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Grain quality and yield response of bread wheat (*Triticum aestivum* l.) varieties to different rates of blended fertilizer at Kulumsa, South-eastern Ethiopia

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ABSTRACT: This study was initiated to assess the effect of blended fertilizer of Nitrogen(N), phosphorus(P), sulfur(S) and boron(B) rate on yield and quality of Ethiopian newly release varieties of wane (2016) and king bird (2015) of bread wheat varieties by Kulumsa Agricultural Research Center Wheat Breeding Program. A field experiment was carried out in 2018 robi season to determine grain quality and yield response of bread wheat varieties to different rate of fertilizer. The treatments was factorial combination of eight levels control, recommended PN (150 kg ha^{-1} TSP (69 P_2O_5) + 158.7 kg ha^{-1} Urea (73 N), 100 kg NPSB (18.1N + 36.1P_2O_5 + 6.7S + 0.71B)**,** 100 kg NPSB + Rec. Urea (46 kg N) , 150 kg NPSB + Rec. Urea, 200 kg NPSB + Rec. Urea, 250 kg NPSB + Rec. Urea, 300 kg NPSB + Rec. Urea) and two bread wheat varieties (wane and king bird). The experiment design was laid in Randomized Complete Block Design with factorial arrangement of two varieties. Phonological traits, grain quality parameters and yield were taken as experimental variables. The result showed that grain yield, thousand kernel weight and hectoliter weight were significantly affected by interaction of fertilizer rate and varieties. However, days to heading, days to maturity, plant height, number of productive tillers, straw yield and number of grains per spike were significantly affected by both fertilizer rate and varieties. The highest Seeds per spick (53.9), thousand kernel weight (37.3 g), and SY (9071.7 kg ha^{-1}) in the main effect were recorded from 300 kg NPSB treatment with supplementary urea, whereas grain protein content (12.1%) was recorded from 73/69 kg recommended NP (12.1%). The interaction effect of PT and BY showed that variety Wane scored Wane7.7 PT and 14053 kg ha^{-1} as compared to 6.0 PT and 12009 kg ha^{-1} BY in variety Kingbird at 300 kg NPSB fertilizer treatment with supplementary urea; whereas the least was observed at control. The higher GY was produced in Wane (4236 kg ha^{-1}) variety at 300 kg NPSB fertilizer treatment; but in Kingbird (3737 kg ha^{-1}) variety 200 kg NPSB fertilizer treatment with supplementary urea. Wane variety was found to be better in terms of both agronomic and economical feasible. However, as the experiment was conducted only for a single season, the repeat of the study is suggested for more seasons around Kulumsa area and similar agro ecology.

Keywords: Bread wheat, Kingbird, NPSB fertilizer, productivity, quality trait, Wane.

INTRODUCTION

Wheat is one of the most important crop plants in the world. Supplementary of the earth's surface is wrapped by wheat more than any additional food crop (FAO, 2013). Wheat grows mostly in the range between 1500 to 3000 m above sea level in Ethiopia, where the need for chilling temperature is satisfied (Daba, 2017). Ethiopia is the second largest wheat producer in Africa next to South Africa. Wheat is one of the major staple crops in the country in terms of both production and consumption. Wheat is modeled here due to its relative importance as well as its wide scale adoption throughout the four main regions of Ethiopia (Minot et al., 2015).

Stewart et al. (2005) reported that 50 to 60% of the increase in crop yields worldwide was due to application of chemical fertilizers. They also stated that during the 21st century, the essential plant nutrients would be one of the factors limiting crop yields, especially in developing countries; the main factors responsible for low yield are less or more plant population and inadequate crop nutrition. Wheat yields especially those of newly developed genotypes are among the most depending nitrogen fertilization plant species (Hirel et al., 2001).

Since its start in the early 1970's, fertilizer use in Ethiopia has focused mainly on the use and application of nitrogen and phosphorous fertilizers in the form of Urea and DAP for almost all crops and soil types. Such unbalanced and blanket application of plant nutrients may aggravate the depletion of other important nutrient elements in the soils (Fayera et al., 2014). 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 (Nyamangara et al., 2001). Low soil fertility due to monoculture cereal production systems is recognized as one of the major causes for declining per capita food production. In Ethiopia, soil degradation and nutrient depletion have gradually increased in area and magnitude and have become serious threats to agricultural productivity (Kebede and Yamoah, 2009). Adequate and timely application of fertilizer should be aligned with fertilizer responsive varieties. This is directly associated with amount of yield harvested and thereby its end quality. *Kingbird* and *Wane* bread wheat varieties are released to for their resistance against rust and early maturity. Besides to genetic and environmental factors, crop management factors like fertilizer application determine productivity. Therefore, this study was initiated to evaluate the effects of blended (NPSB) fertilizers rate, varieties and their interaction on yield, yield components and quality attributes of bread wheat varieties.

MATERIALS AND METHODS

Study area description

The field experiment was conducted at Kulumsa Agricultural Research Center (KARC), which is located in Tiyo district of Arsi Administrative Zone, Oromia Regional State, Ethiopia during 2018. The site is located at 167 km south-east of Addis Ababa and 8 km north of Asella town at an altitude of 2200 meters above sea level (m. a.s.l), 8° 01' N latitude and 39° 09' E longitude. Even though, Gora Silingo kebele is the potential area for cereals and highland pulses, the area is dominated by continuous mono cropping of cereals especially wheat which exhaust the same kind of nutrients season to season. Agro-ecological zones of the area is from highland to semi-arid and receives a uni-modial mean annual rainfall of 809.2 mm from March to September; however, the peak season is from July to August.

Treatment and experimental deign

The blended NPSB fertilizer rates (18.1% of N, 36.1% of P_2O_5, 6.7% of S and 0.71% of B) in 100 Kg bags as shown in Bellete (2015), TPS (69% P_2O_5) and Urea (73% N) was used as the supplementary fertilizers for making NPSB optimum amount for the crop productivity.

The experimental design used for this experiment was Randomized Complete Block Design with factorial arrangement of two varieties (*Kingbird* and *Wane*) and six rates of NPSB (0, 100, 150, 200, 250, and 300) including the local check and recommended rate with three replications. This gave a total of 16 treatment combinations. The treatments includes control, recommended PN (150 kg ha^{-1} TSP (69%P_2O_5) + 158.7 kg ha^{-1} Urea (73 N), 100 kg NPSB (18.1N + 36.1P_2O_5 + 6.7S + 0.71B)**,** 100 kg NPSB + Rec. Urea (100 kg), 150 kg NPSB + Rec. Urea, 200 kg NPSB + Rec. Urea, 250 kg NPSB + Rec. Urea, 300 kg NPSB + Rec. Urea (Table 1). Supplementary nitrogen fertilizer in the form of Urea was applied in split form at two times, two weeks after germination and before booting to maintain the N requirement of the crop. This means about 36 kg ha^{-1} of Urea was applied two weeks after planting in all plots except the control and blended alone.

Experimental procedure

The gross experimental area was 49.1m x 14m (687.4m^2), with inter-row spacing of 0.20 m, and 0.5 and 1 m between the plots and blocks, respectively. The gross plot size of 4m x 2.6m (10.4m^2) and the net plot size of 3 m x 2 m (6m^2), leaving the two outer rows from both sides of a plot and a 0.25 m row length on both ends of each plant row of each plot to avoid border effects resulting into a net plot size. A surface soil sample was collected from five spots at a plough depth of 0 to 30 cm diagonally from each block to form composite samples for pre-planting soil analysis and also the soil samples were analyzed for selected physicochemical properties following the standard procedures.

Management of the experiment

The land was ploughed three times by oxen including land clearing or removing unwanted materials from the field. The seed rate was 125 kg ha^{-1} and sown in row of 3 cm depth by using mechanical row marker and the seed was drilled manually in the rows at the beginning of July 2018. All the necessary field management practices were carried out as per the practices followed by Kulumsa Agricultural Research Center. The crop was finally harvested on the basis of maturity stage of each variety after physiological maturity from the net plot area and was threshed manually.

Table 1. Fertilizer treatment rates used with their nutrient contents in kg/ha for the experiment field at Kulumsa research in 2018 main cropping season.

Fertilizer rates	N	P_2O_5	S	B
Control	0	0	0	0
Rec. NP (73 kg N+69 kg P_2O_5)	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

NPSB = Nitrogen Phosphorus Sulfur, S = Sulfur, N=Nitrogen, P_2O_5 = di phosphorus pento Oxide, B = Boron and Boron.

Determination of yield and yield components

All the plants of different treatments were harvested in the same physiological growth state. Plants were hand-harvested at 5 cm from the above soil level at 180 days after planting. Data on wheat total dry biomass, grain and straw yields, harvest index, tiller and spike numbers per plant, seed number per spike, plant and spike height and weight of 1000 kernels were recorded. Spikes were oven-dried at 70.1°C for 72 hours and their dry weights determined. Tiller and spike numbers per plant were recorded from 5 randomly chosen plants. Spike weight per plant was recorded from 5 randomly chosen plants. Dried biomass was calculated corresponding to relative moisture of 86% dry weight (DW).

Thousand kernel weight (g)

It was determined based on the weight of 1000 kernels sampled from the grain yields used to determine each treatment, using an electric seed counter, weighing with an electronic balance and adjusted to 12.5% moisture level.

Harvest index (HI)

It was calculated as the ratio of grain yield per the above ground dry biomass yield per plot expressed as a percentage. HI (%) = (Grain yield/ plot x 100)/ (Above ground dry biomass/plot).

Phonological parameters

Days to emergency were recorded as the number of days from sowing to when 50% of the plant emerged in each plot. Similarly, days to heading was recorded as the number of days from planting to 50% of heads fully matured, while physiological maturity was recorded as the number of days from planting to when 90% of heads fully matured was recorded.

Soil sampling and physico-chemical analysis

Soil samples were collected from representative points within the experimental field (0 to 30 cm depth) before planting by auger to make two composite samples. Similarly, surface soil samples of the same depth were collected at the time of full maturity for each treatment by taking samples from 3 points within each plot. Soil analyses were carried out at the soil laboratory of Kulumsa Agricultural Research Center (KARC). The pre-planting soil samples were used to analyze available nitrogen, available phosphorus, organic carbon, and soil pH, available S, particle size, CEC and soil pH in a single plot basis.

Available Phosphorus was measured using Bray II (Bray, 1945). The pH of the soil measured potentiometrically in the supernatant suspension of 1:5 soil: water mixture by using a pH meter, and Organic Carbon was determined by following Walkely and Black wet oxidation method as described by Jackson (1958). Total Nitrogen was determined by using Kjedahl method as described by Neas (1988). Cation Exchangeable Capacity (CEC) was determined by using the NH_4AC pH 7.0 methods. Digestion with acid-dichrome and heat modified Walkely-Black (Nelson and Sommers, 1982). Available sulfur will be determined by using available sulfur in the form of sulphate and determined by using 0.15% $CaCl_2$ as extractant and measured turbidometrically using spectrophotometer at 420 nm (Jackson, 1973). Texture or particle size was determined by Hydro meter method. Exchangeable Boron was determined by using Spectrophotometer, measure absorbance at a wavelength of 420 nm.

Quality assessment

Wheat samples were uniformly divided through Boerner Divider and analyzed for quality characteristics such as hectoliter weight, moisture content, protein according to standard procedures as described in AACC (2000).

Hectoliter weight: random sample grain weight of one liter volume was estimate for each experimental unit. Protein Content: Protein content in grain was determined by Near Infra-Red Spectroscopy.

Growth parameters

Plant height was measured at the time of physiological maturity from central rows as the mean height of five randomly selected plants from the ground level to the apex of each plant. Spike length per plants was determined from 5 randomly taken plants. Similarly, number of tillers per plant was estimated by counting tillers from five randomly selected plants.

Data analysis

All data was subjected to analysis of variance (ANOVA) for both sites following the standard procedure for split plot design. Variety and nitrogen fertilizer interaction will be performed using PROC GLM Procedure of SAS software version 9.1(SAS, 2004). Correlation analysis was conducted using Pearson correlation coefficient. Then path analysis was used to investigate cause relationships and direct and indirect effects of traits on grain yield and quality traits. Mean separation was employed following the significance of mean squares using least significant difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

According to the initial soil laboratory test results, the soil reactions were found to be moderately acidic vertisols with a pH value of 6.17. According to EthioSIS (2013), pH values classified as < 4.5 strongly acidic, 4.5 to 5.5 highly acidic, 5.6 to 6.5 moderately acidic, 6.6 to 7.3 neutral, 7.4 to 8.4 moderately alkaline, >8.5 strongly alkaline. Mengel and Kirkby (1996) found that the optimum soil pH values range from 4.1 to 7.4 were recommended for wheat and barley production.

The study area soil organic carbon was 1.76 having the organic matter content of 3.03 which can be classified in medium range according to EthioSIS (2013) as it classified soil organic carbon percentages of < 0.60, 0.6 to 1.0, 1.0 to 1.80, 1.80 to 3.0, and >3 as very low, low, medium, high, and very high, respectively. According to (Tekalign et al., 1991) rating, organic matter content of the soil is very low (<0.86%), low (0.86 to 2.59%), medium (2.59 to 5.17%), high (>5.17%), and very high (not given). Azlan et al. (2012) reported that soil texture influences the rate of soil organic matter (SOM) decomposition. Soils with high clay content may have higher SOM content due to slower decomposition of organic matter.

Total nitrogen (TN) value of the experimental soil was low (0.11). According to Ethio SIS (2014), TN content <0.1, 0.1 to 0.15, 0.15 to 0.3, 0.3 to 0.5, and >0.5 was very low, low, medium, high and very high, respectively. The result also indicated the N is limiting factor for crop growth. The optimum N level needed for crop production under most soils of Ethiopia is reported to be <0.2% according to EthioSIS (2013). Analysis of variance for germination date, seedling density, days to 50% heading, days to 90% maturity and plant height of wheat as affected by variety and rate of blended fertilizer (Table 2).

As indicated in Table 3, the laboratory analysis result revealed that the available P was low (8.21). According to Bray (1954), the range of phosphorus in Bray method is <7, 8 to 19, 20 to 39, 40 to 58 and >59 was very low, low, medium, high and very high, respectively. Habtamu et al. (2015) reported that low contain of P was due to fixation problem.

The study soil CEC value was medium (22.86 cmol kg^{-1}) (Table 3). According to Landon et al. (1991), soil CEC ranges soils having CEC of >40, 25 to 40, 15 to 25, 5 to 15, < 5 cmol kg^{-1} categorized as very high, high, medium, low and very low, respectively. According to the result from soil laboratory, the mean B value of the soil is 0.43 mg kg^{-1} (Table 3). According to EthioSIS (2013), critical B value for most Ethiopian soils is 0.8 mg/kg. This shows that soils of the study area are deficit in B suggesting application of fertilizer which contains B. Intensive cultivation in the area was responsible for low B content of the soil.

It was also related to continuous cultivation which result intensive mining of S from the soil. Bulk density of the experimental site was 0.85 g cm^{-3} (Table 3). White (1997) stated that values of bulk density ranges from < 1 g cm^{-3} for soils high in OM, 1.0 to 1.4 g cm^{-3} for well- aggregated loamy soils and 1.4 to 1.8 g cm^{-3} for sands and compacted horizons in clay soils. Based on these, soils of the study area were good for production with regarding to bulk density. Memon et al. (2018) who found decrease in bulk density as a result of nutrient and crop management.

The shortest and longest days to maturity were recorded from 0 and 300 kg ha^{-1} blended fertilizer rates and Urea, respectively. Abedi et al. (2011) and Sofonyas and Lemma (2016) reported significant increments in plant height due to application of high nitrogen rate. Generally, increased combined application of N and blended fertilizer showed inconsistent increment in plant height. These results were in line with Abebe and Abebe (2016) who reported that N fertilizer rate significantly affected days to maturity on wheat.

Wheat variety significantly ($p<0.05$) affected only days to heading and maturity having longer heading and maturity period on *Kingbird* variety as compared to *Wane* (Table 4). It is also important to note that the differences in maturity can be caused by the combined effect of genetic and environmental factors during the growth stage of the crops. This difference could be attributed to the genetic makeup (Table 6). In line with this, bread wheat varietal differences with respect to heading were reported by Abdulkerim et

Table 2. Analysis of variance for germination date, seedling density, days to 50% heading, days to 90% maturity and plant height of wheat as affected by variety and rate of blended fertilizer at Tiyo Woreda 2018 main cropping season.

Source of variation	Mean squares					
	DF	GD	SD	DTH	DTM	PLH
Replication	2	0.02	0.17	65.58***	34.19***	11.04
Varieties(V)	1	0.00ns	0.27ns	325.52***	295.02***	5.67ns
Fertilizer(F)	7	0.04ns	3.95***	105.69***	38.97***	271.45***
F x V	7	0.05ns	0.34ns	10.85ns	3.74ns	11.40ns
Error	30	0.04	0.55	4.81	1.45	6.59
CV (%)		3.26	3.25	3.30	1.10	2.89

GD = Germination date, SD = Seedling density DTH = Days to 50% heading, DTM = Days to 90% maturity, PH (cm) = Plant height, NPSB = Nitrogen Phosphorus Sulfur, and Boron, LSD = Least Significant Difference, CV = Critical Value. ns,*** = non-significant and very highly Significant 1% probability level, respectively.

Table 3. Major soil physical and physicochemical characteristics of the experimental field before planting in 2018 cropping season at Kulumsa, South-eastern Ethiopia field experiment.

Soil Parameter	Unit	Value	Rates
Bulk Density	g/cm^3	0.85	high
PH	%	6.17	slightly acidic
Organic Carbon	%	1.76	Low
Total Nitrogen	%	0.11	Low
Available Phosphorous	mg kg^{-1}	7.67	Low
Available Boron	mg kg^{-1}	0.43	Low
Available sulfur	mg kg^{-1}	2.09	Low
Cation Exchange Capacity	meq/100 g	22.86	Medium
Particle size distribution			
Sand	Silt	Clay	Textural class
11.25%	39.75 %	49.00%	Clay

al. (2015). Tuteja and Sarvajeet (2012) reported that plant sensitivity to drought and high temperature result in disturbed metabolic processes coupled with shorter plant life cycle which could be the reason for varietal differences in heading and maturity.

The analysis of variance showed that the main effect of varieties and blended fertilizer rates significantly ($p<0.01$) affected thousand seed weight (TKW), but there was no interaction effect (Table 7). *Wane* variety (37.0 gm) was weighed more than *Kingbird* variety (35.3 gm) in TKW. The highest TKW (37.3g) was produced by the application of 300 kg ha^{-1} NPSB while in most fertilizer treatments there was no significant difference (Table 4). The lowest thousand seed weight was recorded from control and the plot fertilized with recommended NPSB alone which was decreased by 9 and 8%, respectively from the highest TKW produced from those fertilized by 300 kg ha^{-1} NPSB. Abedi et al. (2011) who reported number seeds $spike^{-1}$ and 1000 grain weight were significantly enhanced by increasing nitrogen levels. However, the results were aligned with Khan et al. (2013) whereby nitrogen rates and sources significantly influence thousand seed weight. In 2018 cropping season there was a shortage of water after post anthesis to maturity according to Tiyo wereda meteorological data recorded (Table 8). Growth parameters, yield components, yield and quality attributes are highly influenced by water and environmental changes. Drought stress from anthesis to maturity, especially if accompanied by high temperatures, hastens leaf senescence; reduce mean kernel weight (Royo et al., 2000). Water stress imposed during later stages might additionally cause a reduction in number of kernels/ear and kernel weight (Gupta et al., 2001; Denčić et al., 2000). The result between varieties and blended fertilizer rates showed that there was highly significant ($p<0.01$) differences in grain yield. The interactions between varieties and blended fertilizer rates were found to be significantly ($p< 0.05$) affect grain yield. These indicating that the varieties grain yield was differently influenced by fertilizer rate (Table 9). Data for mean grain yield is presented in Table 10. The ultimate goal in crop production is maximum economic yield, which is a complex function of individual yield components in response to the genetic potential of the varieties and inputs used.

Table 4. Main effect of variety and blended fertilizer rate on germination date, seedling density, days to 50% heading, days to 90% maturity and plant height in 2018 cropping season at kulumsa field research experiment.

Fertilizer rates (kg ha^{-1})	GD	SD	DTH	DTM	PH (cm)
0 kg F ha^{-1}	6.2	21.1^{c}	61.3^{d}	106.2^{c}	75.6^{f}
150 kg TSP + 158.7kg Urea h^{-1}	6.0	23.4^{ab}	68.0^{bc}	109.7^{b}	90.5^{cd}
Rec. NPSB (100 kg ha^{-1})	6.0	22.7^{b}	61.0^{d}	106.7^{c}	83.0^{e}
100 kg NPSB + 100 kg Urea ha^{-1}	6.0	23.4^{ab}	63.3^{d}	108.8^{b}	87.6^{d}
150 kg NPSB + 100 kg Urea ha^{-1}	6.0	22.8^{ab}	66.5^{c}	109.8^{b}	92.3^{bc}
200 kg NPSB + 100 kg Urea ha^{-1}	6.2	23.2^{ab}	69.7^{ab}	112.3^{a}	92.6^{bc}
250 kg NPSB + 100 kg Urea ha^{-1}	6.0^{a}	23.4^{ab}	70.7^{a}	112.0^{a}	94.5^{ab}
300 kg NPSB + 100 kg Urea ha^{-1}	6.0	23.6^{a}	71.7^{a}	113.0^{a}	95.5^{a}
LSD (5%)	NS	0.92	2.72	1.49	3.18
CV (%)	3. 26	3.25	3.30	1.10	2.89

GD = Germination date, SD = Seedling density DTH = Days to 50% heading, DTM = Days to 90% maturity, PH = Plant height, NPSB = Nitrogen Phosphorus Sulfur, and Boron, LSD = Least Significant Difference, CV = Critical Value.

Table 5. Interaction effect of blended fertilizer rates and bread wheat varieties on productive tillers in 2018 cropping season in kulumsa research field experiment, south-eastern Ethiopia.

Fertilizer rates (kg ha^{-1})	Varieties	
	Wane	Kingbird
0 kg F ha^{-1}	4.4^{fg}	4.4^{fg}
150 kg TSP + 158.7 kg Urea h^{-1}	5.8^{bc}	4.8^{efg}
100 kg NPSB + 0 kg Urea ha^{-1}	4.8^{efg}	4.8^{efg}
100 kg NPSB + 100 kg Urea ha^{-1}	4.8^{efg}	5.2^{cde}
150 kg NPSB + 100 kg Urea ha^{-1}	$5.1d^{def}$	5.0^{defg}
200 kg NPSB + 100 kg Urea ha^{-1}	7.0^{a}	5.1^{def}
250 kg NPSB + 100 kg Urea ha^{-1}	7.3^{a}	5.5^{bcd}
300 kg NPSB + 100 kg Urea ha^{-1}	7.7^{a}	6.0^{b}
Mean	5.9	5.1
LSD (5%) 0.67		
CV (%) 7.33		

NPSB = Nitrogen Phosphorus Sulfur, and Boron, 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, ns: Not significant.

Table 6. Descriptions of the bread wheat varieties for the research conducted in Kulumsa, South-eastern Ethiopia during 2018 cropping season.

Variety name	Date of released	Potential yield (Qt ha^{-1})	Agro-ecology above-sea level (m)	Maturity date	Rainfall(mm)	Research center
Wane	2016	50 – 65	2000-2300	120	750-1500	Kulumsa
King Bird	2015	40 – 50	2000-2200	133	800-1000	Kulumsa

Source: Ethiopian institute of agricultural research, Ethiopian National wheat research program.

Results showed significant differences ($p<0.01$) among NPSB blended fertilizer rate treatments and varieties for productive tiller. However, the interaction effect of the two factors was not significant (Table 5). The mean productive tiller varied from the control (4.4%) to the highest 300 kg NPSB + 100 kg Urea ha^{-1} rates (7.7%). Variety *wane* had the highest mean productive tiller of 7.7% at a fertilizer rate of 300 kg NPSB + 100 kg Urea ha^{-1} and the lowest 4.8% to 100 kg NPSB + 0 kg Urea ha^{-1} rate were recorded. While Variety *kingbird* had the highest mean productive tiller of 6.0% at a fertilizer rate of 300 kg NPSB + 100 kg Urea ha^{-1} and the lowest 4.8% to 150 kg TSP + 158.7 kg Urea h^{-1}

Table 7. Main effect of variety and blended fertilizer rate on Spike length, Seeds per spike and thousand kernel weight in 2018 cropping season at Kulumsa, South-eastern Ethiopia.

Varieties	SL (cm)	SPS	TKW (gm)
Wane	6.5^{b}	45.2^{a}	37.0^{a}
Kingbird	7.3^{a}	43.1^{b}	35.3^{b}
LSD (%)	0.14	0.75	0.73
Fertilizer rates (kg ha^{-1})			
0 kg F /ha	6.4^{d}	32.3^{e}	33.9^{c}
150 kg TSP + 158.7kg Urea h^{-1}	7.0^{ab}	48.2^{b}	36.9^{ab}
100 kg NPSB	6.6^{cd}	34.0^{e}	34.4^{c}
100 kg NPSB + 100 kg Urea ha^{-1}	6.9^{bc}	39.9^{d}	35.9^{b}
150 kg NPSB + 100 kg Urea ha^{-1}	6.9^{bc}	44.5^{c}	36.7^{ab}
200 kg NPSB + 100 kg Urea ha^{-1}	7.1^{ab}	48.3^{b}	36.8^{ab}
250 kg NPSB + 100 kg Urea ha^{-1}	6.9^{bc}	52.2^{a}	37.2^{ab}
300 kg NPSB + 100 kg Urea ha^{-1}	7.3^{a}	53.9^{a}	37.3^{a}
LSD (5%)	0.28	1.49	1.45
CV (%)	3.34	2.73	3.24

SL = Spike length, SPS = Seeds per spick, TKW = Thousand kernel weight, NPSB = Nitrogen Phosphorus Sulfur, and Boron, 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, ns: Not significant.

Table 8. Average monthly minimum and maximum temperature and monthly total rainfall of the experimental site in Kulumsa, South-eastern Ethiopia in 2018 main cropping season.

Months	Rainfall (mm)	Min. Temp. (°C)	Max. Temp. (°C)
January	0.0	9.7	23.6
February	43.9	10.4	25.3
March	30.2	12.5	25.2
April	165.1	13.2	24.7
May	57.2	13.2	24.7
June	127.3	12.8	22.7
July*	121.6	11.7	21.4
August*	199.3	12.3	21.3
September*	70.2	12.0	22.8
October*	15.8	12.0	24.2
November*	31.5	11.5	23.4
December	0.6	10.4	24.0
Mean	71.89	11.8	23.6

and 100 kg NPSB + 0 kg Urea ha-1 rate were recorded. The differences in the number of tillers produced by the wheat varieties could be attributed to genetic differences (Alam et al., 2007).

Wane variety showed better performance of grain yield (4236kg ha^{-1}) at the highest rate of 300 kg NPSB fertilizer application which may be due to the highest response of cultivars to N and use efficiency. The lowest grain yield (2165kg ha^{-1}) was also recorded from control. But *Kingbird* variety showed better performance of grain yield (3737 kg ha^{-1}) at 200 kg NPSB fertilizer application, and the lowest yield (1991 kg ha^{-1}) at control. The grain yield obtained from *Wane* variety at 200 kg NPSB (3966 kg ha^{-1}), 250 kg NPSB (4107 kg ha^{-1}) and 300 kg NPSB (4236kg ha^{-1}) fertilizer rates applications was statistically non-significant from each other, but there was significant difference from the recommended NP (3562 kg ha^{-1}) (Table 7). Variety *Kingbird* was statistically non-significant between the treatments recommended NP (3647 kg ha^{-1}), 200 kg NPSB (3737 kg ha^{-1}), 250 kg NPSB (3499 kg ha^{-1}) and 300 kg NPSB (3682 kg ha^{-1}). The highest result of *Wane* and *Kingbird* were improved by 48.9% and 46.7%, respectively as compared to the lowest grain yield produced from control; and by 33.8% and 24.1% as compared to recommended NPSB alone for *Wane* and *Kingbird* varieties respectively. Mulugeta et al. (2017) reported that

Table 9. Analysis of variance for adjusted grain yield, harvest index, above ground biomass yield and straw yield of wheat as affected by variety and NPSB fertilizer rate at Tiyo Woreda in 2018 main cropping season.

Source of Variation	Mean Squares				
	DF	GY (kg h^{-1})	HI (%)	BY (kg h^{-1})	SY (kg h^{-1})
Replication	2	592030.75^{***}	10.22	1637593.3^{*}	314048.5
Varieties (V)	1	568763.02^{**}	0.05^{ns}	4264380.2^{**}	1718768.5^{*}
Fertilizer (F)	7	2398130.19^{***}	82.66^{***}	40594102.0^{***}	24086607.9^{***}
F x V	7	92637.07^{ns}	8.38^{ns}	1057381.9^{ns}	709206.7^{ns}
Error	30	38238.4	6.99	386091.3	343850.9
CV		5.82	7.30	6.53	9.52

AGY = Adjusted grain yield, HI = Harvest index, BY = Above ground biomass yield, SY = Straw yield, NPSB = Nitrogen Phosphorus Sulfur, and Boron, LSD = Least Significant Difference, CV = Critical Value. ns,*, ** ,*** = non significant, Significant, highly Significant, very highly Significant 5% and 1% probability level, respectively.

Table 10. Mean values of the interaction effect of blended fertilizer rates and bread wheat varieties on grain yield at kulumsa research field experiment in 2018 main cropping season, South-eastern Ethiopia.

Fertilizer rates (kg ha^{-1})		Grain Yield (kg/ ha) Varieties	
		Wane	Kingbird
0 kg F ha^{-1}		2165^{h}	1991^{h}
150 kg TSP + 158.7 kg Urea h^{-1}		3562^{cde}	3647^{cde}
100 kg NPSB + 0 kg Urea ha^{-1}		2806^{g}	2832^{fg}
100 kg NPSB + 100 kg Urea ha^{-1}		3425^{de}	3252^{ef}
150 kg NPSB + 100 kg Urea ha^{-1}		3489^{de}	3375^{de}
200 kg NPSB + 100 kg Urea ha^{-1}		3966^{abc}	3737^{bcd}
250 kg NPSB + 100 kg Urea ha^{-1}		4107^{ab}	3499^{de}
300 kg NPSB + 100 kg Urea ha^{-1}		4236^{a}	3682^{cd}
Mean		3469	3252
LSD (5%)	421.03		
CV (%)	7.53		

NPSB = Nitrogen Phosphorus Sulfur, and Boron, 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, ns: Not significant.

application of nutrients like K, S, Zn, Mg and B significantly increased grain yield and yield component of bread wheat as compared to the control (no fertilizer).

In this cropping season, the amount of yield production by different fertilizer rate was low when compared with the actual potential of varieties productivity. Because after anthesis to maturity in the cropping season of 2018 there was a shortage of rain (Table 8). These factors greatly affected the genetic potential of bread wheat varieties production capacity (Table 6) in the experimental sites. Grain yield is a complex polygenic trait influenced by genotype, environment and genotype x environment (GxE) interaction. According to Bukhat (2005), moisture stress is known to reduce biomass, tillering ability, grains per spike and grain size at any stage when it occurs. So, the overall effect of moisture stress depends on intensity and length of stress. Water stress imposed during later stages might additionally cause a reduction in number of kernels/ear and kernel weight (Gupta et al., 2001; Denčić et al., 2000). Grain yield is a function of yield components, so that any stress on growth and development phase of these traits do have a cumulative effect on the final grain yield and productivity.

Hussain et al. (2013) also reported that plants have limited nutrient uptake capacity and photosynthetic efficiency under heat and drought stress. These stresses can also reduce organ size (leaf, tiller, and spikes) and growth period for various development stages (tillering, jointing, booting, heading, anthesis, and grain filling). Laura et al. (2007) reported that water stress during grain filling period greatly reduced grain yield, and the yield reduction resulted from a little decrease of the number of kernels per spike and a great decrease of mean kernel weight. He demonstrated that post-anthesis water stress

Table 11. Analysis of variance for number of productive tillers per plant, Spick length, Seeds per spike and thousand kernel of wheat as affected by variety and NPSB fertilizer rate at Tiyo Woreda in 2018 main cropping season.

Source of Variation	Mean Squares				
	DF	PT (cm)	SL (cm)	SPS	TKW (g)
Replication	2	0.27	0.86***	40.61***	9.09**
Varieties (V)	1	7.52***	6.75***	56.12***	32.34***
Fertilizer (F)	7	4.59***	0.51***	390.40***	10.72***
F x V	7	1.09**	0.09ns	1.18ns	2.08ns
Error	30	0.18	0.05	1.45	1.37
CV		7.72	3.34	2.73	3.24

PT = Productive tillers, SL = Spike length, SPS = Seeds per spick, TKW = Thousand kernel weight, NPSB = Nitrogen Phosphorus Sulfur, and Boron, LSD = Least Significant Difference, CV = Critical Value. ns,** ,*** = non-significant, highly Significant, very highly Significant 5% and 1% probability level, respectively.

Table 12. Mean values of the interaction effect of blended fertilizer rates and bread wheat varieties on above ground Biomass Yield at kulumsa research field experiment in 2018 main cropping season.

Fertilizer rates (kg ha^{-1})		Above ground biomass Yield (kg /ha) Varieties	
		Wane	Kingbird
0 kg F ha^{-1}		5302^{i}	5053^{i}
150 kg TSP + 158.7 kg Urea h^{-1}		9581de	10167^{cd}
100 kg NPSB + 0 kg Urea ha^{-1}		7283^{gh}	6923^{h}
100 kg NPSB + 100 kg Urea ha^{-1}		8749^{ef}	8108^{fg}
150 kg NPSB + 100 kg Urea ha^{-1}		9905^{d}	8691^{ef}
200 kg NPSB + 100 kg Urea ha^{-1}		11281^{bc}	11498^{b}
250 kg NPSB + 100 kg Urea ha^{-1}		12392^{b}	11325^{b}
300 kg NPSB + 100 kg Urea ha^{-1}		14053^{a}	12009^{b}
Mean		9818	9222
LSD (5%)	1136.1		
CV (%)	7.18		

NPSB = Nitrogen Phosphorus Sulfur, and Boron, 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, ns: Not significant.

greatly reduced grain yield at all N rates. Analysis of variance for number of productive tillers per plant, Spick length, Seeds per spike and thousand kernel of wheat as affected by variety and NPSB fertilizer rate (Table 11).

The analysis of variance for above ground biomass yield between varieties and blended fertilizer rates and their interaction showed highly significant ($p<0.01$) differences (Table 9). Above ground biomass production of Wane variety (14053 kg ha-1) was better than Kingbird variety (12009 kg ha-1). The highest production of above ground biomass yield in Wane (14053 kg ha-1) and Kingbird varieties (12009 kg ha^{-1}) were recorded from those plants fertilized with 300 kg NPSB and the lowest (5302 kg ha^{-1}) and (5303 kg ha^{-1}) was obtained from the control treatments of the two varieties, respectively (Table 12). The above ground biomass yield obtained from *Wane* variety at 300 kg NPSB (14053kg ha^{-1}) was significantly different from other fertilizer treatments. On the other hand, *Kingbird* variety was statistically not-significantly different between the fertilizer treatments of 200 kg NPSB (11498 kg ha^{-1}), 250 kg NPSB (11325 kg ha^{-1}) and 300 kg NPSB (12009 kg ha^{-1}) (Table 7). The highest result of *Wane* and *Kingbird* was improved by 62.3 and 55.8% respectively as compared to the lowest biomass produced on the control of each; and by 48.2 and 42.3%, 31.8 and 16.3% as compared to recommended NPSB alone and recommended NP for both varieties, respectively. Even though in the application of recommended NPSB without supplementary urea and recommended NP fertilizer rate, the productions were low. The application of fertilizer treatment rates significantly improved the production of the biomass yield. According to Melkamu et al. (2019), blended fertilizer supply had a marked effect on the aboveground biomass, grain yield, and straw yield.

The main effect of variety and blended fertilizer rate exhibited significant ($p<0.05$) differences in straw yield, but their interaction was not significant (Table 13). *Wane* variety (6349 kg ha^{-1}) was more productive than *Kingbird*

Table 13. Mean values of the interaction effect of blended fertilizer rates and bread wheat varieties on hectoliter weight in 2018 cropping season at kulumsa research field experiment.

Fertilizer rates (kg ha^{-1})		Hectoliter Weight (kg/ ha) Varieties		
		Wane	Kingbird	Mean
0 kg F ha^{-1}		71.2^{ef}	71.3^{def}	71.3
150 kg TSP + 158.7 kg Urea h^{-1}		74.3^{a}	70.8^{ef}	72.6
100 kg NPSB + 0 kg Urea ha^{-1}		72.2^{bcde}	70.0^{f}	70.9
100 kg NPSB + 100 kg Urea ha^{-1}		73.7^{ab}	72.1^{bcde}	72.3
150 kg NPSB + 100 kg Urea ha^{-1}		73.2^{abc}	71.1^{ef}	72.2
200 kg NPSB + 100 kg Urea ha^{-1}		74.5^{a}	70.3^{ef}	72.7
250 kg NPSB + 100 kg Urea ha^{-1}		73.2^{abc}	70.4^{ef}	71.8
300 kg NPSB + 100 kg Urea ha^{-1}		72.0^{bcde}	71.7^{cde}	71.9
Mean		73.03	70.96	
LSD (5%)	1.91			
CV (%)	1.59			

NPSB = Nitrogen Phosphorus Sulfur, and Boron, 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, ns: Not significant.

variety (5970 kg ha^{-1}). The highest production of straw yield (9072 kg ha^{-1}) was recorded by those fertilized 300 kg NPSB and the lowest (3099 kg ha^{-1}) was from the control (Table 7). Wheat treated with 200 kg NPSB (7338 kg ha^{-1}), 250 kg NPSB (8056 kg ha^{-1}) and 300 kg NPSB (9072 kg ha^{-1}) fertilizer rates were significantly different from the recommended NP (6270 kg ha^{-1}) (Table 9). This difference might be attributed to the higher productivity of yield and yield components of *Wane* variety (Table 6). According to Abebe (2012), straw yield increased with increasing the fertilizer rates, whereby the lowest nitrogen increases vegetative growth of plants, especially at higher doses.

The analysis of variance for harvest index showed that main effect of blended fertilizer rates was significantly ($p<0.01$) affected, but not for varieties and their interaction effects (Table 9). The control treatment had resulted in the highest harvest index (40.1%) and the lowest (30.2%) was those fertilized by 300 kg NPSB (Table 7). Reductions in HI relative to the control were 8.5, 15.2, 20.2 and 24.2% due to recommended NP, 200, 250 and 300 kg blended fertilizer rate treatments, respectively. Fertilizer rate treatments significantly reduced harvest index as compared to the control. According to Abdulkerim et al. (2015), significant varietal differences on harvest index in bread wheat varieties were reported. A mean harvest index of about 50% with a positive trend due to increasing N rate was previously reported in Ethiopia (Taye et al., 2000). In contrast, Marcelo et al. (2013) reported that rates and sources of N did not affect harvest index of wheat.

Main effect of NPSB rate and varieties showed highly significantly ($p<0.01$) effect on thousand kernels weight, while the interaction effect was not significant (Table 14). Thousand kernels weight obtained from the overall fertilized plots was significantly higher than thousand kernels weight from the unfertilized/ control, plot which might be due to the improvement of seed quality and size due to balanced nutrients application. In line with this result, Rahman et al. (2011) reported maximum 1000 kernels weight (49.4 g and 46.6g).

Grain protein content of the experiment showed highly significant ($p<0.0001$) difference in the main effect of blended fertilizer rates and varieties. But the interaction between the two factors was non-significant (Table 15). Variety *Wane* gave the highest grain protein content of 11.5% whereas variety *Kingbird* gave significantly lower grain protein content of 10.8%. Fertilizer treatments above 200 Kg NPSB was not significantly different with the recommended NP (Table 10). Ferdoush and Rahman (2013) reported the protein content in wheat grains ranged from 9.23 to 15.11%.

There was a shortage of water in a cropping season after anthesis. This was consistent with the findings of Gooding et al. (2003) and Labuschagne et al. (2006), demonstrated that both N fertilization and post-anthesis water stress slightly increased grain protein concentration. The protein content in flour increases significantly with bread wheat as the result of the heat stress (Bencze et al. 2004; Balla and Veisz 2007; Labuschagne et al. 2009).

Main effect of blended NPSB fertilizer rates had highly significant ($p<0.01$) influence on grain yield. However, the main effect of the varieties and the interaction of the two factors were not significant (table 16). The number of kernels per spike was significantly affected by main effects of blended NPSB fertilizer and variety while the interaction of two factors was not significant (Table16). These components are in direct connection with productivity in wheat (Knezevic et al., 2007), which can modify under

Table 14. Main effect of variety and blended fertilizer rate on harvest index, straw yield and grain protein content in 2018 main cropping season in kulumsa research field experiment.

Verities	HI (%)	Straw yield (kg/ ha)	Grain Protein content (%)
Wane	36.24[a]	6349[a]	11.5[a]
Kingbird	36.17[a]	5970[b]	10.8[b]
LSD (%)	NS	363.06	0.19
Fertilizer rates (kg ha^{-1})			
0 kg F ha^{-1}	40.1[a]	3099[f]	9.2[c]
150 kg TSP + 158.7 kg Urea h^{-1}	36.7[bc]	6270[c]	12.1[a]
100 kg NPSB + 0 kg Urea ha^{-1}	39.7[ab]	4284[e]	9.3[c]
100 kg NPSB + 100 kg Urea ha^{-1}	39.7[ab]	5090[d]	11.4[b]
150 kg NPSB + 100 kg Urea ha^{-1}	37.1[ab]	5867[c]	11.3[b]
200 kg NPSB + 100 kg Urea ha^{-1}	34.0[cd]	7538[b]	11.8[a]
250 kg NPSB + 100 kg Urea ha^{-1}	32.0[de]	8056[b]	11.9[a]
300 kg NPSB + 100 kg Urea ha^{-1}	30.4[e]	9072[a]	12.0[a]
LSD (5%)	3.27	726.12	0.37
CV (%)	7.30	9.52	2.69

HI = Harvest index, SY = Straw yield, NPSB = Nitrogen Phosphorus Sulfur, and Boron, 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, ns: Not significant.

Table 15. Analysis of variance for hectoliter weight and grain Protein content of wheat as affected by variety and NPSB fertilizer rate in Kulumsa, South-eastern Ethiopia in 2018 main cropping season.

Source of Variation	Mean Squares		
	DF	Hectoliter weight (kg hl^{-1})	Grain Protein content (%)
Replication	2	8.21	0.12
Varieties (V)	1	50.84***	6.02***
Fertilizer(F)	7	2.48*	8.50***
F x V	7	3.08*	0.20[ns]
Error	30	0.87	0.09
CV		1.29	3.69

HLW=Hectoliter weight, P = Grain protein, NPSB = Nitrogen Phosphorus Sulfur, and Boron, LSD = Least Significant Difference, CV = Critical Value. ns,*,*** = non significant and very highly significant 5% and 1% probability level, respectively.

Table 16. Analysis of variance Mean values of the interaction effect of blended fertilizer rates and bread wheat varieties on productive tillers, hectoliter weight, grain yield, and above ground biomass yield of wheat at Tiyo Woreda in 2018 main cropping season.

Source of Variation	DF	Mean Squares			
		PT	HLW	GY (kg h^{-1})	BY (kg h^{-1})
Replication	2	0.14	8.15	591725	1638003
Varieties (V)	1	7.52***	51.17***	568538***	4264908***
Fertilizer (F)	7	4.44***	2.44*	2398243***	40591463**
F x V	7	1.32***	3.13**	92572*	1057213*
Error	30	0.16	1.32	64086	466667
CV		7.33	1.59	7.53	7.18

GY = Grain yield, HLW = Hectoliter weight, BY = Aboveground biomass yield, NPSB = Nitrogen Phosphorus Sulfur, and Boron, CV=Critical Value. ns,*, ** ,*** = non significant, Significant, highly Significant, very highly Significant 5% and 1% probability level, respectively.

different environmental factor including genetic factors.

As indicated in Table 8, the highest HLW were recorded in *Wane* variety from those plots fertilized with 200 kg NPSB (74.5 kg hl^{-1}) and 150 kg TSP (74.3 kg hl^{-1}) with supplementary urea, respectively. The lowest was obtained from *Kingbird* variety for plots treated with100 kg NPSB (70.0 kg hl^{-1}) with supplementary urea. This could be related to difference in variety with respect to applied fertilizer.

The result of the study affirmed that the value of HLW of the tested bread wheat varieties was medium. This is important to millers just as grain yield is important to wheat producer. Atwell (2001) who reported that, HLW may range from about 57.9 kg hL^{-1} for poor wheat to about 82.4 kg hL^{-1} for sound wheat. Gooding and Davies (1997) reported slight increase in HLW in response to N application under more favourable growing conditions. Tayyar (2010) report showed that HLW of the varieties significantly influenced by genotype. However, flour yield was decreased by water stress at jointing and dough stages compared with optimum irrigation (Day and Barmore, 1971).

Conclusions

The results showed that the soil of the study site was clay in texture (49% clay, 11.25% sand and 39.75% silt), medium (22.86 meq/100g) CEC value , high in bulk density (0.85 g/cm^3), slightly acidic (with pH value of 6.1), low in organic carbon (1.76%), total nitrogen (0.11%), available phosphorus (7.67 mg kg^{-1}), available boron (0.43 mg kg^{-1}) and available sulfur (2.09 mg kg^{-1}).

The results of phonological and growth parameters investigations showed that there was no significant differences due to varieties for germination date, sowing date, plant height and harvest index. On the other hand, number of days to 50% heading, number of days to 90% maturity, spike length, number of seeds per spike, thousand kernel weights, straw yield and grain protein content was significantly affected by varieties and fertilizer. Grain yield, above ground biomass yield, number of productive tillers and hectoliter weight were significantly affected by the interaction of varieties and fertilizer rate. With regard to yield components and growth parameters, *Wane* variety had better performance than *Kingbird* variety. Seeds per spike (53.9), thousand kernel weight (37.3 g), and straw yield (9072 kg ha^{-1}) were best performed at 300 kg NPSB treatment with supplementary urea; while low performance was recorded at control and from 73/69 kg recommended NP fertilizer for GPC (12.1%). The interaction of *Wane* and *Kingbird* varieties for the number of productive tillers (7.7, 6.0) and above ground biomass yield (14053 kg ha^{-1}, 12009 kg ha^{-1}), respectively had good performance at 300 kg NPSB fertilizer treatment with supplementary urea, and the least was observed at control for both varieties. Higher grain yield was obtained from *Wane* (4236 kg ha^{-1}) variety at 300 kg NPSB fertilizer treatment; but in *Kingbird* (3737 kg ha^{-1}) at 200 kg NPSB fertilizer treatment with supplementary urea was the best one. With respect to quality parameter, the highest HLW were recorded in *Wane* variety from those plots fertilized with 200 kg NPSB (74.5 kg hl^{-1}) and 150 kg TSP (74.3 kg hl^{-1}) with supplementary urea, respectively. The lowest was obtained from *Kingbird* variety for plots treated with100 kg NPSB (70.0 kg hl^{-1}) with supplementary urea. As a conclusion, since this study was conducted in one location for one season, it should be repeated in more locations and seasons for further recommendation under similar agro ecologies.

ABBREVIATIONS

GY, grain yield; **SD,** seedling density; **HLW,** hectoliter weight; **OM,** organic matter; **BY,** aboveground biomass yield; **DAP,** Di-Ammonium Phosphate; **PN,** phosphorus and nitrogen fertilizer; **PT,** productive tillers; **SY,** Straw yield; **PT,** Productive tillers; **NPSB,** Nitrogen Phosphorus Sulfur, and Boron; **CV,** Critical Value; **AGY,** Adjusted grain yield; **HI,** Harvest index; **SL,** Spike length; **SPS,** seeds per spick; **TKW,** Thousand kernel weight; **GD,** germination date; **LSD,** Least Significant Difference; **PH,** plant height; **SD,** seedling density.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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