimental Materials Used for the Study

Experimental Planting Material

Bread wheat of *Kakaba* variety was used for the study. The variety was released in the year 2010 by *Kulumsa* Agricultural Research Centre. The ecological requirement for optimum production of *Kekeba* ranges from 1600 to 2000 m.a.s.l of altitude and from 1300 to 1800 mm annual rainfall. The optimum seeding rate for this variety is reported to be 150 kgha^{-1} and its days to heading and days to maturity are reported to be 50-70 and 90-120, respectively. The variety is also moderately resistant to stem rust.

Fertilizer Materials

Fertilizer types blended fertilizer or NPSB (N 18.9%, P 37.7%, S 6.95% , B 0.1%) and DAP or Di-ammonium phosphate (N 18%, P 46%) were used as treatments at their blanket recommendation rates of 100 kgha^{-1} each, while Urea at the rate of 200 kgha^{-1} was applied to all treatments correcting the N requirements of the crop.

Cultivation Technique

Prior to dividing the field into experimental plots, the experimental field was plowed three times with oxen driven local plowing implement *Maresha*. The prepared land was further divided into plots as per the treatments and design of the study and leveled manually. The treatments were assigned randomly on the plots of each replication and as per the treatments the seeds were drilled in manually opened furrows and thinly covered with soil. Weeds were controlled manually, while all other remaining agronomic practices were applied as per their recommendations for bread wheat.

Experimental Treatments, Design and Procedures

Factorial combinations of six seeding rates of bread wheat (75,100 125,150, 175 and 200 kgha^{-1}) and two fertilizer types (blended NPSB and DAP), totally 12 treatment combinations, were laid out in a randomized complete block design (RCBD) with three replication. As per the treatments, all NPSB and DAP were applied during sowing of bread wheat. But, urea was applied in split form. The gross plot size was 1.6m x 2.5m (4m^2), consisting 8 rows with 20cm inter-row spacing. With the exclusion of two outer rows on both sides of each plot and 0.5m at both ends of the rows so as to avoid possible border effects, the net plot size was 0.8m x 1.5m (1.2m^2).

Data Collection

Grain and Yield Related Parameters Like

Total number of tillers (number m^{-2}), Spike length (cm), Number of kernels per spike (number spike^{-1}), Total biomass yield (kg ha^{-1}), Thousands kernel weight (g), Straw yield (SY), Grain yield (GY) (kg ha^{-1}) were collected to analysis.

Data Analysis

The data collected from the experiment at different growth stages were subjected to statistical analysis (ANOVA) as per the experimental design using SAS (Statistical Analysis Software) version 9.0. Whenever the ANOVA results showed significant differences between treatments, mean separation was carried out using the least significant difference (LSD) test.

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Correlation analysis was carried out by Pearson correlation coefficient.

Results and Discussion

Total Numbers of Tillers (Number m^{-2})

The analysis of variance indicated that total numbers of tillers per m^{-2} were very highly significantly ($p<0.001$) influenced by the main effects of both seeding rate and fertilizer types. The highest total numbers of tillers (417.66 per m^{-2}) were observed at a seeding rate of 200 $kgha^{-1}$ while the lowest total numbers of tillers (325.50 per m^{-2}) were recorded at a seeding rate of 75 $kgha^{-1}$. It might be due to increasing sowing density that attributed to increasing number of plants per m^{-2}. This finding is in consonance with those of [5] who reported that increasing seed rate increased the total tillers significantly.

Spike Length (cm)

The analysis of variance showed that spike length was very highly significantly ($P<0.001$) influenced by the main effect of seeding rate. Whereas spike length was highly significantly ($P<0.01$) influenced by the interaction effects. The result was in agreement with (5) who reported reduced spike length, fewer spikelet per spike and kernels per spikelet of triticale with increased seeding rate or plant density. The maximum spike length of (8.95 cm) was recorded at those plots which received seeding rate of 75 $kgha^{-1}$ and NPSB combination, whereas minimum spike length of (7.05cm) was obtained from plots those received the seeding rate of 125 $kgha^{-1}$ in combination with NPSB.

Number of Kernels Per Spike

Analysis of variance showed that the number of kernels per spike was very highly significantly ($P<0.001$) influenced by the main effect of seeding rate. Whereas the interaction effects of seeding rate and fertilizer types were significantly ($p<0.05$) affect number of kernels per spike. As seeding rate increased from 75 $kgha^{-1}$ to 200 $kgha^{-1}$, the number of kernels per spike was decreased from 57 to 49. It might be due to more light penetration and low competition under lowest seeding rate, as a result, high grains would be produced and less competition leads to produce more seeds per spike and the longest spike length that was produced from the lesser seeding rate was responsible for more seeds per spike. The result obtained from this study was in agreed with [5] who reported that the higher grain number per spike obtained in the lowest seeding rate. In addition to this, a maximum number of kernels per spike (60.73) were obtained from the interaction of seeding rate of 75 $kgha^{-1}$ and NPSB fertilizer type and minimum numbers of kernels per $spike^{-1}$ (46.10) were obtained from the combination of seeding rate of 150 $kgha^{-1}$ and NPSB fertilizer type. Table 1

Total Biomass Yield (kg ha^{-1})

Analysis of variance showed that the main effect of seeding rate was very highly significantly ($P<0.001$) affect above ground biomass yield. Whereas the main effect of fertilizer types and interaction effects were highly significantly ($p<0.01$) influence above ground biomass yield. The highest total biomass yield (10919.5 $kgha^{-1}$) was observed at the seeding rate of 200 kg ha^{-1} while lowest total biomass yield (8599.8 $kgha^{-1}$) was obtained from the seeding rate of 100 $kgha^{-1}$. Similar results were obtained by [3] who found that biological yield was increased by increasing seeding rate in wheat and also found that biological yield was increased as seeding rate increased from 125 $kgha^{-1}$ to 150 and 175 $kgha^{-1}$.

Grain Yield (kg ha^{-1})

The present research result showed that the main effects of seeding rate and fertilizer types didn't significantly affect grain yield of bread wheat. However the interaction effect of the two factors affect grain yield of bread wheat highly significantly ($p<0.01$). The interaction effects of seeding rate of 200 $kgha^{-1}$ and blended fertilizer (NPSB) showed maximum grain yield (4166.7 $kgha^{-1}$), while lower grain yield of (2815.7

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Table 1. Main effect of seeding rate and fertilizer types on grain and yield related parameters.

Treatment Seeding rate(kg ha^{-1})	NKPS	TBY(kgha^{1})	SY(kg ha^{-1})
75	57.23^{a}	9063.58^{bc}	5617.77^{c}
100	51.48^{b}	8599.84^{c}	5322.73^{c}
125	50.73^{b}	9479.81^{b}	5700.89^{bc}
150	46.53^{c}	9817.19^{b}	6431.26^{ab}
175	47.36^{c}	8600.08^{c}	5410.84^{c}
200	49.16^{bc}	10919.51^{a}	7163.03^{a}
Sign. Diff.	***	***	**
SE$\pm$	1.17	258.11	259.81
Fertilizer type			
NPSB	51.28	9878.83^{a}	6307.33^{a}
DAP	49.55	8947.77^{b}	5574.81^{b}
Sign. diff.	ns	**	**
CV (%)	5.31	6.73	10.73
SE$\pm$	0.63	148.61	149.86

** & *** indicates significant at 1% and 0.1% probability level, respectively. ns= non-significant, Sign. dif= Significant difference, SE= standard error, CV (%) = coefficient of variation in percent, NKPS = number of kernels per spike, TBY= total biomass yield, SY= straw yield

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Table 2. Interaction effect of seeding rate and fertilizer types on grain and yield.

Fertilizer type	Seeding rate (kg ha^{-1})	NKPS	GY (kg ha^{-1})	TBY(kgha^{-1})	SY (kgha^{-1})
	75	60.73^{a}	4076^{ab}	10956^{bc}	6720^{cde}
	100	50.76^{bc}	3103de	8466de	5363^{def}
	125	50.26^{bcd}	3647^{abcd}	10072^{bc}	6425^{bcd}
	150	46.10^{d}	3252de	10717^{b}	7465^{ab}
NPSB	175	47.70^{cd}	3184de	8083de	4899^{f}
	200	52.16^{b}	4167^{a}	11839^{a}	7672^{a}
	75	53.73^{b}	2816^{e}	8031^{e}	5216^{ef}
	100	52.20^{b}	3451^{bcde}	8734de	5283^{ef}
	125	51.20^{bc}	3911^{abc}	8888de	4977^{ef}
DAP	150	46.96^{cd}	3520^{abcd}	8918de	5398^{def}
	175	47.03^{cd}	3194de	9117^{cd}	5922^{cdef}
	200	46.16^{d}	3346^{cde}	10000^{bc}	6654^{abc}
Sig. diff		*	**	**	**
CV (%)		5.32	11.62	6.79	10.77
SE±		1.55	232.08	364.91	367.47

*& ** indicates significant at 5% and 1% probability level, respectively. Sig. dif.= significant difference, SE= standard error, CV (%) = coefficient of variation in percent, NKPS = number of kernels per spike, GY=grain yield, TBY= total biomass yield, SY= straw yield

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kgha-1) was recorded when seeding rate of 75 kgha-1 was combined with DAP fertilizer. Furthermore, the increment of grain yield obtained from interaction might be due to the combined effects of nutrients like NPSB in blended fertilizer to enhance the better growth and development of the crop and/or combination of four nutrients together might be made a positive association with crops. As it was explained by [6] the increase in grain yield may be the combined effects of a greater number of tillers per unit area, and number of grains per m^{-2} as the case in this research finding is similar.

Straw Yield (kg ha-1)

Among seeding rates, the use of 200 kgha-1 seed was produced the highest straw yield (7163 kgha-1), while the seeding rate 100 kgha-1 recorded the lowest straw yield (5322 kgha-1). This might be due to the fact that higher seeding rates more plant population which resulted in higher straw yield. This result is in agreed[11] who indicated that as seeding rate increased, correspondingly straw yield increased due to higher stand number at crop establishment period. Table 2

Correlation Analysis

The correlation study among bread wheat agronomic parameters was quantified and a strong correlation was observed between some of bread wheat yield components analyzed. Plant height was positive and strongly very highly significant correlated with spike length (*r=0.63*) and Number of kernels per spike (*r=0.72*) [7]. In other case, numbers of productive tillers were positively strongly and very highly significantly correlated with total numbers of tillers, spike length and numbers of kernels per spike (*r = 0.99, 0.81* and *0.75*) respectively. These results were in agreement with that of [8]. Grain Yield shown positive and non-significant correlation with number of productive tillers (*r=0.19*), total number of tillers (*r=0.16*) and straw yield (*r=0.12*) and positively and moderately significant correlated with plant height(*r=0.36*), spike length(*r=0.33*), number of kernels per spike(*r=0.38*) and positively and strongly significantly correlated with total biomass yield (*r=0.56*) [1]. Table 3

Partial Budget Analysis

Economic analysis was performed to investigate the economic feasibility of the seeding rates and fertilizer types for wheat production. Due to this fact increasing both grain and straw yields can increase farmers' income. Analysis of the net benefits, total costs that vary and the marginal rate of return. It is indicated that a maximum (51683.00 ETB ha-1) net benefit was obtained from the combination of 200 kgha-1 seeds and blended (NPSB) fertilizer. The highest 573.02 (MRR) was obtained from the use of 200 kgha-1 seeding rate and blended (NPSB) fertilizer type. Therefore, the most attractive rates for small-scale farmers of the study area with low cost of production and higher benefits, in this case, were 200 kgha-1 seeding rate with NPSB fertilizer type combination. Table 4

Conclusion

Wheat is the major staple grain which accounts for overs several years of the food of the people in Ethiopia and cultivated by small holders in every region of the country. Based on CSA and FAOSTAT official data of recent, the production and productivity of wheat shows nearly increasing pattern, but constrained by low depilation of soil fertility as well as farmers long time experienced blanket recommendations of fertilizer application which are the major causes of yield losses. Based on the result of this study, application of different seeding rates and fertilizer types had significant effects on yield and yield components of bread wheat. The results of the study showed that high-yield was obtained when wheat was sown from the seeding rate of 200 kgha-1 in combination with NPSB fertilizer type. As the seeding rate increased from 75 to 200 kgha-1 number of productive tillers, total numbers of tillers, total biomass yield and straw yield were increased. From the present study, it is possible to conclude that interaction effects of seeding rate 200 kgha-1 and blended fertilizer type

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Table 3. Pearson correlation analysis among all parameters and yield related components of bread wheat

	TNT	SL	NKPS	TBY	SL	GY
TNT	1					
SL	0.83***	1				
NKPS	0.78***	0.85***	1			
TBY	0.46**	0.03ns	0.13ns	1		
TKW	0.16ns	0.14ns	0.16ns	-0.31ns		
SL	0.51**	-0.13ns	-0.03ns	0.91***	1	
GY	0.16ns	0.33*	0.38*	0.56**	0.12ns	1

**=very highly significant at 0.1% level of significance; ** highly significant at 15 level of significance; * significant at 0.5 % level of significance; ns= non-significant; TNT=total numbers of tillers, SL=spike length; TBY= total biomass yield; GY=grain yield.

Table 4. Summary of partial budget analysis in bread wheat in 2017 cropping season

Interactions	TVC	UGY	AGY	USY	ASY	GB	NB	MRR (%)
$S_1 F_1$	2227	41	37	60	54	40946	38719	
$S_2 F_2$	2680	35	32	53	48	44955	42275	785
$S_3 F_1$	2965	36	32	64	58	47520	44555	800
S_3F_2	3049	39	35	50	45	48870	45821	150.1
S_6F_1	4072	42	38	77	69	55755	51683	573.02

S_1=Seeding Rate (75 $kgha^{-1}$);$s_{2=}$ Seeding Rate (100 $kgha^{-1}$); s_3=Seeding Rate (125 $kgha^{-1}$); S_6=Seeding Rate (200 $kgha^{-1}$); F_1= blended fertilizer type (NPSB), F_2= DAP fertilizer type, S=Seeding Rate (kg ha^{-1}); F= Fertilizer Types; TVC=Total variable cost; UGY=unadjusted Grain Yield ; AGY=Adjusted grain yield; USY=Unadjusted Straw Yield ; ASY=Adjusted straw yield; GB=gross benefit ; NB=Net benefit and MRR=Marginal rate of return (%). Price of Bread wheat and straw was 30 $ and 37.5 $ respectively. Seed cost of bread wheat was 27.67, 36.9, 46.12, 55.36, 64.57 and 73.8 $ for 75 kg, 100 kg, 125 kg, 150 kg, 175 kg and 200 kg respectively and Fertilizer cost was 28 and 30.1 $ for NPSB and DAP respectively

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performed better and gave higher grain yield (4166.7 kgha^{-1}) and had highest grain yield advantage over the remaining seeding rates.

The maximum net benefit was obtained from the combination of 200 kgha^{-1} seeding rate and blended fertilizer type (NPSB). Similarly, the highest Dollar was obtained from combinations 200 kgha^{-1} seeding rate and blended fertilizer type (NPSB). Therefore, 200 kgha^{-1} seeding rate and blended fertilizer type (NPSB) is the most attractive for small-scale farmers of the study area with low cost of production and higher benefits.

Recommendation

Therefore, 200 kgha^{-1} seeding rate and blended fertilizer type (NPSB) is the most attractive for small-scale farmers of the study area with low cost of production and higher benefits. Therefore, maximum grain yield (4166.7 kgha^{-1}) which was recorded at the seeding rate of 200 kgha^{-1} combined with NPSB fertilizer types would be best, economical and tentatively recommended for the production of bread wheat in the study area. This study is in agreement with[13], who reported that increasing seeding rates with optimum fertilizer application resulted in increased grain yield.

The highest total biomass yield (10919.5 kgha^{-1}) was observed at the seeding rate of 200 kg ha^{-1} while lowest total biomass yield (8599.8 kgha^{-1}) was obtained from the seeding rate of 100 kgha^{-1}. Similar results were obtained by who found that biological yield was increased by increasing seeding rate in wheat [9]. The maximum net benefit was obtained from the combination of 200 kgha^{-1} seeding rate and blended fertilizer type (NPSB). Similarly, the highest MRR was obtained from combinations 200 kgha^{-1} seeding rate and blended fertilizer type (NPSB). Therefore, 200 kgha^{-1} seeding rate and blended fertilizer type (NPSB) is the most attractive for small-scale farmers of the study area with low cost of production and higher benefits.

Application of a single fertilizer may decrease the yield of bread wheat, and then to solve such problems blended type of fertilizer application as well as increasing the rate of seed is more applicable to increase the yield and those growing populations. We should or need to focus on secondary nutrients that are considered useless by farmers as well as researchers because those secondary nutrients deficiency today shows different symptoms on crops and those secondary nutrients must be supplied as blended fertilizer like sulphur.

Fertilizer suppliers or cooperative unions should pay attention to supply or blended type of the fertilizer instead of supplying single elements, the fact that the government and recognized researchers should give due attention to blended fertilizer to increase production of bread wheat.

Conflict of Interest

There is no conflict of interest

Authors Contribution

DBH (Post Graduate Student): Conducted field experiments and recorded field observations. SS (Professor of Agronomy): Conceived the idea and supervised the experiment and written the concept and discussion. PG (Technical Officer): written the draft, data analysis and references.

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