Duga RD, et al., J Agron Agri Sci 2023, 6: 049
DOI: 10.24966/AAS-8292/100049

HSOA Journal of
Agronomy & Agricultural Science

Research Article

Quality and Economic Advantage of Bread Wheat (*Triticum Aestivum L.*) Varieties Fertilized by Different Rates of Blended Fertilizer

Rut-Duga D[1], Diriba-Shiferaw G[2]*and Wogayehu W[1]

[1]Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research, Ethiopia.

[2]Department of Horticulture and Plant Sciences, College of Agriculture and Environmental Science, Arsi University, P.O. Box 193 Asella, Ethiopia

Abstract

Bread wheat (*Triticum aestivum L.*) quality is an important component of the crop productivity as it improves both food security and income sources for farmers. However, its grain quality and economic yields are mainly constrained by poor soil fertility and lack of site specific blended fertilizer (NPSB) recommendation in the study area for specific variety. Therefore, a field experiment was conducted in Tiyo district of Arsi Zone, Ethiopia, on farmer's field in 2018 main cropping season to evaluate the effect of blended fertilizer rates on quality and economy of bread wheat varieties. Factorial combination of two improved bread wheat varieties (Wane and Kingbird) and eight blended fertilizer treatments [Control, Recommended NP (150 kgha-1 TSP (69%P2O5) + 158.7 kgha-1 Urea (73 N)), 100 kg NPSB (18.1N + 36.1P2O5 + 6.7S + 0.71B), 100 kg NPSB + recommended urea (46 kg N), 150 kg NPSB + recommended urea, 200 kg NPSB + recommended urea, 250 kg NPSB + recommended urea, 300 kg NPSB + recommended urea] were laid out in randomized complete block design in three replications. Results revealed that grain protein content was significantly affected by the main effect of varieties and fertilizer rates with highest grain protein obtained from Wane variety and 200kgha-1, and recommended NP applied. Hectoliter weight was significantly affected by the interaction effect of varieties and fertilizer rates with highest hectoliter weight obtained from Wane variety fertilized with NPSB at 200 kg ha-1. The partial budget analysis results revealed that the application of 200 kg NPSB ha-1 on Wane and Kingbird varieties were gave maximum marginal rates of return of 992.8% and 546.3% with highest net benefits, respectively. Therefore, application of NPSB at a rate of 200 kg NPSB ha-1 for the production of Wane and Kingbird varieties produced better wheat quality and economical advantages for the area wheat production. However, the research should be repeated in season and location to have a remarkable recommendation of the result for producers in the study area and the like.

Keywords: Blended fertilizer; Bread wheat; Economic benefit; Grain quality; Wheat varieties

***Corresponding author:** Diriba-Shiferaw G, Department of Horticulture and Plant Sciences, College of Agriculture and Environmental Science, Arsi University, P.O. Box 193 Asella, Ethiopia. E-mail: dsphd2010@gmail.com

Citation: Duga RD, Diriba SG, Wogayehu W (2023) Quality and Economic Advantage of Bread Wheat (*Triticum Aestivum L.*) Varieties Fertilized by Different Rates of Blended Fertilizer. J Agron Agri Sci 6: 049.

Received: October 13, 2023; **Accepted:** November 02, 2023; **Published:** November 09, 2023

Introduction

Wheat is one of the most important cereals cultivated in Ethiopia; largest producer of wheat in sub-Saharan Africa (SSA), over 1.8 million hectares annually [1]. It ranks fourth after maize, teff and sorghum both in area coverage and production in Ethiopia [2]. Wheat production in the country is adversely affected by low soil fertility and suboptimal use of mineral fertilizers in addition to diseases, weeds, erratic rainfall distribution in lower altitude zones, and water-logging in the Vertisols areas [3]. Stewart et al. [4] reported that 50 to 60% of the increase in crop yields worldwide was due to application of chemical fertilizers. Wheat yields especially those of newly developed genotypes are among the most depending nitrogen fertilization plant species [5].

Declining of soil fertility in agricultural soils exacerbated by improper land use, yield and water productivity in the rain fed systems in many SSA countries is decreasing or stagnating. About 97% of agricultural land in SSA is under rain fed system and [6] described nutrient depletion as a major biophysical factor limiting small-scale production in Africa. Inappropriate cropping systems, mono cropping, nutrient mining, unbalanced nutrient application, removal of crop residues from the fields and inadequate re-supplies of nutrients have contributed to decline in crop yields [7]. Declining soil fertility is also an important bottlenecking for smallholder cereal growers many parts of Ethiopia [8]. Continuous monocultures of cereals also result in reduction of yields and soil nutrients [9,10].

Grain quality is expressed through a complex of indices including its physical properties, chemical composition and bio-chemical and technological characteristics, which are variety-specific [11]. Wheat quality can be assessed using a variety of approaches that range from the physical measurement of the dough characteristics to chemical fractionation of the protein [12]. Protein content is a character determining the water absorbing ability, stability, resistance and elasticity of flour; and in flour it is the main quality criterion for wheat, especially for bread making [13]. Wheat grain protein content is frequently used as the main measurement of grain quality [14] and indicators for milling and baking [15].

Recent studies have indicated that elements like N, P, K, S and Zn levels as well as B and Cu are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country [16]. Most Ethiopian soils are deficit in macronutrients (N, P, K and S) and micronutrients (Cu, B, and Zn) [17]. The farmers in most parts of the country have limited information on the impact of different types and rates of fertilizers except blanket recommendation of nitrogen (41 kg N ha-1) and phosphorus (46 kg P2O5 ha-1), i.e. 50 kg Urea and 100 kg DAP ha-1 for wheat while according to the soil fertility map made over 150 districts, most of the Ethiopian soils lack about seven nutrients (N, P, K, S, Cu, Zn and B) [18]. Except blanket recommendation of nitrogen and phosphorus, the effect of other blended fertilizers on grain quality attributes of bread wheat are unknown, even though new blended fertilizers such as NPSB are currently introduced into the country. The response of wheat plant to application of different fertilizers varies with varieties and soils at optimum agronomic practices and crop management. Because of that, there is a need to develop location specific recommendation on the blended fertilizer rates to increase the productivity as well as grain quality of wheat. Thus, the study was initiated to evaluate the effect of blended fertilizer rates application on grain qualities and economic advantages of bread wheat varieties.

Materials and Methods

Description of the Study Area

The experiment was conducted at Tiyo district around Kulumsa Agricultural Research Center (KARC) on farmer field located at about 167km South East of Addis Ababa (Arsi Zone, Oromia-Ethiopia). Its geographical location is 8° 02' N latitude and 39° 10' E longitude, representing a medium altitude at 2200m above sea level with moderate rainfall of 848 mm per annum. Tiyo District is a potential area for cereals and highland pulses; the area is dominated by continuous monoculture of cereals especially wheat which exhaust the same kind of nutrients season to season. It has a unimodal rainfall pattern with extended rainy season from March to September with a peak rain in July and August. The mean annual maximum and minimum temperature is 23.1°C and 9.9°C, respectively. During the months of July to September, the rainfall is higher than the full potential evapotranspiration.

The weather data recorded during 2018 indicated that the area received a total annual rainfall of 862.7mm; the rainfall pattern was unimodal with extended rainy season from February to November. However, expecting the peak rainy season was from July to September, but in 2018 cropping season there was a shortage of rainfall in September. The mean annual maximum and minimum temperatures of 23.6°C and 11.8°C with monthly values ranged from 21.3°C to 25.3°C and from 9.7 to 13.2°C, respectively [19].

Experimental Materials

Planting Materials: Two bread wheat varieties (Wane and Kingbird) were used as planting materials. For the recommend appropriate application of NPSB blended fertilizer rate in the experimental area, these varieties were selected based on their adaptability to agro-ecological zone of the area; also their productivity and disease resistance is better than others (Table 1).

Fertilizer Materials: The blended NPSB fertilizer rates (18.1% of N, 36.1% of P2O5, 6.7% of S and 0.71% of B) in 100 kg bags , TSP (69% P2O5) and Urea (73% N) for recommended rate of NP and Urea (46% N) was used as the supplementary fertilizers for making NPSB optimum amount for the crop quality. Farmers and other bread wheat producers use Urea (100 kg) and DAP (150 kg) for recommended NP (73% N and 69% P2O5). But in this time DAP was out of the market. For this research TSP was used instead of DAP fertilizer as 150 kg of DAP have 69% P2O5 + 27% N; but 150 kg TSP have only 69% of P2O5. Thus to compensate the remaining 27% of N and fulfill the 73%N requirement by the crop, Urea fertilizer was added until the recommended fertilizer was balanced in the check treatment.

S.N.	Varieties name	Year of release	Area of adaptation		Maturity days	Agro-ecology	On station yield (q ha-1)
			Altitude(m)	Rainfall(mm)			
1	Wane	2016	2000-2300	750-1500	120	Midland	50 - 65
2	Kingbird	2015	2000-2200	800-1000	133	Midland	40 - 50

Table 1: Descriptions of the Bread Wheat varieties used for the experiment

Source:- Kulumsa Agricultural Research Center (KARC), Wheat breeding program (2017)

Treatments and Experimental Design: The experimental design used for this experiment was Randomized Complete Block Design (RCBD) with a factorial arrangement of two varieties (Wane and Kingbird) and eight fertilizer rates in three replications which comprised a total of 16 treatment combinations (Table 2).

Fertilizer rates	N	P2O5	S	B
Control	0	0	0	0
150 kg TSP + 158.7 kg Urea h^{-1}	73	69	0	0
100 kg NPSB	18.10	36.10	6.70	0.71
100 kg NPSB + 100 kg Urea ha^{-1}	64.10	36.10	6.70	0.71
150 kg NPSB + 100 kg Urea ha^{-1}	73.15	54.15	10.05	1.07
200 kg NPSB + 100 kg Urea ha^{-1}	82.20	72.20	13.40	1.42
250 kg NPSB + 100 kg Urea ha^{-1}	91.25	90.25	16.75	1.78
300 kg NPSB + 100 kg Urea ha^{-1}	100.30	108.30	20.10	2.13

Table 2: Detail treatment of fertilizer rates used for the experiment and their nutrient contents

N, Nitrogen; P2O5, di phosphorus pentoxide; S, Sulfur; B, Boron; TSP, Triple Super Phosphate; and NPSB, Nitrogen, Phosphorus, Sulfur and Boron combination

Experimental Procedures and Management: The gross experimental area was 687.4m2 (49.1m x 14m), gross plot size of 10.4m2 (4m x 2.6m) and net plot size of 6m2 (3m x 2m). The spacing between rows, plots and blocks were 0.20m, 0.5m and 1m, respectively. By excluding the two outer rows from both sides of a plot and a 0.25m row length on both ends of each plant, row of each plot was left to avoid border effects resulting in to a net plot size.

The land was ploughed two times by oxen including land clearing or removing unwanted materials from the field. Then, a field layout was made and each treatment was assigned randomly to the experimental units within a block. Bread wheat seed was sown at the recommended seed rate was 125 kgha-1 in rows of 20cm spacing sown at 3cm depth in row by using mechanical row marker and the seed was drilled manually in the rows on 12 July 2018. NPSB blended fertilizer rates were applied at sawing time for all plots except control. Supplementary nitrogen fertilizer in the form of Urea was applied in two times splits to maintain the nitrogen requirement of the crop. Thus the whole amount of blended (NPSB) fertilizer and 1/3 of recommended Urea were applied at sowing and the rest of 2/3 of Urea was applied at booting time by top-dressing. Weeding was done two times and Rexido fungicide was applied. The crop was finally harvested on the basis of crop maturity stage of each variety from the net plot area and was threshed manually.

Quality Data Assessment: Wheat samples were uniformly divided through Boerner Divider and analyzed for quality characteristics such as hectoliter weight and protein content according to standard procedures as described in [20]. Hectoliter grain weight of one liter volume (random sampled) was estimated for each experimental unit by following standard procedure of [20]. Protein content in wheat grain was determined by Near Infra Red Spectroscopy [20].

Economic Analysis: The economic analysis was performed whenever significant difference was observed for mean grain yields with respect to the applied blended fertilizer rates as per the procedures of CIMMYT (1988). Then, gross yield benefit was obtained by multiplying the adjusted yield by the price of grain (12.5 birr kg-1) for Tiyo district. The mean market price of wheat was obtained by assessing the market price during 2018 cropping season. Net benefit or net revenue was calculated, by subtracting labor cost (assuming 75 ETB per person) from gross yield. 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). The average open market price (9 birr kg-1) for wheat crop and the official prices of DAP (7.98 birr kg-1), Urea (10.66 birr kg-1), NPSB (11.40 birr kg-1). 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. This enables' to make farmer recommendations from marginal analysis.

Accordingly, those factors with significant effect were considered for partial budget analysis, dominance and marginal analysis. The net benefit was equal to the gross field benefit minus the total variable cost. Actual yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same size field. Any treatment that has higher total variable cost but net benefits that are less than or equal to the preceding treatment (with lower total variable cost but higher net benefits) is dominated treatment (marked as "D"). The dominance analysis illustrated that to improve farmers' income, it is important to pay attention to net benefits rather than yields, because higher yields do not necessarily mean high net benefits. The discarded and selected treatments using this technique were referred to as dominated and undominated treatments, respectively. For each pair of ranked treatments, % marginal rate of return (MRR) was calculated using the formula:

MRR (%) = (Change in NB (NBb-NBa))/(Change in TVC (TVCb-TVCa)) x 100

Where, NBa = the immediate lower NB, NBb = the next higher NB, TVCa = the immediate lower TVC and TVCb = the next highest TCV

The % MRR between any pair of undominated treatments was the return per unit of investment in fertilizer. To obtain an estimate of these returns, the % MRR was calculated as changes in NB (raised benefit) divided by changes in cost (raised cost). Thus, a MRR of 100% implied a return of one Birr on every Birr spent on the given variable input.

Data Analysis: Data quality parameters were subjected to analysis of variance procedure using GenStat (17th edition) software [21]. The comparisons among treatments means with significant difference for measured characters was done by LSD test at 5% level of significance.

Results and Discussion

Effect of Blended NPSB Fertilizer Rates and Varieties on Wheat Quality Parameters

Grain Protein Content: Grain protein content of the experiment showed highly significant (P<0.01) difference due to the main effects of blended fertilizer rates and varieties; but the interaction between the two factors was non-significant (Table 3). Wane variety of wheat was produced highest grain protein content (11.5%); whereas, Kingbird variety of wheat was gave significantly lower grain protein content (10.8%). The highest grain protein content (12.1%) was recorded from treatment received recommended NP; while, the lowest was produced from the control and 100 kgha-1 NPSB fertilizer applied without supplemental urea. Above 150 kgha-1 NPSB fertilizer applied was statistically not differed from the recommended NP (Table 3). Reported the protein content in wheat grains ranged from 9.23% to 15.11%. [22, 23] also demonstrated that both N fertilization and post-anthesis water stress slightly increased grain protein concentration.

Verities	Grain protein content (%)
Wane	11.5^{a}
Kingbird	10.8^{b}
LSD (%)	0.19
Fertilizer rates (kg ha^{-1})	
0 (Control)	9.2^{c}
150 TSP + 158.7 Urea	12.1^{a}
100 NPSB	9.3^{c}
100 NPSB + 100 Urea	11.4^{b}
150 NPSB + 100 Urea	11.3^{b}
200 NPSB + 100 Urea	11.8^{a}
250 NPSB + 100 Urea	11.9^{a}
300 NPSB + 100 Urea	12.0^{a}
LSD (5%)	0.37
P Value	<.0001
CV (%)	2.69

Table 3: Main effect of variety and blended fertilizer rates on wheat grain protein content

TSP, Triple Super Phosphate; NPSB, Nitrogen Phosphorus Sulfur and Boron composition; LSD, Least Significant Difference; CV, Critical Value. Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance.

Hectoliter Weight: The hectoliter weight was significantly (p<0.01) affected by the interaction effect of fertilizer rates and varieties (Table 4). The highest hectoliter weights (74.5 kg hl-1 and 74.3 kg hl-1) were recorded from Wane variety at those plots fertilized with 200 kg-1 NPSB and 150 kg-1 TSP along with supplementary urea applied, respectively. The lowest hectoliter weight (70.0 kg hl-1) was obtained from Kingbird variety in plots treated with 100 kg ha-1 NPSB without supplementary urea (Table 4). This could be related to the difference in variety with respect to applied fertilizer. Similarly, [24] reported that the hectoliter weights were ranged from about 57.9 kg hL–1 for poor wheat to about 82.4 kg hL–1 for sound wheat. The result of the study affirmed that the value of hectoliter weight for both varieties from the highest value of Wane (74.5 kg hl-1) to the lowest value of Kingbird (70.0 kg hl-1) of the tested bread wheat varieties was as a medium range. The amount of powder of wheat was important for millers just as grain yield is important to wheat producer. [22] reported that there was a slight increment in hectoliter weight in response to nitrogen application under more favorable growing conditions. Reported that hectoliter weight of wheat was significantly influenced by genotypes.

Fertilizer rates (kg ha^{-1})	Varieties	
	Wane	Kingbird
0 (Control)	71.2^{ef}	71.3^{def}
150 TSP + 158.7 Urea	74.3^{a}	70.8^{ef}
100 NPSB	72.2^{bcde}	70.0^{f}
100 NPSB + 100 Urea	73.7^{ab}	72.1^{bcde}
150 NPSB + 100 Urea	73.2^{abc}	71.1^{ef}
200 NPSB + 100 Urea	74.5^{a}	70.3^{ef}
250 NPSB + 100 Urea	73.2^{abc}	70.4^{ef}
300 NPSB + 100 Urea	72.0^{bcde}	71.7^{cde}
Grand mean	72.0	
LSD (5%)	1.91	
P value	0.0002	
CV (%)	1.59	

Table 4: Interaction effect of blended NPSB rates and varieties on hectoliter weight (kgha-1) of bread wheat.

TSP, Triple Super Phosphate; NPSB, Nitrogen Phosphorus Sulfur and Boron composition; LSD, Least Significant Difference; CV, Critical Value. Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance.

Effect of Blended NPSB Fertilizer Rates and Wheat Varieties on Economic Feasibility: Partial budget analysis is an important to identify experimental treatments with an optimum return to the farmer's investment and to develop recommendation for the crop productivity. Experimental yields were often higher than the yields that farmers could expect using the same treatments; hence in economic calculations, yields of farmers were adjusted by 10% less than that of the research results (CIMMYT, 1988). As indicated in Table 5, the partial budget analysis showed that highest net benefit (50,536 Birr ha-1) was obtained from Wane variety which received 300 kg ha-1 NPSB. However, the lowest net benefit (26,496 Birr ha-1) was obtained from Kingbird variety in unfertilized plot. Thus, Wane variety was produced better economic benefit (48,540 Birr ha-1) with higher marginal rate of return (992.8 %) at 200 kg ha-1 NPSB fertilizer applied along with supplemental urea; but, highest economic benefit (50536 Birr ha-1) was obtained from Wane variety at 300 kg ha-1 NPSB applied with lowest (45.3%) marginal rate of return (Table 5). Similarly, Kingbird variety at 200 kg ha-1 NPSB fertilizer applied was gave the maximum economic benefit (46,551 Birr ha-1) with highest marginal rate of return (546.3%); but lowest (81.1%) marginal rate of return at 300 kg ha-1 NPSB applied. According to CIMMYT (1988) suggestion, the minimum acceptable marginal rate of return should be more than 100%. Therefore, both Wane and Kingbird varieties fertilized with NPSB at 200 kg ha-1 were economical and recommended for production of bread wheat in the study area and other areas with similar agro-ecological conditions.

Treatments		GY (kg ha^{-1})	SY (kg ha^{-1})	Income(ETB ha^{-1})		GFB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	MRR (%)
Var.	Fer.			Yield	Straw				
W	0	2165	3137	28140	627	28768	0	28768	-
W	100^{a}	2806	4477	36479	895	37374	2070	35304	315.7
W	100	3425	5324	44524	1065	45589	3390	42409	538.3
W	150	3489	6416	45351	1283	46634	3600	42804	188.1
W	NP	3561	6020	46299	1204	47503	4266	43437	95.1
W	200	3966	7315	51557	1463	53020	4780	48540	992.8
W	250	4107	8285	53369	1657	55046	5130	49916	393.1
W	300	4236	9816	55072	1963	57036	6500	50536	45.3
KB	0	1991	3062	25884	612	26496	0	26496	-
KB	100^{a}	2832	4091	36815	818	37633	2070	35563	438.0
KB	100	3252	4856	42279	971	43250	3390	40070	341.4
KB	150	3375	5317	43871	1063	44939	3600	41109	494.8
KB	NP	3647	6520	47405	1304	47709	4266	43743	395.5
KB	200	3737	7761	48579	1552	50131	4780	46551	546.3
KB	250	3499	7827	45481	1565	47046	5130	41916	D
KB	300	3682	8327	47861	1665	49527	6500	43027	81.1

Table 5: Summary of economic analysis due to the effects of blended NPSB fertilizer rates applied to bread wheat varieties.

Where; W-Wane; KB-Kingbird; a- without application of supplementary Urea; Var-variety; Fer-fertilizer (kg ha-1); GY-grain yield; SY-straw yield; GFB-gross field benefit; TVC-total variable costs; NB-net benefit; MRR-marginal rate of return; ETB ha-1-Ethiopian Birr per hectare; D-dominated treatment.

Conclusion and Recommendation

The highest grain quality attributes (protein and hectoliter weight) were recorded from Wane variety (11.8% and 74.5 kg hl-1) fertilized at 200 kg ha-1 NPSB along with supplemental urea with a maximum marginal rate of return (992.8%) and highest economic benefit from Kingbird variety fertilized at 200 kg ha-1 NPSB with highest (546.3%) marginal rate of return. Therefore, it is possible to conclude that the application of NPSB at the rate of 200 kg ha-1 for the production of Wane and Kingbird varieties is economically feasible with better quality attributes for the study area and similar growing areas. However, the study should be repeated in more location and season using various rates and types of fertilizers for a remarkable recommendation to the study area and similar agro-ecologies as the study was conducted in one location for one season.

References

1. Abeyo B, Braun H, Singh R, Ammar K, Payne T, et al. (2012) The performance of CIMMYT wheat germplasm in East Africa with special emphasis on Ethiopia. In: Book Abstracts of Wheat for Food security in Africa conference AA, Ethiopia 22.
2. CSA (2018) Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season): Agricultural Sample Survey. Addis Ababa, Ethiopia.
3. Amanuel G, Kuhne RF, Tanner DG, Vlek PLG (2003) Recovery of 15- N labeled urea applied to wheat in the Ethiopian Highlands as affected by P fertilization. J. Agron. Crop Sci 189: 30-38.
4. Stewart WM, Dibb DW, Johnston AE, Smyth TJ (2005) The contribution of commercial fertilizer nutrients to food production. Agronomy Journal 97: 1-6.
5. Hirel B, Bertin P, Quilleré I, Bourdoncle W, Attagnant C, et al. (2001) Towards a better understanding of the genetic and physiological basis for nitrogen use efficiency in maize. Plant Physiology 125: 1258-1270.
6. Mosisa W, Wende A, Berhanu T, Legesse W, Alpha D, et al. (2007) Performance of CIMMTY maize germplasm under low nitrogen soil conditions in the mid altitude sub humid agro-ecology of Ethiopia. African Crop Science Society Conference 18:15-18.
7. Nyamangara J, Gotosa J, Mpofu SE, (2001) Cattle manure effects on structural stability and water retention capacity of granitic sandy soil in Zimbabwe. Soil and Tillage Research 64: 157-162.
8. Tolera A, Feyisa D, Friesen DK (2009) Effects of Crop Rotation and N-P Fertilizer Rate on Grain Yield and Related Characteristics of Maize and Soil Fertility at Bako, Western Oromia, Ethiopia. East African Journal of Sciences 3: 70-79.
9. Zerihun A, Sharma JJ, Nigussie D, Fred K, (2013) The effect of integrated organic and inorganic fertilizer rates on performances of soybean and maize component crops of a soybean/maize mixture at Bako, Western Ethiopia. African Journal of Agricultural Research 8: 3921-3929.
10. Kombiok JM, Buah SSJ, Segbedji JM (2012) Enhancing Soil Fertility for Cereal Crop Production through Biological Practices and the Integration of Organic and In-Organic Fertilizers in Northern Savanna Zone of Ghana. Soil Fertil.
11. Ivanova A, Tsenov N, (2010) Effect of some agronomy practices on main traits of grain yield in winter wheat varieties of different quality. Bulgarian Journal of Agricultural Science 16: 559-564.
12. Kharel TP, Clay DE, Clay SA, Beck D, Reese C, et al. (2011) Nitrogen and Water Stress Affect Winter Wheat Yield and Dough Quality. Agronomy Journal 103: 1389-1396.
13. Triboi E, Triboi BAM (2002) Productivity and grain or seed composition: a new approach to an old problem. European Journal of Agronomy 16: 163-186.
14. Ricardo C, Claudio J, Pablo U (2010) Effects of Nitrogen on Productivity, Grain Quality, and optimal Nitrogen rates In Winter Wheat Cv. Kumpa-Inia in Andisols of Southern Chile. Chilean Journal of Agricultural Research 70: 122-131.
15. Mohammed YA, Kelly J, Chim BK, Rutto E, Waldschmidt K, et al. (2013) Nitrogen Fertilizer Management for Improved Grain Quality and Yield in Winter Wheat in Oklahoma. Journal of Plant Nutrition 36: 749-761.
16. ATA (Agricultural Transformation Agency) (2016) Soil Fertility Status and Fertilizer Recommendation Atlas of the Southern Nations Nationalities and Peoples' Regional State, Ethiopia, by Ministry of Agriculture and Natural Resources and Agricultural Transformation Agency. Addis Ababa, Ethiopia.
17. EthioSIS (Ethiopian Soil Information System) (2014) Soil Fertility and Fertilizer recommendation Atlas of Tigray Region. Addis Ababa, Ethiopia.
18. EthioSIS (Ethiopian Soil Information System) (2013) Towards improved fertilizer recommendations in Ethiopia – Nutrient indices for categorization of fertilizer blends from EthioSIS woreda soil inventory data. Addis Ababa, Ethiopia.
19. KARC (Kulumsa Agricultural Research Center) (2018) Kulumsa Agricultural Research Center; Meteorological data, Ethiopia.
20. AACC (American Association of Cereal Chemists) (2000) Approved Methods of the American Association of Cereal Chemists. AACC, United States.
21. GenStat. (2011) GenStat Procedure Library Release. VSN International Ltd, United Kingdom.
22. Gooding MJ, Ellist RH, Shewry PR, Schofield JD (2003) Effects of restricted water availability and increased temperature on the grain filling, drying and quality of winter wheat. Journal of Cereal Science 37: 295-309.
23. Labuschagne MT, Meintjes G, Groenewald FPC (2006) The influence of different nitrogen treatments on the size distribution of protein fractions in hard and soft wheat. Journal of Cereal Science 43: 315-321.
24. Austin RB (1999) Yield of winter wheat in the United Kingdom: recent advances and prospects. Crop Science 39: 1604-1610.