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Interaction Effect of Blended (NPSB) Fertilizer Rates and Seed Sources on Yield Components and Seed Quality of Bread Wheat (*Triticum aestivum* L) Varieties in Southern Ethiopia

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Abstract

Low soil fertility and poor quality seed sources are the major yields and seed quality limiting constraints of bread wheat in Ethiopia. Therefore, a field experiment was conducted in Doyogana district during the 2020 cropping season to determine the interaction effect of blended fertilizer rates and seed sources on the yield and seed quality of bread wheat varieties. Factorial combinations of four blended NPSB levels (0, 75, 100 and 125 kg ha^{-1}), three seed sources (Research, C_2 and C_3) and three wheat varieties (Hidase, Digalu and Ogolicho) were laid out in randomized complete block design with three replications. A combined analysis of the results revealed that days to 50% heading, days to maturity and germination percentage were significantly affected by the main and their interaction effects of fertilizer rate and seed sources. Grain filling period, plant height and the number of kernels were significantly affected by the main effects of fertilizer and their interaction with seed sources whereas spike length, grain yield, 1000 kernels weight, speed of germination, seedling dry weight, seedling length, vigor index i and ii were significantly affected by 3-way interaction. The maximum values of grain yield were recorded in the interaction of 125 kg ha^{-1} NPSB fertilizer rates, seeds obtained from the research center and Hidase variety. Therefore, it could be concluded that the application of 125 kg blended NPSB fertilizer rate, seeds obtained from the research center and Hidase variety were economically profitable in the study area.

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Introduction

Wheat (*Triticum aestivum* L) is one of the most important cereals cultivated in Ethiopia (Jemal *et al.*, 2015). It belongs to the family Poaceae, subfamily Pooideae and tribe Triticeae (Clayton *et al.*, 2015). Wheat is a staple food that provides around 20% of protein and calories consumed worldwide (FAOSTAT, 2015). It has the highest content of protein of all the staple cereals and contains essential minerals, vitamins, and lipids. It is the primary source of protein in developing countries where 1.2 billion people are dependent on wheat for survival (CIMMYT, 2011). Bread wheat in Ethiopia is used in different forms such as bread, porridge, soup and roasted grain. In addition to the grain, the straw of bread wheat is used for animal feed, hatching roofs and bed decking. Wheat production in 2019 was 764.49 million tons around the globe. It ranks first in the world in cereal crops accounting for 30% of all cereal food worldwide (USDA, 2020). Ethiopia is one of the largest wheat producers in Sub-Saharan Africa, with a yearly estimated production of 4.5 million tons on 1.69 million hectares of land (CSA, 2019). The total wheat production in the Kambata zone is 152,153.6 tons with a productivity of 2.4 tons ha^{-1} in the 2018/19 cropping season (CSA, 2019) which is lower than the national average of 2.66 tons ha^{-1} (CSA,2019) and the world 2.8 tons ha^{-1} (USDA, 2019).

The low yield per hectare is attributed to many factors, among these inappropriate uses of fertilizer rate and unavailability of quality seed for varieties that are high yielding as well as adapted to a wide range of agro-ecologies of the country and the use of farm-saved poor quality seeds of local varieties are some of the major factors. Poor quality seed results in poor germination and poor crop stands on the farm and becomes a significant factor affecting wheat productivity (Bewley and Black, 1994). The low yield is also allied to the depletion of soil fertility due to continuous nutrient uptake of crops, low fertilizer use and insufficient organic matter application (Kidane Giorgis, 2015). Nutrient mining due to sub-optimal fertilizer use on one hand and unbalanced fertilizer use on the other has favored the emergence of multi-nutrient deficiency in Ethiopian soils (Haile and Boke, 2011). On the other hand, the sources of plant nutrients for Ethiopian agriculture over the past five decades have been limited to urea and Diammonium Phosphate fertilizers which contain only nitrogen and phosphorus that may not satisfy the nutrient requirements of crops (EthioSIS, 2014). Based on the national soil database, in addition to the macronutrients, due to long-year cultivation, some of the micronutrients like sulfur, zinc, boron, and copper are depleted from the soil in the major crop-producing area of the country. To avert the situation the Ministry of Agriculture of Ethiopia has recently introduced a new blended fertilizer (NPSB) containing nitrogen, phosphorous, sulfur and boron with a ratio of 18.9% N, 37.7% P_2O_5, 6.95% S, and 0.1% B (EthioSIS, 2014).

Increasing N fertilizer greatly affected grain yield and the quality of wheat protein content (Dawit *et al.*, 2015). Adequate phosphorus enhances many aspects of plant physiology like photosynthesis, flowering, seed maturity and seed development (Ziadi *et al.*, 2008). Sulfur is an essential nutrient required to build yield and achieve grain quality. Boron is essential for cell division and elongation in meristematic tissues, and floral organs and for flower male fertility, pollen tube germination along with it's and seed/fruit formation. Boron deficiency impairs grain setting in wheat, resulting in an increased number of open spikelet's and decreased number of grains per spike (Marschner, 1995). Therefore, the use of balanced fertilizers containing both macro and micronutrients, which is based on the site-specific soil fertility assessment, is believed to be one of the solutions for reducing such production constraints. The NPSB fertilizer and seed source and its effects on bread wheat yield components and seed quality have not been studied extensively. Information is lacking on the interaction effects of NPSB fertilizer rate with seed source on bread wheat yield and seed quality. However, limited research has been done to elucidate the response of bread wheat to mineral NPSB fertilizer rates application and seed source in the study area. Therefore, the present study was undertaken with the following objectives: to determine the interaction effects of seed sources and NPSB fertilizer rates on the productivity of bread wheat; to assess the effect of seed sources and NPSB fertilizer rates on seed quality of bread wheat varieties.

Materials and methods

Description of the experimental site

The field experiment was conducted at Sadicho Farmers Training Centre in Doyogana district, Southern Ethiopia during the main cropping seasons of 2020. The site is located at the latitude of 9^{o}07' to 9^{o}32'N, the longitude of 41^{o}29' - 41^o 44'E and an altitude of 1700 - 2800 meters above sea level. The experimental area is classified into *Dega* and *Weynadega* agro-climatic zones with an average annual temperature of 14.5 ^{o}C - 18 ^{o}C and 700 - 1100 mm of annual rainfall (Doyogana *Woreda* Agriculture and Natural Resource Office Report, 2020). A laboratory experiment was conducted at Wachemo University laboratories as per international seed testing association rules and procedures ISTA (2014).

Experimental materials

Three bread wheat varieties namely; Hidase, Digalu and Ogolicho were used as test crops at the experimental site. The seeds were collected from the research centre which was considered quality seeds and farmers saved seeds (C_2 and C_3) which represent low seed quality.

The seeds of the varieties from all sources were collected from the 2018/209 cropping season harvest. The farmers saved seeds were collected from six farmers each considered three bread wheat varieties in equal proportions as two composite samples for field and laboratory work. Different levels of blended fertilizer in the form of NPSB (18.9% N, 37.7% P_2O_5, 6.95% S, and 0.1% B) were used and it was applied at the time of planting.

Treatments and experimental design

In a field experiment with treatments of a factorial combination of four blended NPSB fertilizer levels (0, 75, 100 and 125 kg ha^{-1}), three varieties (Hidase, Digalu and Ogolicho) and three seed sources (research, FC_2 and FC_3 seeds) were used. The experiment was laid out in Randomized Complete Block Design (RCBD) in 4 x 3 x 3 factorial arrangements with three replications. Each plot size in the experiment was 2.75 m x 2 m, with 10 rows 20 cm apart giving a gross plot area of 5.5 m^2. Spacing of 1 m and 0.5 m was maintained between adjacent blocks and plots, respectively. All the required data were collected from the middle eight rows leaving the outermost rows on both sides and some distance at both ends as the border at each plot of the experiment based on the net harvestable plot area. The laboratory experiment was laid out as a Completely Randomized Design with three replications.

Experimental procedure and field management

Before planting soil samples were taken from the experimental site according to the appropriate sampling technique and subjected to soil analysis to determine the chemical and physical properties of the soil. The soil sample was taken from 0 to 30 cm depth of the experimental site by using an auger. While taking the sample zigzag method of soil sampling was implemented. A composite sample of 1 kg was prepared from the primary samples through the quartering method. After passing through the proper drying and grinding processes composite sample was submitted to the soil laboratory for the analysis of physical and chemical properties. Total nitrogen, available phosphorus, available boron, available sulphur, exchangeable potassium, organic matter, soil pH, and Cat ion exchange capacity (CEC) and soil texture are the chemical and physical properties were determined in the laboratory from the sample submitted.

The experimental field was prepared before sowing. Seeds were drilled in rows at depths of 4-5 cm. While experimenting all the necessary agronomic and management practices were carried out accordingly to the recommended practice for bread wheat except the different levels of blended NPSB fertilizer rates were studied.

Data collection and measurements

Days to 50% heading: Days to heading was recorded by counting the number of days from the date of sowing until when 50% of the plants in a plot produced spikes above the sheath of the flag leaf that was determined by visual observation.

Days to 90% physiological maturity: Days to physiological maturity was recorded by counting the number of days from date of sowing until when 90% of the plants changed green colour to yellowish, lose their water content and attain physiological maturity in each plot.

Grain filling period: The grain filling period was recorded by counting the number of days from heading to maturity, *i.e.* the number of days to maturity minus the number of days to heading.

Plant height (cm): It was measured in cm from ground level to the top of the spike excluding the awns from ten randomly pre-tagged plants at maturity time.

Spike length (cm): The main spikes from the ten sampled plants were measured in cm and the average represents the spike length in cm for each replication.

Number of kernels per spike: Number of kernels per spike was counted from ten randomly sampled plants.

Grain yield (kg): The plants in the central rows were harvested and threshed after sun-dried. Grain yield per hectare was calculated based on grain yield per plot and it was converted to kg ha^{-1}.

1000 kernels weight (g): It was determined based on the weight of 1000 seeds sample from the grain yields of each treatment by counting using an electric seed counter and weighted with an electronic balance and the weight was adjusted to 12.5% moisture level.

Germination test: The working samples consisted of 300 pure seeds in three replicates of 100 seeds each germinated in double moist filter paper. The seed was placed in each of the Petri dishes at a temperature of 25^{o}C under optimum relative humidity for eight days. The seed was checked every day and the papers were moistened with distilled water. At the end of the germination period, the seedlings were recorded as normal seedlings; abnormal seedlings; dead seeds and fresh seeds in accordance with the protocol described in ISTA (2014). The normal seedlings were considered those possessing well-developed and vigorous shoot and root systems. Seeds, which germinated, but did not fall to the normal seedlings, were categorized as abnormal seedlings. Fresh seeds are seeds that remain firm and apparently viable and un-germinated after the prescribed period. Dead seeds are one type of seed which at the end of the test period are neither hard nor fresh and have not produced seedlings. The present germination was determined by considering only the proportion of normal seedlings as follows:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds sown}} \times 100$$

Speed of germination: The same procedures were used with that of germination percentage, but the only difference was, the number of normal germinated seeds was recorded daily until there was no further germination. The germinated seedlings each day were removed after recording. The speed of germination was calculated by adding the quotients of daily counts of normal seedlings divided by the number of day's germination.

$$\text{Speed of Germination} = \frac{N1}{C1} + \frac{N2}{C2} + \cdots + \frac{NF}{CF}$$

Where: N1= number of normal seedlings at first count, N2= number of normal seedlings at the second count, NF= number of normal seedlings at final count, C1= days to the first count, C2= days to the second count and CF= days to the final count.

Seedling shoots and root length (cm): Seeds from the different treatments were germinated as per the standard germination test. At the end of the germination period, shoot and root length of five normal seedlings were measured. Shoot length was measured from the point of attachment to the seed to the tip of the seedling, and the average shoot length was calculated by dividing the total shoot length by the number of normal seedlings measured. Similarly, the root length was measured from the point of attachment to the seed to the tip of the root, and the average root length was computed by dividing the total root length by the total number of normal seedlings as per ISTA (2014) procedure.

Seedling vigor index i: To determine the seedling vigor index I, seedling lengths (shoot and root length) were measured on the day of the final count and determined by using the method developed by ISTA (2014) as follows: Seed vigor index I = GP × SL Where: GP = Germination Percentage; SL = Seedling Length Seedling vigor index ii: To determine the seed vigor index II, seedling dry weight was taken after the final count in grams using a sensitive balance and determined by using the method developed by ISTA (2014) as follows: Seed vigor index II = GP x SDW Where: GP = Germination Percentage; SDW = Seedling Dry Weight

Seedling dry weight (g): The weight of five normal seedlings randomly taken from normal germination percentage excluding the cotyledons was oven dried at 80°C for 24 hours and then the seedlings were transferred from the oven to desiccators with active silica jel and left for 30 minutes.

The seedling dry weight was determined after the final count in grams using a sensitive balance as per the ISTA (2014) procedure and the average seedling dry weight was calculated.

Statistical data analysis

Data were subjected to analysis of variance (ANOVA) using Gen Stat 15th edition statistical software package (Gen Stat, 2012). All treatment means were compared using the least significant difference (LSD) test at 5% level of significance.

Results and discussion

A composite sample was taken from 30 cm depth of the experimental site before sowing of the crop and the physico-chemical properties of the soil were analyzed at Wolaita Sodo soil laboratory. On the basis of particle size distribution, the soil contained 52% sand, 30% silt and 18% clay (Table 1).

Table 1. Physico-chemical properties of the top soil (0 to 30 cm) of the experimental fields.

Properties	Contents/ Values	Rating
Soil Ph	5.7	Moderately acidic
Organic carbon (%)	1.89	Medium
Total nitrogen (%)	0.169	Low
Available phosphorus (ppm)	7.570	Low
Exchangeable potassium (ppm)	3.153	Very high
Available Sulfur (mg kg^{-1})	17.18	Low
Available Boron (mg kg^{-1})	0.65	Medium
Particle size proportion (%)		
Sand	52	High
Silt	30	Moderate
Clay	18`	Low
Soil texture	Loam	

The results revealed that days to 50% heading, days to maturity, spike length, germination percentage, seedling dry weight and seedling vigor index ii were significantly affected by the main effects of fertilizer rate and seed sources. Grain filling period, plant height, number of kernels per spike, grain yield, 1000 kernels weight, speed of germination, seedling length and seedling vigor index i were also significantly affected by the main effects of fertilizer rates whereas days to 50% heading was affected by varieties. NPSB fertilizer and seed source interaction significantly affect days to 50% heading, days to maturity, grain filling period, plant height, spike length, number of kernels per spike, grain yield, 1000 kernels weight, germination percentage, speed of germination, seedling dry weight, seedling length, seedling vigor index i and ii. In addition, the number of kernels per spike was significantly influenced by the interaction of seed source and variety, while spike length, grain yield, 1000 kernels weight, speed of germination, seedling dry weight, seedling length, seedling vigor index i and ii were significantly affected by 3-way interaction.

The delayed days to 50% heading (58.33 days) and days to 90% physiological maturity (73.00) period were observed in plots that received 125 kg NPSB ha^{-1} fertilizer application and seeds obtained from the research center, while farmers seed 3 (FC_3) and control enhanced days to 50% heading (40.56 days) and days to 90% physiological maturity (57.56 days) (Table 2).

Table 2. Interaction effect of NPSB fertilizer and seed sources on days to 50% heading, days to 90% physiological maturity and grain filling period of bread wheat varieties at Sadicho.

NPSB fertilizer (kg ha^{-1})	Seed sources								
	Days to 50% heading			Days to 90% maturity			Grain filling period		
	FC_3	FC_2	R	FC_3	FC_2	R	FC_3	FC_2	R
0	40.56^{a}	42.89^{ab}	40.67^{a}	57.56^{a}	58.89^{ab}	59.56^{abc}	13.00^{a}	12.33^{a}	13.67^{a}
75	42.56^{ab}	41.11^{a}	49.11^{b}	58.89^{ab}	60.44^{abc}	59.00^{ab}	18.11^{bcd}	17.78^{bc}	16.22^{b}
100	45.22^{ab}	47.22^{ab}	46.78^{ab}	62.33^{cd}	62.11^{cd}	64.33^{d}	17.11^{b}	19.44^{cde}	20.56^{e}
125	43.56^{ab}	42.56^{ab}	58.33^{c}	61.11^{bc}	60.11^{abc}	73.00^{e}	20.22^{de}	20.89^{e}	24.89^{f}
LSD (0.05)		5.99			2.74			2.09	
CV (%)		14.2			4.8			12.5	

Means followed by the same letter (s) within a column are not significantly different at 5% level of significance, R = Research, FC_2 = Farmers seed 2, FC_3 = Farmers seed 3.

Delay of treated mean for days to heading and days to maturity might be due to adequate blended NPSB fertilizer having a great contribution to vigorous vegetative growth and development. The result is in conformity with the findings of Diriba, *et al* (2018) who reported that the longest days to heading (71.7) and physiological maturity (113.0) were observed at 300 kg of NPSB application with supplementary urea. The result of this study is also in agreement with the findings of Tagesse *et al.* (2017) which indicated the significant influence of blended NPS fertilizer on days to heading. The longest duration (24.89 days) of the grain filling period was recorded in the interaction of plots that received 125 kg NPSB ha^{-1} fertilizer and seeds obtained from the research center, while the shortest duration (12.33 days) of the grain filling period was recorded from farmers seed 2 (FC_2) and non fertilized once (Table 2). Bread wheat varieties with the longest grain filling period might be due to the time needed for plants to uptake the nutrient in the soil. This result was in agreement with the finding of Tilahun and Tamado (2016) who reported that increasing the rates of N supplemented from nil to the highest 92 kg N ha^{-1} increased days for the grain filling period by about 7.76%.

The highest plant height was recorded from the interaction of the highest blended fertilizer rate (125 kg NPSB ha^{-1}) and seeds obtained from the research center, while the shortest plant height was obtained from the control plot (0 kg NPSB ha^{-1}) and seeds obtained from farmers seed 2 (FC_2) (Table 3). The increased plant height in response to the increasing rate of blended NPSB fertilizer application from control to 125 kg NPSB ha^{-1} was probably due to the vital role of nitrogen fertilizer in promoting vegetative growth and resulted in a significant increase in plant height. Seeds obtained from the research center play a catalytic role i.e. high genetic purity and identity, as well as high physical, physiological and health quality.

Table 3. Interaction effect of NPSB fertilizer and seed sources on plant height and number of kernels per spike of bread wheat varieties.

NPSB fertilizer (kg ha^{-1})	Seed sources					
	Plant height			Number of kernels per spike		
	FC_3	FC_2	R	FC_3	FC_2	R
0	126.1^{a}	124.2^{a}	133.7^{b}	36.78^{a}	36.22^{a}	40.11^{ab}
75	143.5^{cd}	142.7^{cd}	140.7^{c}	57.96^{cd}	48.90^{bc}	53.56^{cd}
100	151.7^{ef}	150.7^{ef}	147.1^{de}	55.69^{cd}	60.31^{d}	59.71^{d}
125	150.0^{ef}	147.4^{de}	154.8^{f}	56.22^{cd}	59.27^{d}	76.78^{e}
LSD (0.05)	5.495			9.074		
CV (%)	4.1			18.1		

Means followed by the same letter (s) within a column are not significantly different at 5% level of significance, R = Research, FC_2 = Farmers seed 2, FC_3 = Farmers seed 3.

This result is in agreement with that of Melesse (2017) who reported that the application of N and P fertilizer rates highly significantly increased the plant height of bread wheat. Dagne (2016) also reported that the application of blended fertilizer NPKSBZn (26:11:11:3.5:0.15:0.6) kg ha^{-1} with micronutrient Cu+Zn (5+5 ha^{-1}) increased plant height of maize by 66.81% over control plot and 6.11% over the recommended NP fertilizers. Number of kernels per spike is an important yield participating parameter and has a direct consequence on the grain yield of wheat. Higher number of kernels per spike was recorded from the interaction of the highest blended fertilizer rate (125 kg NPSB ha^{-1}) and seeds obtained from the research center, while the lower number of kernels per spike was recorded from the control treatment and seeds obtained from farmers seed 2 (FC_2) (Table 3). The number of kernels per spike was more enhanced by NPSB might be due to the fact that P is essential in the development of grains.

This result is in agreement with that of Rut Duga *et al.* (2018) who reported that the number of seed per spike becomes significantly increased as the rate of NPSB application increased from 0 to 300 kg ha^{-1}. But disagree with that of Tilahun and Tamado (2016) who reported that non-response of number of kernels per spike to applied NPS and N rates.

Table 4. Interaction effect of NPSB fertilizer, seed sources and varieties on spike length of bread wheat varieties.

NPSB fertilizer (kg ha^{-1})	Seed sources	Varieties		
		Digalu	Ogolicho	Hidase
0	FC_3	5.917^{ab}	6.167^{a-d}	6.500^{a-f}
	FC_2	5.567^{a}	6.417^{a-f}	6.267^{a-e}
	R	6.167^{a-d}	6.000^{abc}	6.500^{a-f}
75	FC_3	7.600^{b-g}	7.383^{a-g}	7.700^{b-g}
	FC_2	7.133^{a-g}	6.900^{a-f}	7.500^{a-g}
	R	7.100^{a-g}	7.617^{b-g}	7.867^{b-g}
100	FC_3	9.000^{gh}	7.967^{c-g}	7.983^{c-g}
	FC_2	7.767^{b-g}	8.100^{d-g}	8.200^{efg}
	R	8.350^{fg}	8.217^{efg}	8.033^{d-g}
125	FC_3	7.833^{b-g}	7.867^{b-g}	7.900^{b-g}
	FC_2	8.167^{d-g}	8.167^{d-g}	7.967^{c-g}
	R	10.433^{h}	14.833^{i}	16.000^{i}
LSD (0.05)		1.6194		
CV (%)		12.6		

Means followed by the same letter (s) within a column are not significantly different at 5% level of significance, R = Research, FC_2 = Farmers seed 2, FC_3 = Farmers seed 3.

The tallest spike length was recorded from the treatment combinations with highest NPSB fertilizer rate (125 kg NPSB ha^{-1}), seeds obtained from research center and Hidase variety, while the shortest spike length was obtained from control treatment, seed obtained from farmers seed 2 (FC_2) and Digalu variety (Table 4). This may be due to different varieties may have different yield performing abilities genetically and an increase in spike length at the highest NPSB rate might have resulted from improved root growth and increased uptake of nutrients and better growth favoured due to the synergetic effect of the nutrients at the highest rate. This result agrees with the findings of Demisew (2017) that indicated NPS fertilizer could increase spike length positively.

Table 5. Interaction effect of NPSB fertilizer, seed sources and varieties on grain yield and 1000 kernels weight of bread wheat varieties.

NPSB (kg ha^{-1})	Seed sources	Varieties					
		Grain yield (kg)			1000 kernels weight (g)		
		Digalu	Ogolicho	Hidase	Digalu	Ogolicho	Hidase
0	FC_3	2820.0^{bc}	1900.3^{a}	1980.0^{a}	39.53^{c-f}	35.57^{bcd}	32.67^{ab}
	FC_2	2590.7^{abc}	2290.3^{ab}	2090.3^{ab}	34.57^{abc}	40.10^{c-f}	29.67^{a}
	R	2250.7^{ab}	2620.7^{abc}	3130.3^{cd}	35.67^{bcd}	33.00^{ab}	37.43^{b-e}
75	FC_3	4400.4^{e-h}	4080.0^{efg}	3600.3^{de}	39.60^{c-f}	39.97^{c-f}	43.83^{f-i}
	FC_2	4200.7^{efg}	4220.0^{efg}	4630.0^{f-i}	43.43^{f-i}	41.40^{e-h}	39.67^{c-f}
	R	4250.3^{efg}	4740.7^{ghi}	4520.0^{fgh}	39.57^{c-f}	44.10^{f-i}	42.83^{e-i}
100	FC_3	4310.4^{efg}	4310.9^{efg}	4610.4^{f-i}	44.07^{f-i}	46.00^{ghi}	42.37^{e-h}
	FC_2	4540.0^{fgh}	4630.0^{f-i}	4740.0^{ghi}	40.57^{d-g}	40.37^{d-g}	43.03^{e-i}
	R	4590.0^{fgh}	4420.0^{e-h}	4660.3^{f-i}	40.93^{d-h}	40.63^{d-g}	43.97^{f-i}
125	FC_3	5250.7^{hij}	5450.3^{ij}	3850.3^{def}	46.50^{hi}	44.27^{f-i}	43.37^{f-i}
	FC_2	5560.7^{jk}	4770.7^{ghi}	4500.7^{fgh}	41.93^{e-h}	45.33^{f-i}	44.00^{f-i}
	R	6270.0^{kl}	6500.7^{l}	6740.0^{l}	48.50^{ij}	48.43^{ij}	52.33^{j}
LSD (0.05)		72.35			4.704		
CV (%)		10.7			7.0		

Means followed by the same letter (s) within a column are not significantly different at 5% level of significance, R = Research, FC_2 = Farmers seed 2, FC_3 = Farmers seed 3.

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. The maximum grain was obtained from 3-way interaction in response to the application of 125 kg ha^{-1} blended NPSB fertilizer, seeds obtained from the research center and Hidase variety, while the minimum grain yield was obtained from control treatment, seed obtained from farmer's seed 3 (FC_3) and Ogolicho variety (Table 5). The minimum grain yield obtained from farmer's seed 3 and Ogolicho variety might be due to low adaptation to agroecology and poor quality seed sources with respect to agronomic management. This result agrees with the findings of Alemayehu *et al.* (2015) who reported that using Kersey Local Seed Business Project seed increases yield by about 23.14% over farmers-saved seeds. The highest grain yield at the highest NPSB rates might have resulted from improved root growth and increased uptake of nutrients and better growth favored due to the synergetic effect of the four nutrients which enhanced yield components and yield. Nitrogen affects the vegetative as well as yields whereas phosphorus plays a fundamental role in metabolism and energy producing a reaction and can withstand adverse environmental conditions, thus resulting in enhanced grain yield. The result is in conformity with the findings of Tilahun and Tamado (2016) who reported that by increasing the rates of blended NPS fertilizer from 100 to 200 kg ha^{-1} and supplemented N from 0 to 92 kg ha^{-1}, the grain yield showed a consistent increase. Also Males *et al.* (2017) reported that the application of 100 kg N ha^{-1} in combination with 13.6 kg S ha^{-1} resulted in highest grain yield of 9.26 tons ha^{-1} while the lowest 3.47 tons ha^{-1} was recorded from the control plot for winter wheat. The application of increasing blended fertilizer rates in the experimental area increased the seeds size and the amount of powder of bread wheat varieties.

Table 6. Interaction effect of NPSB fertilizer and seed sources on germination test of bread wheat varieties.

NPSB fertilizer (kg ha^{-1})	Seed sources		
	FC_3	FC_2	R
0	83.67^{ab}	81.11^{a}	85.67^{abc}
75	94.22^{fg}	89.44^{c-f}	91.00^{def}
100	92.89^{efg}	89.11^{cde}	92.67^{efg}
125	86.89^{bcd}	86.56^{bcd}	97.11^{g}
LSD (0.05)		4.399	
CV (%)		5.3	

Means followed by the same letter (s) within a column are not significantly different at 5% level of significance, R = Research, FC_2 = Farmers seed 2, FC_3 = Farmers seed 3.

The maximum thousand kernels weight (52.33 g) was recorded from the treatment combinations with highest NPSB fertilizer rate (125 kg NPSB ha^{-1}), seeds obtained from research center and Hidase variety, while the minimum thousand kernels weight (29.67 g) was obtained from control treatment, seed obtained from farmers seed 2 (FC_2) and Hidase variety (Table 5). Higher thousand kernels weight might be due to the reflection of improved nutrient use efficiency as a result of increased application of blended fertilizer levels. This result is in line with Muhammad *et al.* (2009) who reported that applying both micro (especially Zn and B) and macronutrient and when N -level application increase there is a positive impact on the yield component of the wheat crop, especially on 1000 seed weight.

The maximum germination percentage was observed due to the interaction of the highest blended fertilizer rate (125 kg NPSB ha^{-1}) and seeds obtained from research center, while the minimum germination percentage was recorded from the control treatment and seeds obtained from farmers seed 2 (FC_2) (Table 6). NPSB fertilizer increases, increase germination of the seed. The possible reason for the maximum germination percentage might be due to N, P, B and S are the main components of the cell that facilitate activity during cell division, which is a sequential event in seed germination.

The variety obtained from research center, which had high germination percentage could be considered high quality seeds. This is because the germination percentage is one of the seed quality and vigourisity parameters. This result agrees with the findings of White and Veneklaas (2012) who reported that NP fertilizer increase germination by playing an important role in energy supplying and cell biosynthesis reactions, especially during germination seedling establishment. The maximum speed of germination was observed from 3-way interaction in response to application of 125 kg ha^{-1} blended NPSB fertilizer, seeds obtained from research center and Hidase variety, while the minimum speed of germination was obtained from control treatment, seed obtained from farmers seed 2 (FC_2) and Ogolicho variety (Table 7). Wheat varieties with the maximum speed of germination might be due to N, P and S are the main components of the cell that facilitate activity during cell division.

Table 7. Interaction effect of NPSB fertilizer, seed sources and varieties on speed of germination of bread wheat varieties.

NPSB fertilizer (kg ha^{-1})	Seed sources	Varieties		
		Digalu	Ogolicho	Hidase
0	FC_3	20.49^{c-h}	14.77^{ab}	16.07^{a-e}
	FC_2	15.45^{a-d}	14.44^{a}	15.26^{abc}
	R	14.49^{a}	16.80^{a-f}	15.12^{abc}
75	FC_3	22.17^{fgh}	23.66^{gh}	24.12^{gh}
	FC_2	22.41^{fgh}	22.03^{fgh}	20.94^{dh}
	R	22.53^{fgh}	18.71^{a-g}	20.11^{a-h}
100	FC_3	22.41^{fgh}	23.52^{gh}	22.05^{fgh}
	FC_2	23.56^{gh}	23.76^{gh}	21.28^{e-h}
	R	24.64^{gh}	24.00^{gh}	23.56^{gh}
125	FC_3	23.79^{gh}	23.87^{gh}	19.35^{a-g}
	FC_2	24.42^{gh}	20.30^{b-h}	24.17^{gh}
	R	22.82^{gh}	26.00^{h}	31.25^{i}
LSD (0.05)		4.798		
CV (%)		13.9		

Means followed by the same letter (s) within a column are not significantly different at 5% level of significance, R = Research, FC_2 = Farmers seed 2, FC_3 = Farmers seed 3.

The variety obtained from research center, which had high speed of germination could be considered high quality seeds. Variation in speed of germination might be inherent nature of the crop of bread wheat varieties. The varieties, which had high speed of the germination, could be considered high quality seeds. This is because the speed of germination is one of the seed quality and vigourisity parameters. This result is in line with the findings of White and Veneklaas (2012) who reported that NP fertilizer increase speed of germination by playing an important role in energy supplying and cell biosynthesis reactions, especially during germination seedling establishment. Khan, *et al.* (2003) also showed that quality seed plays an important role in germination and seedling vigour and ultimately for seed yield. The tallest seedling length was recorded from 3-way interaction of 125 kg ha^{-1} blended NPSB fertilizer, seeds obtained from research center and Hidase variety, while the shortest seedling length was obtained from control treatment, seed obtained from farmers seed 2 (FC_2) and Hidase variety (Table 8). Seed sources which produced in different management practices have different potential of germination and potentiality of seedling length. Seeds obtained from research center had heavier seed weight results well-developed shoot and root systems that can withstand any adverse conditions and provide better seedling emergence and seedling establishment in the field. This result was in agreement with the findings of Gharineh and Moshatati (2012) who reported that more seedling length and seedling weight of the heavy seeds might be attributed to large food reserves of the seeds.

The highest seedling dry weight was recorded from 3-way interaction of 125 kg ha^{-1} blended NPSB fertilizer, seeds obtained from research center and Hidase variety, while the lowest seedling dry weight was obtained from control treatment, seed obtained from research and Hidase variety (Table 8). As increasing NPSB fertilizer level seedling dry weight increases. The possible reason for the highest seedling dry weight might be due to NPSB fertilizer had contributions to shoot and root development. This result was in agreement with the finding of Demisew Amare (2017) who reported that application of 150 kg NPS rate increased seedling dry weight by 26.29% than non- fertilized.

Table 8. Interaction effect of NPSB fertilizer, seed sources and varieties on seedling shoots and root length and seedling dry weight of bread wheat.

NPSB fertilizer (kg ha^{-1})	Seed sources	Varieties					
		Seedling length (cm)			Seedling dry weight (g)		
		Digalu	Ogolicho	Hidase	Digalu	Ogolicho	Hidase
0	FC_3	18.83^{ab}	21.00^{bc}	21.43^{bc}	0.02600^{ab}	0.03167^{a-d}	0.02300^{a}
	FC_2	25.60^{def}	21.17^{bc}	17.33^{a}	0.02200^{a}	0.02733^{abc}	0.02567^{ab}
	R	21.83^{bc}	23.50^{cd}	21.67^{bc}	0.02733^{abc}	0.03000^{abc}	0.02133^{a}
75	FC_3	27.40^{ef}	24.53^{cde}	28.17^{ef}	0.03533^{a-d}	0.03567^{a-d}	0.03367^{a-d}
	FC_2	27.33^{ef}	27.93^{ef}	26.30^{def}	0.03400^{a-d}	0.03400^{a-d}	0.03500^{a-d}
	R	27.57^{ef}	26.10^{def}	26.73^{def}	0.03533^{a-d}	0.04133^{bcd}	0.03567^{a-d}
100	FC_3	27.67^{ef}	26.40^{def}	27.03^{def}	0.03267^{a-d}	0.03467^{a-d}	0.03600^{a-d}
	FC_2	26.73^{def}	26.37^{def}	29.07^{f}	0.03400^{a-d}	0.04467^{cde}	0.04333^{bcd}
	R	27.67^{ef}	28.00^{ef}	28.03^{ef}	0.04167^{bcd}	0.04800^{de}	0.03400^{a-d}
125	FC_3	28.27^{ef}	29.20^{f}	27.93^{ef}	0.03800^{a-d}	0.03367^{a-d}	0.03300^{a-d}
	FC_2	28.20^{ef}	27.90^{ef}	26.13^{def}	0.03833^{a-d}	0.03600^{a-d}	0.03000^{abc}
	R	28.50^{f}	27.90^{ef}	34.17^{g}	0.03167^{a-d}	0.05933^{e}	0.08200^{f}
LSD (0.05)		3.140			0.014208		
CV (%)		7.4			24.4		

Means followed by the same letter (s) within a column are not significantly different at 5% level of significance, R = Research, FC_2 = Farmers seed 2, FC_3 = Farmers seed 3.

As increasing NPSB fertilizer level, speed of germination, germination percentage, seedling length and seedling dry weight increases and consequently increase vigourity. Seed obtained from farmers seed 2 (FC_2) had lower vigor index i and ii as compared to research seed (Table 9).

Table 9. Interaction effect of NPSB fertilizer, seed sources and varieties on seedling vigor index i and ii of bread wheat varieties.

NPSB fertilizer (kg ha^{-1})	Seed sources	Varieties					
		Seedling vigor index I			Seedling vigor index II		
		Digalu	Ogolicho	Hidase	Digalu	Ogolicho	Hidase
0	FC_3	15.99^{ab}	17.19^{abc}	18.06^{bc}	0.02227^{a-d}	0.02243^{a-e}	0.01948^{abc}
	FC_2	20.65^{cde}	17.70^{abc}	13.70^{a}	0.01764^{a}	0.02649^{a-f}	0.02034^{abc}
	R	19.13^{bcd}	20.30^{cde}	17.96^{bc}	0.02394^{a-f}	0.02598^{a-f}	0.01777^{ab}
75	FC_3	26.14^{fg}	23.53^{efg}	25.83^{fg}	0.03372^{b-g}	0.03411^{c-g}	0.03082^{a-g}
	FC_2	25.27^{fg}	25.57^{fg}	22.38^{def}	0.03133^{a-g}	0.03105^{a-g}	0.02958^{a-g}
	R	24.75^{efg}	23.91^{efg}	24.41^{efg}	0.03177^{a-g}	0.03766^{d-g}	0.03267^{a-g}
100	FC_3	26.17^{fg}	24.41^{efg}	24.70^{efg}	0.03095^{a-g}	0.03215^{a-g}	0.03288^{a-g}
	FC_2	24.50^{efg}	23.15^{d-g}	25.73^{fg}	0.03105^{a-g}	0.03911^{fg}	0.03837^{efg}
	R	24.18^{efg}	26.49^{fg}	27.01^{fg}	0.03648^{d-g}	0.04459^{g}	0.03275^{a-g}
125	FC_3	24.78^{efg}	25.48^{fg}	23.90^{efg}	0.03329^{a-g}	0.02940^{a-g}	0.02831^{a-f}
	FC_2	24.78^{efg}	23.96^{efg}	22.45^{def}	0.03371^{b-g}	0.03096^{a-g}	0.02571^{a-f}
	R	26.96^{fg}	27.26^{g}	33.83^{h}	0.02990^{a-g}	0.05811^{h}	0.08118^{i}
LSD (0.05)		3.754			0.012845		
CV (%)		9.9			24.5		

Means followed by the same letter (s) within a table are not significantly different at 5% level of significance, R = Research, FC_2 = Farmers seed 2, FC_3 = Farmers seed 3.

The possible reason for the lowest vigor index i and ii might be due to its lower standard germination percentages, hundred kernel weight, seedling length and seedling dry weight. This result was in conformity with that of Khan (2003) who reported that with increase in thousand grain weight, significantly increased seedling length and dry weight that was effective measures of vigor.

Conclusions

In spite of its tremendous importance, wheat production in Ethiopia faced immense production constraints that are affecting both its yield potential and quality. The results of yield components and seed quality investigations showed that days to 50% heading, maturity, grain filling period, plant height, number of kernels per spike and germination percentage were significantly affected by the interaction effects of fertilizer rate and seed sources, while spike length, grain yield, 1000 kernels weight, speed of germination, seedling dry weight, seedling length, seedling vigor index i and ii were significantly affected by 3-way interaction. The maximum values of all parameters were recorded in the interaction of 125 kg ha^{-1} blended NPSB fertilizer, seeds obtained from the research center and Hidase variety.

Therefore, the application of NPSB at the rate of 125 kg ha^{-1}, seeds obtained from the research center and Hidase variety were economically profitable and recommended for farmers around Sadicho district and other areas with similar agroecology.

Conflict of interest

The authors declare no conflict of interest.

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