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RESEARCH PAPER

Effects of Seed and NPS Fertilizer Rates on Yield Components and Yield of Bread Wheat (Triticum aestivum L.) in East Badawacho District, Southern Ethiopia

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Abstract

Low soil fertility and use of inappropriate seeds rates are among the major constraints limiting the productivity of bread wheat in Ethiopia in general and in the study area in particular. Thus, a field experiment was conducted to assess the effects of rates of seed and sulfur NPS fertilizer rates on growth, yield components and yield of bread wheat. Factorial combinations of three seed rates (100, 125 and 150 kg ha^{-1}), and five rates of NPS (0, 50, 100, 150, and 200 kg ha^{-1}) fertilizer, and blanket recommendation of 100 kg ha^{-1} of Di-ammonium phosphate were used for the study. The treatments were laid out in a Randomized Complete Block Design with three replications. The main effect of NPS fertilizers and seed rates significantly ($P < 0.01$) affected on yield and yield components of bread wheat. The highest spike length (7.77 cm), number of kernels per spike (61.5), and total dry biomass yield (12303 kg ha^{-1}) recorded at 200 kg NPS ha^{-1}, while the highest harvest index (0.42) was recorded at 150 kg NPS ha^{-1}. Similarly, the highest spike length (7.72 cm) and number of kernels per spike (56.85) were obtained at a seed rate of 100 kg ha^{-1}, while the highest aboveground dry biomass yield (11568 kg ha^{-1}) and harvest index (0.41) were recorded at seed rate of 150 kg ha^{-1}. The interaction of seed and fertilizer rates gave significantly the highest number of productive tillers per m2 (413) and the maximum grain yield (6250 kg ha^{-1}) at the combination of 200 kg NPS ha^{-1} with 150 kg seed rate ha^{-1}. The partial budget analysis showed the highest net return (44878.2 birr ha^{-1}) with marginal rate of return 97.7% was obtained from a combination of 200 kg NPS ha^{-1} with seed rate of 150 kg ha^{-1}. Thus, it can be concluded that seed rate of 150 kg ha^{-1} and 200 kg NPS ha^{-1} to be appropriate for bread wheat production in the study area.

Keywords: Bread wheat, Hidase, Nitrogen, Partial budget analysis, Phosphorus

Introduction

Wheat is one of the major staple and strategic food security crops in Ethiopia. It was cultivated on about 1.69 million hectares and contributed about 4.54 million tons of grain yields in the country in 2016/2017 main cropping season, which makes Ethiopia the second largest wheat producer in sub Saharan Africa next to South Africa (CSA, 2017). Bread wheat covers about 60% of the total wheat area while durum wheat covers about 40% (Alemayehu et al., 2011).

Bread wheat is also one of the most important crops in South Region and it is the third important crop next to maize and tef in area coverage and second in productivity (2584 kg ha^{-1}) after maize (3364 kg ha^{-1}). The total wheat cultivated area and production in the South Region in 2017 were reported as 127,211.62 ha and 3287,759.19 tons, with the productivity of 2584 kg ha^{-1} (CSA, 2017).

The study area (Hadiya Zone) is also one of the major bread wheat producing Zones of Southern Nations, Nationalities and Peoples Region that covered an area of 35,795.2 ha with production of 102,894.7 tons and yield of 2.87 t ha^{-1} in 2016/17 cropping season (CSA, 2017). However, grain yield of wheat in Ethiopia (2. 67t ha^{-1}) in general and in the study zone in particular is low as compared to the attainable yield of 5 t ha^{-1} (MoA, 2012). Diseases, poor soil fertility, moisture stress, slow progress in developing wheat cultivars with durable resistance to diseases and inappropriate seed and fertilizer rate are most important constraints limiting wheat production in Ethiopia and in study area. Among the several factors responsible for low yield in Ethiopia, the use of low and unbalanced rate of fertilizers and inappropriate seed rats are important agronomic factors (Teklu and Hailemariam, 2009).

Soil erosion and nutrient mining due to sub optimal and unbalanced fertilizer uses have favored the emergence of multi-nutrient deficiency in Ethiopian soils (Agegnehu et al., 2013; Zeleke et al., 2010). Di-ammonium phosphate (DAP) and urea have been the only chemical fertilizers used for crop production with initial understanding that nitrogen and phosphorus are the major limiting nutrients of Ethiopian soils. However, in addition to N and phosphorus (P), sulfur (S), boron (B) and zinc (Zn) deficiencies are widespread in Ethiopian soils (EthioSIS, 2013).

Several researchers in Ethiopia have reported the role of N and P in wheat production in the highlands as substantial increases in yield and yield components have been obtained with the application of N and P fertilizers (Amanuel et al., 2000; Muluneh and Nebyou, 2016). Sulfur is also required for the synthesis of S containing amino acids such as cystine, cysteine and methionine. Sulfur addition showed increased N uptake when S was applied at the highest N rate, indicating a synergism between both nutrients (Fernando et al., 2009). Higher wheat grain yield with better quality requires appropriate seeding rate for different cultivars. Increase in seed rate above optimum level may only enhance production cost without any increase in grain yield (Rafique et al., 2010). Stand densities above the optimum may increase disease, plant height and lodging and do not result in higher yield. On the other hand, if less seed rate is used, yield will be less due to lesser number of plants per unit area due to less efficient utilization of growth resources (Hamid et al., 2002). Hence, achieving higher agronomic performance and better end-use quality requires optimizing and periodically reviewing management practices such as seeding rates (Asnakew et al., 1991).

The farmers in the study area use blanket recommendation of nitrogen (64 kg N ha^{-1}) and phosphorus (46 kg P2O5 ha^{-1}), i.e. 100 kg Urea and 100 kg DAP per ha^{-1} 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) (EthioSIS, 2013; Lelago et al., 2016). Except the blanket recommendation of nitrogen and phosphorus, the effect of other fertilizers on yield components and yield of bread wheat in the study area are unknown. According to the soil analysis map of EthioSIS the nutrient N, P and S is majour deficint nutrients in the destrict. The farmers in the study area started to use new compound fertilizer such as NPS (19% N, 38% P2O5 and 7% S). However, the rate of this fertilizer was not experimentally determined particularly for the study area for bread wheat production. The farmer in the study area use 100 kg blanket national recomandation of NPS fertilizer. Similarly, farmers in the study area use blanket recommendation of 125 kg ha^{-1} seed rate (Woreda agricultural office). However, the optimum seed rate, fertilizer type and rate at one site may not be applied at other locations because of variation in weather, soil type, soil moisture, varieties of crops, management practices, etc. which indicates the need to develop location or agro ecologic based recommendation of fertilizer and seed rates.

Therefore, this study was conducted to assess the effect of rates of seed and NPS fertilizer on growth, yield components and yield of bread wheat.

Materials and methods

Description of the Study Area

The experiment was conducted at Bantewosan Farmers' Training Centre (FTC), in East Badawacho District, Hadiya Zone during main rainy season from July to October in 2017/18. East Badawacho District is located in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) between 7° 00' 05''N - 7°18' 35'N latitude and 37° 52' 0'E - 38° 11'0''E longitude. East Badawacho district is located at 277 km in the south of Addis Ababa, capital city of Ethiopia. The elevation at study site is 1850 m above sea level. It receives mean annual rainfall 1050 mm and the annual average minimum and maximum air temperatures are 11.81 °C and 27.74 °C, respectively (MBWOA, 2017).

Treatments and experimental design

The treatments consisted of factorial combination of three wheat seeding rates (100, 125 and 150 kg ha-1) and five levels of NPS (0, 50, 100, 150, 200 kg ha^{-1}) fertilizer and blanket recommended 100 kg ha^{-1} of Di-ammonium phosphate. For all the plots, 46 kg N ha^{-1} in the form of urea was applied uniformly except for the control.The details of the fertilizer treatments are shown in Table1. Bread wheat variety "Hidase (ETBW5795)" and NPS (19% N, 38% P2O5 and 7% S) fertilizer were used for the study. The variety 'Hidase' was developed and released by Kulumsa Agricultural Research Center in 2012 with on-station yield average of 4.5-7.0 t ha-1 and maturity duration of 133 days.

The experiment was laid out in a randomized complete block design (RCBD) with three replications in factorial arrangement of 3 □ 6 = 18 treatment combinations. The gross size of each plot was 2 m × 3 m (6 m2) consisting of ten rows and the distance between adjacent plots and blocks were 0.5 m and 1 m apart, respectively. The outermost one row on both sides of each plot and 25 cm of two ends was considered as border plants, and were not used for data collection to avoid border effects. Thus, the net plot was 1.6 m × 2.5 m (4 m2) consisted of eight rows of 2.5 m length. Bread wheat seeds were sown in rows of 20 cm spacing manually by drilling on 22 July 2017. The whole NPS and DAP, and ½ of the urea fertilizers were applied at sowing, while the remaining ½ of urea was applied at mid-tillering crop growth stage as top dressing.

Table 1. Nutrient composition of the fertilizer treatment used for the study

No.	Fertilizer treatments	N	P_2O_5	S
1	0 kg NPS/ha + 0 kg urea/ha	0	0	0
2	100 kg DAP/ha + 100 kg urea/ha	64	46	0
3	50 kg NPS/ha +100 kg urea/ha	55.5	19	3.5
4	100 kg NPS/ha +100 kg urea/ha	65	38	7
5	150 kg NPS/ha +100 kg urea/ha	74.5	57	10.5
6	200 kg NPS/ha +100 kg urea/ha	84	76	14

Crop data collected

Growth parameters

Plant height was measured from the soil surface to the tip of the spike excluding the awns from 10 randomly taken plants from the net plot area at physiological maturity using ruler and expressed on per plant basis in cm. Similarly, the spike length was measured from the bottom of the spike to the tip of the spike excluding the awns from 10 randomly tagged spikes from the net plot and expressed on per plant basis in cm. The productive numbers of tillers, i.e. tillers bearing spikes with grain, were determined at physiological maturity of the crop by counting from randomly selected two rows of 0.5 m length from the net plot area and converted to m2. The degree of lodging was assessed just before the time of harvest by visual observation based on the scales of 1-5 where 1(0-15o) indicates no lodging, 2(15-30o) indicate 25% lodging, 3(30-45o) indicate 50% lodging, 4(45-60o) indicate 75% lodging and 5(60-90o) indicate 100% lodging (Donald, 2004).

Yield components and yield

The number of kernels per spike was determined by counting from randomly taken 10 spikes per net plot at maturity and averaged to per spike. The thousand kernels weight (g) was determined by counting 1000 kernels sampled from each net plot after threshing using electronic seed counter from the net plot and weighing using a sensitive balance and then the weight was adjusted to 12.5% moisture content. The aboveground biomass (kg ha^{-1}) was determined by weighing the aboveground biomass per net plot area after sun drying for five days. The grain yield (kg ha^{-1}) was determined by weighed using a sensitive balance after threshing the sundried aboveground biomass and the grain yield was adjusted to 12.5% moisture content. Then, harvest index was calculated as ratio of grain yield per plot to total aboveground dry biomass yield per plot.

Data Analysis

All data collected were subjected to analysis of variance (ANOVA) procedure using GenStat 18th edition software (GenStat, 2015). Comparisons among treatment means with significant difference for measured characters were done by using Fisher's protected Least Significant Difference (LSD) test at 5% level of significance.

Economic analysis

Gross field benefit (GFB) (ETB ha^{-1}) was computed by multiplying field/farm gate price that farmers receive for the crop when they sell it as adjusted yield as GFB = AGY × field/farm gate price for the crop. Total variable cost (TVC) (ETB ha^{-1})was calculated by summing up the costs that varied, including the cost of NPS, DAP, Urea, seed and the fertilizer application costs. Cost of the variables were; NPS (11.20 birr kg^{-1}), DAP (15.76 birr kg^{-1}), urea (9.42 birr kg^{-1}) and bread wheat seed (15 birr kg^{-1}) during sowing time (July 22, 2017). Market price of bread wheat grain = 8.5 Birr kg-1and straw= 0.5 Birr kg^{-1}in Shone town at harvesting time in December 2017. The labour cost for application of NPS and DAP (6 persons ha^{-1}, each 50 ETB day^{-1}), and split application of urea two times(6 persons ha-1, each 50 ETB day^{-1}). Marginal rate of return (MRR), which refers to net income obtained by incurring a unit cost of seed rate and fertilizer, for each pair of ranked treatments was calculated using the formula

$$MRR(\%)=\frac{\text{Change in NB (NBb}-\text{NBa)}}{\text{Change in TCV (TCVb}-\text{TCVa)}}\times 100;$$

where NB_a, NB with the immediate lower, NB_b = NB with the next higher, TCV_a = the immediate lower TCV and TCV_b = the next highest TCV.

The dominance analysis procedure as described in CIMMYT (1988) was used to select potentially profitable treatments from the ranges that were tested. The discarded and selected treatments using this technique were referred to as dominated and non-dominated treatments, respectively. Then, among the non-dominated treatments, the treatment with the highest net benefit and marginal rate of return of more than 50% was considered for the recommendation as described by CIMMYT (1988).

Results and discussion

Soil physico-chemical properties of the experimental site

The laboratory analytical results of the experimental soil indicated that the soil textural class was sandy loam with a particle size distribution of 70% sandy, 21% silt and 9% clay, slightly acidic (pH of 6.4), medium in available P (18.34 mg kg^{-1}), moderate in total N (0.23%), very low in S (6.98 mg/kg), low in organic carbon (1.5%), and high in CEC (29.54 cmol (+) kg^{-1} soil). According to Hailu (1991), soil types used for wheat production vary from well-drained fertile soils to waterlogged heavy Vertisols. Thus, the soil of experimental site is suitable for the production of wheat. The pH of the soil was 6.4, which is slightly acidic (Tekalign, 1991). FAO (2000) reported that the preferable pH ranges for most crops and productive soils are 4 to 8.

Growth Parameters

Plant height (cm)

The main effect of seed rate significantly ($P < 0.05$) influenced plant height of bread wheat while the main effect of NPS and their interaction had no significant effects (Table 2). The height of wheat plants increased as seed rate increased where the shortest plant (72.37 cm) was recorded at seed rate of 100 kg ha-1 while the tallest plant (76.10 cm) was obtained at the seed rate of 150 kg ha^{-1} (Table 2). The tallest plant height at the highest seed rate might be due to aerial intra-specific competition among wheat plants for light and space which promoted elongation of stems of wheat. In line with this result, Abiot (2017) reported that as seeding rate of bread wheat increased from the lowest (100 kg ha^{-1}) to the highest (175 kg ha^{-1}), the height of the plant correspondingly increased from 76.86 to 81cm.

Spike length (cm)

The main effect of NPS and seed rate had highly significant ($P < 0.01$) effect on the spike length of bread wheat, while the interaction effect was notsignificant. The result showed that increasing the rate of NPS increased spike length. Thus, the longest spike (7.77 cm) was obtained at the rate of 200 kg NPS ha^{-1}, while the shortest spike (6.7 cm) was recorded at unfertilized treatment (Table 2). Generally, spike length recorded over all the treated plots was significantly higher than the unfertilized plot. The increase in spike length at the highest NPS rate might have been resulted from improved root growth and increased uptake of nutrients, better growth and activate cell division. This result agrees with the findings of Muluneh and Nebyou (2016) who reported the highest spike length (7.7 cm) for wheat at the rate of 50/150 N/P2O5 kg ha^{-1}.

The result also showed that increasing the seed rates decreased spike length. Thus, the shortest spikes (7.18 cm) were obtained at the seed rates of 150 kg ha^{-1}, whereas the longest spikes (7.72) were recorded at the lowest seed rate (100 kg ha^{-1}) (Table 2). The decrease in spike length with the increase in seed rate might be due to more competition among the plants for the growth resources at higher seed rate. In agreement with this result, Ghulam et al. (2011) reported that increasing seed rate of wheat from 125 to 200 kg ha^{-1}; the spike length was decreased from 14.5 cm to 7.8 cm.

Table 2. Main effects of NPS fertilizer and seed rates on plant height and spike length of bread wheat

Treatments	PH (cm)	SL (cm)
NPS rate (kg ha^{-1})		
0	72.76	6.69^{c}
100 (DAP)	72.81	7.34^{b}
50	73.5	7.47^{ab}
100	75.67	7.61^{ab}
150	76.36	7.70^{ab}
200	74.95	7.77^{a}
Significance	NS	**
LSD (0.05)	NS	0.41
Seed rate (kg ha^{-1})		
100	72.37^{b}	7.72^{a}
125	74.55^{ab}	7.41^{b}
150	76.10^{a}	7.18^{b}
Significance	*	**
LSD (0.05)	2.78	0.29
CV (%)	5.5	5.6

¥DAP = Di-ammonium phosphate; * and ** = Significant at 5% and 1% level of probability, respectively; Means followed with the same letter (s) or no letter in the column are not significantly different at 5% level; CV (%) = Coefficient of variation; NS= non-significant; LSD $_{(0.05)}$ = Least Significant Difference at 5% level.

Number of productive tillers

The analysis of variance indicated that number of productive tillers per meter square was highly significantly (P < 0.01) affected by the interaction of NPS and seed rates (Table 3). The maximum number of productive tillers (413.3 m-2) was recorded from the application of the highest NPS and seed rates (200 kg NPS ha^{-1} with 150 kg seed rate ha^{-1}) and it was statistically at par with the combination of 100 and 150 kg NPS ha^{-1} with 150 kg seed rate ha^{-1} (Table 3). In contrast, the minimum number of productive tillers (110 m-2) was recorded from the combination of no fertilizer + 100 kg seed ha^{-1}. The highest number of productive tillers were recorded at the highest seed and NPS rates, this might be the increasing seed rates increased plants emerged in unit area. The current result is in line with the result of Workineh et al. (2015) who reported the highest number of effective tillers (357.3 m-2) from the combination of 92/69 N/P2O5 kg ha^{-1} fertilizer with seed rate of 177 kg ha^{-1} ha^{-1}fertilizer with seed rate of 177 kg ha^{-1} rather than the other treatment.

Lodging percent

The lodging percent was highly significantly (P < 0.01) affected by the main effects of NPS and seed rates as well as by the interaction of the two factors (Table 4). The highest lodging percent (38%) was recorded at the combined application of 200 kg NPS with 150 kg seed rate ha^{-1}, whereas the lowest lodging percent (21%) was recorded under application of 0 kg NPS with 100 kg seed rate ha ha^{-1}. The highest lodging percent recorded at the highest rates of NPS and seed rate might have resulted from the higher internode length, tall plant height and weak stalks due to high plant density which are easily affected by wind. In agreement with this result, Ghulam et al. (2011) reported increased lodging from 4.2 to 16.4% as the seed rate of wheat increased from 125 to 200 kg ha^{-1}. Similarly, Wakjira (2018) reported the highest lodging index (62.4%) of tef from plants that were supplied with 150 kg NPS ha^{-1}and the lowest lodging index (44.2%) from nil fertilizer application.

Table 3. Interaction effect of NPS fertilizer and seed rates on mean number of productive tillers per meter square of bread wheat

	Seed rate (kg ha^{-1})			
NPS rate (kg ha^{-1})	100	125	150	Mean
0	110.0^{j}	170.0^{i}	186.7^{i}	155.57
100 (DAP)	293.3^{def}	286.7^{defg}	293.3^{def}	291.10
50	203.3^{hi}	213.3^{hi}	320.0^{cde}	245.53
100	243.3^{gh}	273.3^{fg}	370.0^{ab}	295.53
150	276.7^{efg}	330.0^{bcd}	396.7^{a}	301.13
200	313.3^{cdef}	340.0^{bc}	413.3^{a}	355.53
Mean	239.98	268.88	330	
Significance	**			
LSD (0.05)	45.7			
CV (%)	9.8			

Table 4. Interaction effect of NPS fertilizer and seed rates on mean number of lodging % of bread wheat

	Seed rate (kg ha^{-1})			
NPS rate (kg ha^{-1})	100	125	150	Mean
0	21^{i}	23^{h}	24.17^{gh}	22.72
100 (DAP)	25.67^{def}	24.53^{fg}	25.83^{def}	25.34
50	24.8^{efg}	24.17^{gh}	25.8^{def}	24.92
100	26de	25.63^{def}	25.93^{de}	25.85
150	26.47^{d}	26.5^{d}	34.33^{c}	29.1
200	26.83^{d}	36.17^{b}	38^{a}	33.66
Mean	25.13	26.66	29.01	
Significance	**			
LSD (0.05)	0.89			
CV (%)	1.7			

Yield component and yield

Number of kernels per spike

The analysis of variance showed highly significant ($P < 0.01$) main effects of NPS fertilizer and significant ($P < 0.05$) main effect of seed rate on the number of kernels per spike (Table 5). However, the interaction effect of the main factors was not significant. The highest number of kernels per spike (61.5) was recorded at NPS fertilizer level of 200 kg ha^{-1}and it was statistically at par with 150 kg ha^{-1} (59.61) while lowest number of kernels per spike (42.12) was recorded at the control fertilizer treatment (Table 5). The highest number of kernels per spike at the highest NPS rate might be due to higher uptake of nutrients by wheat that resulted into enhanced number of grains per spike due to the synergistic effect of nitrogen, phosphorus and sulfur. In agreement with this result, Yasir et al. (2015) reported the maximum number of wheat kernels per spike (56.4) at 140 kg N ha^{-1}and 20 kg S ha^{-1}. Similarly, Workineh et al. (2015) reported the highest number of kernels per spike (38.83) of wheat from the maximum fertilizer rate (138/115 N/P2O5 kg ha^{-1}).

The highest number of kernels per spike (56.85) was recorded at seeding rate of 100 kg ha^{-1} while the lowest number of kernels per spike (51.96) was recorded at seeding rate of 150 kg ha^{-1} (Table 5). As seed rate per hectare increased, the number of kernels per spike decreased which might be due to the increase in the intra plant competition for growth resources. In line with this result, Amare and Mulatu (2017) reported that the maximum number of kernels spike-1 (41.33) was recorded from the plot that received 100 kg ha^{-1}seed rate, while the minimum number of kernels spike-1 (37.03) was from the plot that received 150 kg ha^{-1} seed rate.

Table 5. Main effects of NPS fertilizer and seed rates on number of kernels per spike, thousand kernels weight, aboveground dry biomass and harvest index of bread wheat

Treatments	NKPS	TKW (g)	AGDB (kg ha^{-1})	HI
NPS rate (kg ha^{-1})				
0	42.12^{d}	40.86	6690^{c}	0.32^{d}
100 (DAP)	52.56^{c}	43.69	9873^{b}	0.38^{bc}
50	53.08^{c}	41.88	9410^{b}	0.36^{c}
100	55.69^{bc}	42.39	9873^{b}	0.40^{ab}
150	59.61^{ab}	42.87	11192^{a}	0.42^{a}
200	61.5^{a}	45.12	12303^{a}	0.41^{ab}
Significance	**	NS	**	**
LSD (0.05)	4.56	NS	1232.4	0.03
Seed rate (kg ha^{-1})				
100	56.85^{a}	42.77	8744^{b}	0.35^{b}
125	53.47^{b}	41.74	9358^{b}	0.38^{a}
150	51.96^{b}	43.89	11568^{a}	0.41^{a}
Significance	*	NS	**	**
LSD (0.05)	3.23	NS	871.4	0.03
CV (%)	8.8	10.5	13.0	10.0

¥DAP = Di-ammonium phosphate; * and ** = Significant at 5% and 1% level of probability, respectively; Means followed with the same letter (s) or no letter in the column are not significantly different at 5% level; CV (%) = Coefficient of variation; NS= non-significant; LSD (0.05) = Least Significant Difference at 5% level.

Thousand kernels weight (g)

Analysis of variance revealed that main effects of NPS fertilizer, seed rate, as well as interaction effects had not significant effect on thousand kernels weight of bread wheat (Table 5). This might be the thousand kernels weight is a genetic characteristic of a plant which is less affected by other factors.

Though the difference was not statistically significant, the highest thousand kernels weight (45.12 g) was recorded from the highest NPS rate (200 kg ha^{-1}) while the lowest thousand kernels weight (40.86 g) was from the control (Table 5). In line with this result, Esayas (2015) reported that blended fertilizer (NPS, NPSB, NPSZnB) application had no significance effect on thousand grain seed weight of wheat.

Aboveground dry biomass

The main effects of NPS fertilizer and seed rate were highly significant ($P < 0.01$) on the aboveground dry biomass yield of bread wheat, while the interaction effect was not significant (Table 5). The highest aboveground dry biomass yield (12303 kg ha^{-1}) was recorded due to the highest (200 kg ha^{-1}) rate of NPS fertilizer and it was statistically at par with 150 kg NPS ha^{-1} whereas the lowest aboveground dry biomass yield (6690 kg ha^{-1}) was recorded from the control treatment (Table 5). The increase in aboveground dry biomass at the highest rates of NPS fertilizer rate might have resulted from improved root growth and increased uptake of nutrients which favored better aboveground growth. This result agrees with that of Dawit et al. (2015) who reported that increasing N from 0 to 184 kg ha^{-1} and P from 0 to 138 kg ha^{-1} increased the aboveground dry biomass yield of wheat by about 70.1% and 40.6%, respectively.

With regards to the effect of seed rate, the highest aboveground dry biomass yield (11568 kg ha^{-1}) was recorded at the seed rate of 150 kg ha^{-1}while the lowest aboveground dry biomass yield (8744 kg ha^{-1}) was recorded when 100 kg ha^{-1} seed rate was used (Table 5). In general, as the seeding rate increased the aboveground dry biomass yield increased which might be due to more plant populations per unit area. In conformity with this result, Abiot (2017) reported the highest biomass yield (12754.50 kg ha^{-1}) at the seeding rate of 175 kg $ha^{-1}$and lowest biomass yield (9696.30 kg ha^{-1}) at the seeding rate of 100 kg ha^{-1}.

Grain yield (kg ha^{-1})

The main effects of NPS fertilizer and seed rate, and their interaction had highly significantly ($P < 0.01$) effect on the grain yield of bread wheat (Table 6).

Table 6. Mean grain yield (kg ha-1) of bread wheat as influenced by the interaction of NPS fertilizer and seed rates

	Seed rate (kg ha^{-1})			
NPS rate (kg ha^{-1})	100	125	150	Mean
0	2014^{h}	2292^{h}	2188^{h}	2164.67
100(DAP)	3576^{f}	3403^{f}	4340^{cde}	3773.00
50	2465^{gh}	3194^{fg}	4688^{bc}	3449.00
100	3333^{f}	3507^{f}	5382^{b}	4074.00
150	3611^{ef}	4514^{cd}	6146^{a}	4757.00
200	3819^{def}	5278^{b}	6250^{a}	5115.67
Mean	3136.33	3698	4832.33	
Significance	**			
LSD (0.05)	737.9			
CV (%)	11.4			

¥DAP = Di-ammonium phosphate; ** = Significant at 1% level of probability;Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance; LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of variation.

The highest grain yield (6250 kg ha^{-1}) was obtained at combined rates of 200 kg NPS ha^{-1} with 150 kg seed rate ha^{-1} and it was statistically at par with 150 kg NPS ha^{-1}with 150 kg seed rate ha^{-1}with grain yield of 6146 kg ha^{-1}. Whereas, the lowest grain yield (2014 kg ha^{-1}) was recorded at zero level of NPS fertilizer with 100 kg seed rate ha^{-1} (Table 6)..The highest grain yield was recorded from highest NPS and seed rates this might be due to the combined effect of nutrients like N, P and S in blended fertilizer which might have boosted growth and development of crop and the highest seed rate which produced higher plant population enhanced yield components, biomass and thereby grain yield

In agreement with this result, Seyoum (2017) obtained the highest grain yield (6430kg ha-1) of bread wheat at combined rates of 150 kg NPS ha^{-1} + 46 kg N ha^{-1}. Similarly, Yasir et al. (2015) also reported the maximum grain yield of wheat (4463.5 kg ha^{-1}) at 140 kg N ha^{-1} and 20 kg S ha^{-1}. The current result noted that an increasing seed rate per hectare showed the increased grain yield per hectare at all the NPS rates which indicate that higher seed rates require higher NPS. This result agreed with the studies of Haile et al. (2013) who reported significantly the lowest grain yield (3851 kg ha^{-1}) at the lowest seeding rate (100 kg ha^{-1}) as compared to higher seeding rates (150 and 175 kg ha^{-1}).

Harvest index

The main effects of NPS fertilizer and seed rate were highly significant ($P < 0.01$) on harvesting index (HI) while the interaction effect was not significant (Table 5). The highest harvest index (0.42) was obtained from 150 kg ha^{-1}NPS fertilizer rate and it was statistically at par with 200 kg NPS ha^{-1} and 100 kg NPS ha^{-1}, whereas the lowest harvest index (0.32) was recorded with no fertilizer (Table 5). Significantly higher harvest index with the application of NPS fertilizer might be attributed to greater photo assimilate production and its ultimate partitioning in to grains as result of provision of balanced nutrition. In agreement with this result, Wakjira (2017) reported that the maximum harvest index of tef (37.53%) with NPS rate of 120 kg ha^{-1} while the lowest harvest index (33.99%) was recorded with NPS rate of 30 kg ha^{-1}. In terms of seed rate, the highest harvest index (0.41) and the lowest harvest index (0.35) were obtained due to the 150 kg and 100 kg seed rate ha^{-1}, respectively (Table 5). The increment in harvest index at higher seed rate might be attributed to proper utilization of resources and ultimate partitioning into grains compared to partitioning in to straw. In line with this result, Abiot (2017) reported the highest harvest index (38.15%) of bread wheat at seeding rate of 150 kg ha^{-1} while the lowest harvest index (31.69%) was recorded at the seeding rate of 100 kg ha^{-1} but further increase of the seed rate to 175 kg ha^{-1} decreased the harvest index to 33.27%.

Partial Budget Analysis

The partial budget analysis showed that the highest net benefit (44878.2 birr ha^{-1}) was recorded at the rate of 200 kg NPS with 150 kg seed rate ha^{-1} followed by 150 kg NPS with 150 kg seed rate ha^{-1} (44045Birr ha^{-1}), whereas the lowest net benefit (16032 Birr ha^{-1}) was recorded from zero fertilizer application at a seed rate of 100 kg ha^{-1} (Table 7).

According to CIMMYT (1988) suggestion, the minimum acceptable marginal rate of return should be more than 50%. In this study application of 200 kg ha^{-1} of NPS fertilizer with 150 kg seed rate ha^{-1} gave the maximum economic benefit (44878.2 birr ha^{-1}) with marginal rate of return of 97.7 (Table 7). In line with this result, Seyoum (2017) obtained the highest economic benefit (42272.5 Birr ha^{-1}) with the marginal rate of return 1728.3% from combined application of 100 kg NPS ha-1 and 92 kg N ha^{-1}for bread wheat.

Table 7. Summary of partial budget analysis for response of bread wheat to NPS fertilizer and seed rates in East Badawacho District, Southern Ethiopia

Treatment							MRR (%)
Seed rate (kg ha^{-1})	NPS rate (kg ha^{-1})	AGY (kg ha^{-1})	ASY (kg ha^{-1})	GFB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	
100	0	1812.6	4249.8	17532	1500	16032	-
100	50	2218.5	4406.4	21060.45	3702	17358.45	60.2
100	100	2999.7	5124.6	28059.75	4262	23797.75	1150
100	100(DAP)	3218.3	5249.7	29980.4	4618	25362.4	439.5
100	150	3249.9	5812.2	30530.25	4822	25708.25	169.5
100	200	3437.1	5625	32027.85	5382	26645.85	167.4
125	0	2062.8	3937.5	19502.55	1875	17627.55^{D}	
125	50	2874.6	5094	26981.1	4077	22904.1	239.6
125	100	3156.3	5082.3	29369.7	4663	24706.7	307.6
125	100(DAP)	3062.7	5156.1	28611	4993	23618 ^{D}	
125	150	4062.6	5562.9	37313.55	5197	32116.55	4166
125	200	4750.2	6187.5	43470.45	5757	37713.45	999.4
150	0	1969.2	4018.5	18747.45	2250	16497.45^{D}	
150	50	4219.2	6593.4	39159.9	4452	34707.9	827
150	100	4843.8	5718.6	44031.6	5012	39019.6	769.9
150	100(DAP)	3906	6062.4	36232.2	5368	30864.2^{D}	
150	150	5531.4	6000.3	50017.05	5972	44045.05	2182
150	200	5625	7781.4	51703.2	6825	44878.2	97.7

Where, AGY = adjusted grain yield; ASY= adjusted 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 treatments. Cost of bread wheat seed= Birr 15 kg-1, NPS cost = 11.20 Birr kg^{-1}, DAP cost = 15.76 Birr kg^{-1}, urea cost= 9.42 Birr kg^{-1};The labor cost for application of NPS and DAP (6 persons ha^{-1}, each 50 ETB day^{-1}) and for two time ureaaplication(6persons ha^{-1}, each 50 ETB day^{-1}), Market price of bread wheat grain = 8.5 Birr kg^{-1}and straw= 0.5 Birr kg^{-1}in Shone town at harvesting time in December 2017.

Conclusion and recommendation

Wheat is one of the most important cereal crops in the world and it is a staple food for about one third of the world's population. Low soil fertility is one of the major constraints responsible for the low productivity of wheat in Ethiopia. From the present study it is possible to conclude that both seeding and NPS fertilizer rate affect most of yield and yield related traits of bread wheat. Based on the result of this study the main effect of fertilizers revealed significantly highest spike length, number of kernels per spike, and total dry biomass yield at 200 kg NPS ha^{-1}. Similarly, the main effect of the seed rate showed the highest total dry biomass yield and harvest index at seed rate of 150 kg ha^{-1}. The interaction of the seed and fertilizer rates gave significantly the highest number of productive tillers and the maximum grain yield at combination of the highest rates of 200 kg NPS ha^{-1} with 150 kg seed rate ha^{-1}. Therefore, this study investigated and concluded that NPS rate of 200 kg ha^{-1} with seed rate of 150 kg ha^{-1} to be appropriate for bread wheat production in study area. However, to reach at a conclusive recommendation, the experiment has to be repeated over years and locations with considerations of higher seed rate and grain quality parameters of bread wheat.

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