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Effects of Blended Fertilizer Type and Rates of Application on Yield and Quality of Durum Wheat (*Triticum turgidum var. durum*) in Southeastern Ethiopia

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Abstract: There are several biotic and abiotic factors that hindered the yield and quality of durum wheat in Ethiopia. To solve the problem, the field experiment was conducted during the 2020/21 cropping season to determine the effect of blended fertilizer type and rate of fertilizer application on the yield and quality of durum wheat in South Eastern Ethiopia. The experiment was laid out in randomized complete block design (RCBD) with three replications in factorial arrangement of three different blended fertilizer type (NPS, NPSB and NPSZnB) and four different rates (50 kg/ha, 100 kg/ha, 150 kg/ha and 200 kg/ha) of fertilizer application and one control in each replication. The results indicated that straw yield, Gluten content and protein content were significantly (P>0.05) affected by the main effect of different blended fertilizer type and rates of fertilizer application significantly (P>0.05) whereas harvest index of the wheat are significantly affected only by the different rates of fertilizer application but the productive tiller number, number of seed per spike and spike length were non significantly (P>0.05) affected by the different blended fertilizer type and rates of fertilizer application. More over the interaction effect of different blended fertilizer type and rate of fertilizer application on wheat yield and quality was affects the plant height, biomass yield, thousand seed weight and Grain yield was significant difference (P>0.05) but all other parameters were not affected by the interaction of different fertilizer type and rates of fertilizer application. Therefore based on the result of yield and quality of the durum wheat sown with NPS had better protein quality than the other fertilizer applied. The interactive effect of NPSZnB with 200 kg ha^{-1} fertilizer rate was superior for achieving higher yield in the study area. However, further study has to be done under different locations based on the soil test with a wide range of different micronutrients and rates of fertilizer application to exploit the tentative recommendation of the present study.

Keywords: Biomass Yield, Yield, Gluten and Protein Content

1. Introduction

Wheat *(Triticumaestivum)* is one of the leading cereals in the world. It belongs to the family Poaceae and it is the world's most widely cultivated cereal crop. Ethiopia is the second largest wheat producer in sub-Saharan Africa. Both bread (*Triticumaestivum L.*) and durum (*Triticumturgidum var. durum*) wheat's are important food crops for pasta or macaroni products, due to high protein and gluten characteristics [2] and traditional ways of consuming it, including several unique dishes that represent with pride the national identities: *couscous, bourghul*, *freekeh, gofio* and *unleavened breads*, just to name a few [13] and they also contains 27% extractable wet gluten, about 3% higher than in common wheat [22]. Durum flour and semolina are good for making pasta because they do not create dough hard to shape. The uncooked dough splits easily and is easier to shape, as for instance to make pies or pastas [10].

In Ethiopia durum wheat production covered about 1,897 million hectares was cultivated and about 5.78 million tons of grain yield in 2020/21 cropping season [6]. There are several biotic and abiotic factors that hindered wheat production in these areas such as low soil fertility, lack of improved wheat varieties and lack of improved management practices.

Among those constraints, low soil fertility that's the most important constraint limiting wheat production in Ethiopia [18]. Thus, addition of nutrients such N, P, S and B to less fertile soil is important to increase wheat yield, yield components and grain quality of wheat whether it is for consumption or industrial purpose while insufficient supply of mineral elements may limit plant growth and development [14]. Application of different blended Fertilizer and rates is the most important input which contributes significantly towards final grain yield of wheat and to exploit the genetic potential of wheat cultivar [11, 5].

Moreover, several combinations of blended fertilizers which include vital elements such as N, P, S, B, K, Zn, Cu, Fe, etc. are developed for different agro-ecologies of the country. However, in addition to N and phosphorus (P), sulfur (S), boron (B) and zinc (Zn) deficiencies are widespread in Ethiopian soils, while some soils are also deficient in potassium (K), copper (Cu), manganese (Mn) and iron (Fe) which all potentially limit crop productivity (EthioSIS, 2013).

However, there is limited information on the effect of blended fertilizer application rate on yield and grain quality of durum wheat varieties grown in Ethiopia. The increases in crop yields from application of B, Cu, Fe, Mn, Mo, and Zn occur in many parts of the world [12, 21]. The different blended fertilizer (NPS. NPSB and NPSZnB) and rate on Durum wheat yield and quality have not yet been studied extensively and there is lack of information regarding the different type and rates of fertilizer application on the wheat yield and quality. Therefore, this study was undertaken to determine the effect of different types and rates of fertilizer application on the yield and quality of durum wheat in Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted during the 2020/21 main cropping season at Sinana Agricultural Research Center located 70 N latitude and 400 E longitudes and elevation 2400 masl. The area was characterized by monthly mean maximum and minimum air temperatures during the growing season were 19.5°C and 9.6°C, and for the long term (mean) was 21.1°C and 9.40°C, respectively. The dominant soil type is pellicVertisol and slightly acidic (pH=6).

2.2. Experimental Design and Treatments

The experiment was laid out in randomized complete block design (RCBD) arranged in factorial arrangement with three replications comprising three level of blended fertilizer (NPS, NPSB and NPSZnB) and five fertilizer rates (0kg/ha, 50 kg/ha, 100kg/ha, 150 kg/ha and 200 kg/ha) for Durum wheat varieties. Bulalla Varieties were used as a test crop. The nitrogen applications were determined in part by considering the national research blanket recommendation of 46 kg N/ha for wheat and on the other hand the farmers' practice of below and above the recommendation. The plot area was 1.6x2m and each plot had 8 rows, 20 cm between rows, 10 cm at the edge of the plot and 1m between the blocks.. The treatment combinations will be shown below table 1.

Table 1. *Composition of Different blended fertilizer.*

Blended Fertilizer	Rate of Fertilizer	N %	P %	S %	B %	Zn %
NPS	50 kg/ha	9.5	19	3.5	0	0
	100 kg/ha	19	38	7	0	0
	150 kg/ha	28.5	47	10.5	0	0
	200kg/ha	38	76	14	0	0
NPSB	50 kg/ha	9.45	18.85	3.475	0.05	0
	100 kg/ha	18.9	37.7	6.95	0.1	0
	150 kg/ha	28.35	56.55	10.425	0.15	0
	200kg/ha	37.8	75.4	13.9	0.2	0
NPSBZn	50 kg/ha	8.45	16.9	3.65	0.35	1.1
	100 kg/ha	16.9	33.8	7.3	0.7	2.2
	150 kg/ha	25.35	50.7	10.95	1.05	3.3
	200kg/ha	33.8	67.6	14.6	1.4	4.4

2.3. Experimental Procedures and Field Management

The field experiments were prepared and leveled manually. Then, a field layout was made and each treatment was assigned randomly to the experimental units within a block. Durum wheat seeds were sown at the recommended seed rate of 150 kg ha^{-1} and planted in rows of 20 cm spacing manually by drilling. During the planting the different types and rates of fertilizer application were done according to the randomization of the treatments and the recommended (150 kg/ha) amount of Nitrogen fertilizer were applied at planting, tillering and booting stage in split application and all agronomic practices were done accordingly.

2.4. Agronomic Data Collection

Plant height (cm): These were measured from the soil surface to the tip of a spike (awns excluded) from five (5) randomly tagged plants from the net plot area at physiological maturity.

Number of Productive Tillers: This was counted at physiological maturity from two randomly selected rows of 0.5 m in length from the net plot as above and converted to m^2.

Number of kernels per spike: were recorded as an average of five (5) randomly taken spikes from the net plot area.

Spike length (cm) was obtained by measuring from the base of the spike up to the apex of the terminal spikelet excluding awns.

Biomass yield (kg ha^{-1}) was obtained by weighing above ground dry matter of plant (straw and grain) in each plot.

Grain yield (kg ha^{-1}) determined from the central five rows harvested and data was given on a 12.5% moisture basis.

Harvest index were calculated as the percentage ratio of grain yield to the total above ground biomass yield multiplied by 100.

$$Harvest\ Index\ (\%HI) = \frac{Grain\ Yield}{Biomass\ Yield} * 100$$

Straw yield (kg ha^{-1}) was obtained by the difference between biomass yield and grain yield.

Thousand kernel weight (TKW) were measured by counting the thousand seed and weighted by the sensitive balance.

Hectoliter weight (HLW) is the weight of flour density produced in a hectoliter of the seed and it was measured using a standard laboratory hectoliter weight apparatus at Sinana Agricultural Research Center.

Grain protein content (GPC) was determined on a dry weight basis by near infrared reflectance spectroscopy (NIRS), by using "Infratec™1241 Grain Analyzer" equipment at Quality laboratory in Sinana Agricultural Research Center. After calibrating the equipment for durum wheat, cleaned and prepared sample of 300 g seeds was added to the equipment and waited for one minute. Then the equipment read grain protein near infrared and displayed on screen.

2.5. Data Analysis

ANOVA was carried out using SAS version 9.00 statistical software programs (SAS, 2009). Significant difference between and among treatment means were assessed using the least significant difference (LSD) at 0.05 level of probability. [9].

3. Result and Discussion

3.1. Effect of Different Type and Rates of Fertilizer Application on Yield and Yield Components of Durum Wheat

Analysis of variance (ANOVA) in Table 1 indicated that productive tillering, number of seed per spike, spike length, straw yield, and harvest index, were non significantly ($P<0.05$) affected by the interaction effect of blended type and rates of fertilizer application but different types of blended fertilizer application were significantly different on the straw yield, gluten content (g) and protein percentage. The highest mean of straw yield (3181.1 kg ha^{-1}) were recorded at the NPS fertilizer application as well as lowest mean straw yield (2694.5 kg ha^{-1}) were recorded at the NPSB types of fertilizer application.

Table 2. *Effect of Different Source and rates of Fertilizer Application on the Yield and Yield Components of Durum Wheat.*

Treatment	TN	NSPS	SPL (cm)	SY (kg)	HI
Control	5.53	18.53	6.23	2846.4	0.52
NPS	5.86	19.25	6.16	3181.1	0.53
NPSB	5.9	19.03	6.12	2694.5	0.59
NPSZnB	5.86	19.5	6.25	2821.5	0.6
LSD	Ns	Ns	Ns	394.69	Ns
Rates of fertilizer application					
50 kg ha^{-1}	6.02	19.15	6.05	3441.4	0.61
100 kg ha^{-1}	6.11	19.2	6.26	2795.2	0.6
150 kg ha^{-1}	6.35	18.8	6.21	2723.9	0.58
200 kg ha^{-1}	5.88	19.88	6.2	2635.6	0.51
LSD (0.05)	Ns	Ns	Ns	455	0.04
CV (%)	21.67	7.5	6.04	16.43	6.98

TN=Number of productive tiller, NSPS=Number of Seed per Spike, SPL=Spike Length, SY=Straw Yield and HI=Harvest Index.

As indicated on table 2 the different rates of fertilizer application were significantly different ($p<0.05$) on the straw yield and harvest index. The maximum straw yield (3441.4kg/ha) were recorded at 50 kg ha^{-1} rates of fertilizer application while the minimum straw yield (2635.6 kg ha^{-1}) were recorded at the 200 kg ha^{-1} rates of fertilizer application. The maximum Harvest index (0.61) were recorded at 50 kg ha^{-1} rates of fertilizer application but the minimum (0.51) harvest index were recorded at the 200 kg ha^{-1} rates of fertilizer application next to the control (0.52). This indicated that the rates of fertilizer application increase the yield of the wheat becomes increased but the straw yield and harvest index become decreased, they also inversely proportional to the yield. Likewise [7] reported that the effect of blended fertilizer application didnon significantly affect the harvest index of the wheat.

3.1.1. Plant Height (cm)

Analysis of variance on table 3 indicated that interaction effects of different and rates of fertilizer applications were significantly different ($P<0.05$) on the plant height. The highest plant heights (90.33 cm) were recorded at the interaction application of the NPSZnB with the 150 kg/ha rates of fertilizer application and the shortest plant height (76.66 cm) were recorded from unfertilized plot. This increment in plant height might be due to the fact that fertilizer improves plant height by taking synthesis of macromolecules (proteins, enzymes, pigments, hormones, etc.) and rate of processes like photosynthesis on cell division and cell elongation, and finally internodes length. Soil applied with increased rates of fertilizer, increased internodes length which ultimately resulted in increased plant height also N application enhanced the overall vegetative growth of bread wheat [16].

The resultindicates a negativecorrelation with the results of (Landon, 1991) that supplementation of S, B and Zn to the recommended NP fertilizers did not bring about a significant difference in plant height. The increment in plant height might be due to increase in cell elongation and more vegetative growth attributed to different nutrient content of blended fertilizer containing NPS and micronutrients. On the other hand the least plant height in unfertilized plots might have been due to low soil fertility level in the study area.

3.1.2. Thousand Kernel Weight (TKW)

Analysis of variance indicated on table 3 the thousand kernel weight (TKW) of durum wheat was significantly (P<0.001) influenced by different types and rates of blended fertilizer application. The result indicates that the maximum thousand kernel weight (41.86g) were recorded at NPSB with 200 kgha^{-1} rates while the minimum thousand kernel weight (33.86g) were recorded at the control (0 kgha^{-1}). The result indicates that as the fertilizer application rate increase the thousand kernel weight also increases.

Application of NPSB fertilizer application at 200kg ha^{-1} rates increased thousand kernels weight by 19.11% percent rather than the control (unfertilized plot). In line with this result, [4] reported that fertilizer application gave the highest thousand kernels weight (57.00 g) than the unfertilized plot (46.79 g) for wheat. Similarly, [19] reported the highestthousand kernels weight (59.99 g) at the highest nitrogen rate (92 kg ha^{-1}) for durum wheat.

Table 3. *Interaction effect of different source and rates of fertilizer application n the plant height, thousand seed weight, biomass yield and Grain yield of durum wheat.*

Different Source	Rates of Fertilizer Application (kg/ha)	Plant Height (cm)	Thousand kernel Weight (g)	Biomass Yield (Kg/ha)	Grain Yield (Kg/ha)
Control	0	76.66	33.86	5944.4	3098
NPS	50	86.4	37.26	7244.4	3319
	100	88.46	38.73	6833.3	3494
	150	87.80	39.33	6638.9	3835.3
	200	89.13	41.36	6222.3	3566.3
NPSB	50	83.53	37.83	6566.7	3699.7
	100	83.73	40	6277.8	3767.3
	150	89.86	38.73	7000	4197
	200	87.40	41.86	6988.9	4391.3
NPSZnB	50	79.93	36.06	7088.9	3557
	100	87.26	37.76	6822.2	4286.3
	150	90.33	41	6777.8	4212.7
	200	87.06	41.16	7655.6	5002.3
LSD		2.1	2.01	958.51	287.32
CV		1.46	3.07	8.43	4.41

3.1.3. Biomass Yield

Analysis of variance revealed that biomass yield of durum wheat was significantly (P<0.001) influenced by different types and rates of blended fertilizer application. As the result indicated on the Table 3 the application of NPSZnB ha^{-1} with the 200 kgha^{-1} fertilizer application rates were recorded the highest biomass yield (7655.6 kgha^{-1}) compared to the other treatments but the minimum biomass yield (5944.4 kgha^{-1}) were recorded from the unfertilized/control/plot. The results were positive with the [3] which indicates that the application of 200 kg rates of blended fertilizer recorded the maximum grain yield as compared to control plot.

Adequate supply of nutrients leads to high photosynthetic activity, vigorous vegetative growth and dark green color and finally improves the utilization of carbohydrates. Sulfur is also reported to enhance the photosynthetic assimilation of N in crop plants [1]. While adequate supply of phosphorus increases tiller emergence, especially secondary tillers and their survival, it helps in increasing the biomass yield through proper regulation of carbohydrates translocation [15]. Ample supply of boron facilitates photosynthetic activities and leaf expansion that leads into improved plant growth [17].

3.1.4. Grain Yield

Analysis of variance revealed that grain yield of durum wheat was significantly (P<0.001) influenced by different type and rates of blended fertilizer application The maximum grain yield (5002.3 kg/ha) were recorded from the NPSZnB with the 200 kg/ha rates of fertilizer application where as the minimum grain yield (3098 kg/ha) were also recorded from the control (0 kg/ha). The rate of fertilizer application increases the grain yield of the durum wheat increases in all different types of fertilizer application. According to [8] reported that the agronomic performance of a crop was improved through application of blend macro and micro nutrient application in suitable form of nutrient deficiency soil as a result increase the nitrogen use efficiency of teff.

3.2. Effect of Different Type and Rates of Fertilizer Application on Gluten and Grain Protein Percentages of Durum Wheat

3.2.1. Gluten Content

The Analysis of variance indicated in the table 4 explains that the gluten content was significantly affected by the different types and rates of blended fertilizer application but the interaction effects were non significantly different. The highest mean of gluten content (29.04) were recorded from the NPSZnB fertilizer application and the lowest gluten (28.46) were recorded at the control. The result indicates that the NPSZnB fertilizer type were increase the gluten content due the amount of the composition on Boron in NPSZnB were higher than that of NPSB and the function of Boron is also an essential element for better utilization of macro-nutrients by plants and thereby for greater translocation of photo-assimilates from source to sink during growth period rather than biomass production [2].

Table 4. *Effect of different type and rates of fertilizer application on the garin protein content and Gluten content of durum wheat.*

Treatment	Gluten	Protein%
Control	28.46	12.5
NPS	28.51	14.27
NPSB	28.23	13.99
NPSZnB	29.04	14.28
LSD	1.01	0.2
Rates of fertilizer application		
50 kg ha^{-1}	28.07	13.75
100 kg ha^{-1}	28.88	13.8
150 kg ha^{-1}	28.08	14.38
200 kg ha^{-1}	29.33	14.78
LSD (0.05)	1.17	0.23
CV (%)	4.45	1.7

3.2.2. Grain Protein Percentage (GPP %)

Grain protein content was significantly ($P<0.005$) affected by different types and rates of blended fertilizers but the interaction between two factors were non significantly different. NPSZnB fertilizer type gave the highest grain protein content, whereas the NPS and NPSB gave lower grain protein content (Table 4). With the respect to fertilizer application rate the maximum grain protein content (14.78) were recorded from the 200 kg/ha rates of fertilizer application and the minimum grain protein percentage (12.5) were recorded from the control. The variation in grain protein content may be attributed to their variation in nutrient uptake and translocation capacities to the sink.

The protein content of the wheat was increased as the rates of fertilizer application increased. The increase in protein content with increasing rates might be due to the presence of higher amounts of N and S which are the major components of grain protein. The results were complementary to the results of [20] reported higher grain protein content ranging from 11.34% without nil rate of nitrogen application to 14.19% with the application of 92 kg N ha^{-1}. Turnbull (2001) reported typical values for protein content in durum semolina ranging from 11-16%. The application of nutrients was improved through application of blend of macro with like K, S, Zn, g and B significantly increased grain yield micronutrient in a suitable form in nutrient deficient soil; and yield component of bread wheat as compare to the as a result, it improved nutrient use efficiency of teff control.

4. Conclusion and Recommendation

The wheat production in Ethiopia was hindered due to different biotic and abioticfactors such as low soil fertility, lack of improved wheat varieties and lack of improved management practices. Among those constraints, low soil fertility was the most important constraints and limiting wheat yield production. To trim down the problem associated among the soil fertility application of different source and rates of fertilizer application to increase the wheat yield productivity from the existing land under cultivation. Therefore the result of the current study indicated that the plant height, thousand kernel weight, Biomass and grain yield were significantly affected by the interaction of different source and rates of fertilizer application while Tillering number, number of seed per spike and spike length were non significantly different among the treatments but Straw yield, harvest index, gluten content and protein percentage were significantly different among the main effect of the treatments. Therefore the result were concluded the maximum grain yields of Bullala variety were recorded from the interaction of NPSZnB with 200kg/ha rates of fertilizer application were more feasible in the study area. Further researches have to be continued to recommend blended fertilizer type and rates over location and year.

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