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Effect of Seed and NPS Fertilizer rates supplemented with N on yield Components, yield and grain quality of bread wheat (*Triticum aestivum* L.) at low land of East Shawa, Ethiopia

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Abstract

Bread wheat (*Triticum aestivum* L.) is an economically important crop due to high demand for food resources. The field experiment was conducted at East Shawa zone of low land area to identify economically feasible seeding and NPS fertilizer rates. The factorial combinations of three wheat seeding rates (100, 125 and 150 kg ha^{-1}) and six levels of NPS fertilizer rates (0, 50, 100, 150, 200 and 250) were laid out in factorial arrangement of randomized complete block design with three replications. Statistical analysis of the data revealed that interactions between fertilizer and seed rates were significant on parameters such as Harvest index (HI), hectoliter weight (HLW) and grain protein content (GPC) at Adami Tulu; productive tiller (PT) at Dugda and spike length (SL), grain per spike (GS), thousand grains weight (TGW), hectoliter weight (HLW) and grain protein content (GPC) at Lume. The highest HI (50.35) was obtained from 150 kg NPS ha^{-1} with 150 kg seed rate ha^{-1} and GPC (16.26) from 200 kg NPS with 100 seed rate at Adami Tulu; the highest PT (631.7) from 150 kg NPS with 150 seed rate at Dugda; the highest TGW (39.73) from 200 kg NPS with 100 seed rate and the highest HLW (82.63) from 100 kg NPS with 125 seed rate at Lume. The overall treatments of highest net benefits the economic feasibility of the fertilizer over seed rate combination indicated that application of 150 kg NPS ha^{-1} fertilizer rates with combination of 150 kg seed ha^{-1} supplemented with 73 kg N ha^{-1}were economical and recommended for production of bread wheat.

Keywords: Bread wheat, economic analysis, fertilizer rate, NPS, Seed rate

Introduction

Bread wheat (*Triticum aestivum* L.) is an economically important crop due to high demand for food resources as well as production of the crop in large-scale including uses of irrigation to satisfy the demand has become a critical in Ethiopia. The importance of wheat is mainly due to the fact that its seed can be ground into flour, semolina, etc., which form the basic ingredients of bread and other bakery products, as well as pastas, and thus it presents the main source of nutrients to most of the world population (Šramková, Z. and Šturdík, 2009). The nutritional value of wheat is extremely important as it takes an important place among the few crop species being extensively grown as staple food sources.

Fertilizer is the most important input which contributes significantly towards final grain yield of wheat and to exploit the genetic potential of a cultivar (Kaleem *et al*., 2009). Nitrogen is one of the important factors that affect the yield and quality of wheat (Dandan and Yan 2013). Nitrogen is one of the key nutrients that limit crop growth of cereals in many production systems (Fatma *et al*. 2014). Its application is an important input for wheat production (Ejaz Ahmad *et al*., 2010). Phosphorus is an essential for cellular respiration, metabolism of starch and fats (Kaleem *et al*., 2009). Application of adequate amount of phosphorus improves wheat grain yield (Alam and Jahan, 2013). Thus, there is a need to apply the adequate level of phosphorus for obtaining higher yield with good quality product of wheat. However, recently it is perceived that the production of such high protein cereals like wheat can be limited by the deficiency of S and other nutrients (Assefa *et al*., 2015). Sulfur is an essential plant nutrient in crop production required for protein and enzyme synthesis as well as it is a constituent of some of the amino acids (Scherer, 2001). Wheat grain protein content is frequently used as the main measurement of grain quality (Ricardo *et al*., 2010) and indicators for milling and baking (Mohammed *et al*., 2013). 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).
Seeding rate is one of the most important production factors. Seed is the most important agricultural input, and it is the basic unit for distribution and maintenance of plant population and it carries the genetic potential of the crop and thus indicates the ultimate productivity of other inputs (Ashagre and Ermias, 2007). Optimum seed rate plays an important role in achieving better yields. On the other hand, using an optimum seeding density can provide suppression of weeds in wheat crop (Ijaz and Hassan, 2007).

Combination of optimum seeding rate and fertilizer rates play an important role in achieving economic yield. Thus, the proper seeding rate and addition of adequate nutrients such N, P and S, to soil is important to increase wheat yield either for consumption or industrial purpose. So that, considerations of better seeding and fertilizer rates interactions are main factor for wheat productions.

In the study area seeding rate and NPS fertilizer rates that contain sulfur for economical production of crops without adequate information concerning actual soil requirements. Moreover, there is no recommendation in previous studies for the interaction of seeding rates and NPS fertilizer rates. Therefore, this study was undertaken with the following objectives**:**

- to determine the effect of seeding rates and NPS fertilizer rates on yield components, yield and grain quality of bread wheat; and
- to identify economically feasible seeding and NPS fertilizer rates at different study area

Materials and Methods

3.1. Description of the Study Area

The field experiment was conducted at Adami Tulu, Dugda and Lume site from July to November of 2019 years under rain fed conditions at each location.

3.2. Experimental Materials

3.2.1. Plant material

Bread wheat variety “Ogolcho” was used as test cultivar. The variety where selected based on its adaptation, better performance in the area.

3.2.2. Fertilizer materials

NPS (19% N, 38% P_2O_5 and 7% S) and Urea 159 kg ha^{-1} (73% N) were used as the sources of phosphorus and sulfur fertilizers.

3.3. Soil Sampling and Analysis

One representative soil sample was taken at a depth of 0-30 cm from five randomly selected spots diagonally across the experimental field using auger before planting. The sample was air dried under shade. The sample was analyzed for selected physico-chemical properties, namely organic carbon, texture, soil pH, cation exchange capacity (CEC), total N, available P and S.

3.4. Treatments and Experimental Design

The treatments were consisted of factorial combination of three wheat seeding rates (100, 125 and 150 kg ha^{-1}) and six levels of NPS fertilizer rates (0, 50, 100, 150, 200 and 250) where 159 kg ha^{-1} Urea for N source was used and arranged in a randomized complete block design (RCBD) with three replications. The experiments were laid out in a randomized complete block design (RCBD) with three replications in factorial arrangement of 3 x 6 = 18 treatment combinations.

The gross plot size were 12 rows of three meter length (3 m×2.4 = 7.2 m^2) with net harvestable rows of 10 with 2.5 m length (2.5 m×2.0 m = 5 m^2) were considered as net plot. The spacing between rows, plots and blocks were 0.20, 0.5 and 1 m, respectively.

3.5. Experimental Procedures and Field Management

The experimental field was ploughed with oxen to a fine tilth three times and the plots were leveled manually. According to the design, a field layout was made and each treatment assigned randomly to the experimental units within a block. Bread wheat seeds were sown in rows of 20 cm spacing manually by drilling. The whole amount of NPS fertilizer applied at time of sowing and uniformly supplemented application of 73 kg N ha^{-1} for all treatment except for control with ½ of nitrogen was applied at the time of sowing and ½ nitrogen top-dressed at tiller initiations stage. Weeding was done as needed; and harvesting and threshing was done manually.

3.6. Crop data collected

3.6.1. Crop phenology and growth parameters

Days to 50% heading (DTH): days to spike heading was determined as the number of days taken from the date of sowing to the date of 50% heading of the plants from each plot by visual observation.

Days to 90% physiological maturity (DTM): days to physiological maturity was determined as the number of days from sowing to the date when 90% of the peduncle turned to yellow in straw color. It was recorded when no green color remained on glumes and peduncles of the plants, *i.e.* when grains are difficult to break with thumb nail.

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

Spike length (cm): It 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.

Lodging percent: No lodging, there was no data recorded and reported.

3.6.2. Yield components and yield

Number of total tillers: number of total tillers were determined from 0.5 m length quadrant of two rows from the net plot and converted to per meter square of net plot at physiological maturity by counting the number of tillers.

Number of productive tillers: number of productive tillers were determined at maturity by counting all kernel bearing spikes from 0.5 m length quadrant of two rows from the net plot and converted to per meter square of net plot at physiological maturity.

Number of kernels per spike: the mean number of kernels per spike was computed as an average of 5 randomly taken spikes from the net plot area.

Thousand kernels weight (g): thousand kernels weight was determined based on the weight of 1000 kernels sampled from the grain yield of each net plot by counting using electronic seed counter and weighed with sensitive balance. Then, the weight was adjusted to 12.5% moisture content.

Aboveground dry biomass (kg ha^{-1}): the aboveground dry biomass was determined from plants harvested from the net plot area after sun drying to a constant weight and converted to kg per hectare.

Grain yield (kg ha^{-1}): grain yield was taken by harvesting and threshing the seed yield from net plot area. The grain weight of each plot was recorded in kg and finally, yield per plot was converted to kg ha^{-1}. The yield was adjusted to 12.5% moisture content.

Straw yield (kg ha^{-1}): Straw yield was obtained as the difference of the total aboveground dry biomass and grain yield.

Harvest index (HI): harvest index was calculated as ratio of grain yield per plot to total aboveground dry biomass yield per plot.

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Aboveground dry biomass}} \times 100$$

3.6.3. Grain quality parameters

Hectoliter weight (HLW)

It is the weight of flour density produced in a hectoliter of the seed and it was measured by a standard laboratory hectoliter weight apparatus.

Grain protein content (GPC)

Grain protein content (GPC) was determined on a dry weight basis by near infrared reflectance spectroscopy (NIRS), by using " Infratec™ 1241 Grain Analyzer " equipment at Food Science and Nutrition Laboratory of Kulumsa Agricultural Research Center.

3.7. Data Analysis

All data collected was subjected to analysis of variance (ANOVA) procedure using GenStat (18th edition) software (GenStat, 2014). The comparisons among treatments means with significant difference for measured characters was done by LSD test at 5% level of significance.

3.8. Economic Analysis

The economic analysis was carried out by using the methodology described in CIMMYT 1988 in which prevailing market prices for inputs at planting and for outputs at harvesting was used. All costs and benefits were calculated on hectare basis in Birr.

The net benefit (NB) was calculated as the difference between the gross field benefit and the total variable (TVC) using the formula

NB= GFB -TVC

Where GFB = Gross Field Benefit, TVC = Total Variable Cost

Actual yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same size field.

Any treatment that has higher TVC but net benefits that are less than or equal to the preceding treatment (with lower TVC but higher net benefits) is **dominated treatment** (marked as "**D**"). For each pair of ranked treatments, % marginal rate of return (MRR) was calculated using the formula:

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

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

The fertilizer cost was calculated for the cost of each fertilizer of NPS (Birr 14.96 kg $^{-1}$) and N/UREA (Birr 14.52 kg $^{-1}$) in 2019 during sowing time. The average open price of bread wheat at Batu/Ziway for Adami Tulu, Meki for Dugda and Mojo for Lume markets were Birr 16.00kg $^{-1}$ in January 2020 during harvesting time.

Results and Discussion

4.1. Soil Physico-chemical Properties of the Experimental Site

According to the laboratory analysis, the soil texture of the experimental area is sandy loam, loam and clay loam at Adami Tulu, dugda and Lume area respectively. The soil texture influences water contents, water intake rates, aeration, root penetration, and soil fertility. (FAO, 2000) reported that the preferable pH ranges for most crops and productive soils are 4 to 8. Thus, the pH of the experimental soil was within the range for productive soils. (Sahlamdihin, 1999) reported the pH of the soil between (5.00 -7.55) was found within the suitable range for crop production.

The Netherlands commission of the ministry of agriculture and fisheries (1985) classified soils having total organic C % greater than 3.50, 2.51-3.5, 1.26-2.5, 0.60-1.25 and less than 0.6 is categorized as very high ,high, medium, low, and very low respectively. According to the (Ethiosis, 2014) reference soil organic carbon content in the experimental site was low. The result of soil analysis has poor total nitrogen according to the rating of (Tekalign *et al*., 1991). Soil analysis also indicated that very high available phosphorus content according to the rating of (Olsen *et al*., 1954).

The analysis for available sulfur indicated that optimum for three sites according to (Ethiosis, 2014). The CEC value of the soil sample is high according to the rating of Landon (Landon, 1991). which indicates that soil has high capacity to hold exchangeable cations.

Table 1. Selected physico-chemical properties of the soil of the experimental site before sowing

No	Soil characters	Values of soil samples			References
		Adami Tulu	Dugda	Lume	
1.	Soil texture				
	Sand (%)	53.91	40.58	36.00	
	Clay (%)	12.57	21.22	29.87	
	Silt (%)	33.52	38.20	34.14	
	Texture Class	Sandy loam	Loam	Clay Loam	
2.	pH-H_2O(1:1.25)	7.53 Moderately alkaline	7.11 Neutral	6.67 Neutral	(Ethiosis, 2014)
3	Organic Carbon (OC) (%)	1.05 Very low	1.01 Very low	0.45 Very low	(Ethiosis, 2014)
4.	CEC (meq/100 gm of soil)	38.18 high	32.64 high	38.34 high	(Landon, 1991)
5.	Total Nitrogen (%)	0.15 moderate	0.13 moderate	0.06 poor	(Tekalign *et al*., 1991)

6.	Available P (mg P_2O_5/kg soil)	50.74 very high	20.91 very high	22.65 very high	(Olsen *et al*., 1954)
7.	Available S (mg/kg soil)	62.12 Optimum	29.92 Optimum	22.54 Optimum	(Ethiosis, 2014)

Days to 50% heading

The analysis of variance revealed that NPS fertilizer rates highly significant difference ($P \leq 0.01$) at three locations (Table 2), the seed rate as well as the interaction of the two factors had no significant effect on days to 50% heading. The highest prolonged duration to reach 50% heading was observed at Adami Tulu, Dugda and Lume in response to zero rates of the fertilizers application. However, the minimum duration to 50% heading (53.11, 54.11 and 42.11) was observed at Adami Tulu, Lume and Dugda respectively with NPS fertilizer rate of 150 kg ha^{-1} in, whereas (57.8, 57.44) was recorded with 250 kg ha^{-1} of NPS and 200 kg ha^{-1} NPS fertilizer rates at Dugda and Lume respectively was recorded (Table 2). This might be due to the Nitrogen feed as NPS fertilizer enhance the vegetative development as well as stimulate shoot growth and due minimum duration of heading days. The result in line with the finding of (Cock and Ellis, 1992) indicated that sufficient nitrogen at right time results in rapid growth and heading. (Bekalu and Arega, 2016) reported that fertilizer applied 92 kg ha^{-1} minimize the date of heading by eight days compared with control.

Days to 90% physiological maturity

The main effect of NPS fertilizer rate was highly significantly ($P \leq 0.01$) on days to 90% physiological maturity of bread wheat at three locations, while the main effect of seed rate and interactions did not significantly affect days to 90% physiological maturity. The longest days to physiological maturity (107.44, 106.33, 105.44 days) was recorded at Adami Tulu, Dugda and Lume respectively with the zero fertilizer rate whereas the early maturing (103.22, 102.33, 102.89 days) was obtained from 150 kg NPS ha^{-1} at Adami Tulu, Dugda and Lume respectively. Increasing of NPS level enhanced the earlier anthesis and early maturity of crop over the control. Similar results are reported by (Hussain *et al*., 2009) who found that increasing rate of phosphorus enhance earlier production in wheat and ultimately early maturity of crop.

Table: 2 Main effects of NPS fertilizers and seed rate on days to 50% heading (DTH), days to 90% physiological maturity (DTM), plant height (PH) and spike length (SL) of bread wheat in 2019/20

Treatments	DTH			DTM			PH			SL		
	Location			Location			Location			Location		
NPS rates (kg ha^{-1})	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume
0	57.44 d	45.44 c	58.56 d	107.44 d	106.33 d	105.44 b	92.67	79.5 a	65.78 a	8.69 a	7.52 a	6.92 a
50	56.00 c	45.22 c	56.78 c	106.56 d	104.89 c	105.56 b	96.44	90.44 b	76.22 b	9.02 abc	8.48 bc	8.02 b
100	54.67 b	44.22 b	55.44 abc	106.33 cd	104.00 bc	105.11 b	97.33	89.44 b	81.22 bc	9.14 bc	7.89 ab	7.88 b
150	53.11 a	42.11 a	54.11 a	103.22 a	102.33 a	102.89 a	99.44	91.22 b	86.67 c	9.08 bc	8.41 bc	8.21 b
200	54.67 b	42.22 a	56.11 bc	104.33 ab	103.22 ab	102.89 a	96.78	92.44 b	82.11 bc	8.86 ab	8.19 bc	7.90 b
250	54.89 bc	42.22 a	54.67 ab	105.22 bc	103.00 ab	102.67 a	96.89	91.44 b	82.89 bc	9.30 c	8.52 c	8.13 b
LSD (0.05)	1.19 ***	0.96***	1.53***	1.15***	1.19***	1.23 ***	NS	3.75***	6.52***	0.36**	0.56***	0.46***
Seed rates (kg ha^{-1})												
100	55.44	43.94	55.72	105.72	103.61	104.39	94.78	91.06	80.1	9.06	8.25	7.93
125	55.06	43.67	56.39	105.56	104.06	104.00	98.44	86.89	78.0	8.92	8.14	7.79
150	54.89	43.11	55.72	105.28	104.22	103.89	96.56	89.33	79.4	9.07	8.11	7.82
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	2.1	2.1	2.7	1.2	1.3	1.2	5.1	4.1	8.4	4.1	7.5	5.1

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; NS= non-significant, Means in column followed by the same letters are not significantly different at 5% levels of Significance

Plant height (cm)

The main effect of seed rate significantly ($P < 0.01$) influenced plant height of bread wheat. On the other hand, the main effect of NPS and interaction had no significant effect. The tallest plant (99.44, 92.44 and 86.67 cm) was recorded at Adami Tulu, Dugda and Lume with fertilizer rate of (150, 200 and 150 kg ha^{-1}) and the shortest plant height was obtained at zero fertilizer rates. The result indicated that height of wheat plants increased as fertilizer rate increase comparatively at different seeding rates (Table 2). The highest plant was recorded at highest fertilizer rate within three locations. This could be due to the combination of NPS nutrients increased plant height with increasing the levels over control. (Memon and Puno, 2005) observed the similar results in plant height due to varying phosphorus in combination with nitrogen. **(Sajid Islam *et al*., 2017) reported** that phosphorus application had significantly increased plant height of wheat. Plant height showed no significant correlation with effective tillers $plant^{-1}$ both at the phenotypic and genotypic levels (Mudasir and Abdul, 2009)**.**

Spike length (cm)

The main effect of NPS fertilizer rate had highly significant ($P < 0.01$) effect on the spike length and the interaction effect of NPS fertilizers and seed rate on spike length have significant influence on this parameter (Table 3). Thus, the longest spikes (8.37 cm) was recorded at the combined application of with both 150 and 200 kg NPS fertilizer of 150 kg seed rate ha^{-1}, whereas the shortest spikes (6.33 cm) was recorded under application of 0 kg NPS and 150 kg seed rate ha^{-1} (Table 4). The result showed that increasing the rate of NPS at higher levels increased spike length. Increase in spike length might be due to adequate NPS fertilizer applications which resulted in better length of the spike. These results are in agreement with (Ahmad *et al*., 2000) he concluded that spike length of wheat was increased significantly with increasing of nitrogen levels. (Amare Assefa, 2017) reported that the longest spike (8.22 cm) was attained at 150 kg seed ha^{-1}. However, the varietal difference in spike length is governed by genetic makeup of the genotype and the environmental effect (Shahzad *et al*., 2007).

Table 3. Interaction effect of NPS fertilizers and seed rate on spike length of bread wheat in 2019/20 at Lume location

NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	7.47 bcd	6.97 ab	6.33 a
50	8.23 de	7.63 bcde	8.20 de
100	8.07 cde	7.93 cde	7.63 bcde
150	8.37 e	7.90 cde	8.37 e
200	7.37 bc	7.97 cde	8.37 e
250	8.07 cde	8.33 e	8.00 cde
LSD(0.05)	0.67 ***		
CV (%)	5.1		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Total number of tillers

The analysis of variance indicated that number of total tiller produced was highly significant ($P < 0.01$) affected by the main effects of NPS fertilizer rates at dugda and lume respectively. The interactions effect of NPS and seed rate was non-significant. The maximum number of total tillers (693, 601, 431 m^{-2}) was produced at Adami Tulu, Dugda and Lume under application of the NPS rates of 100, 150 and 150 respectively (Table 4). Whereas, the minimum numbers of total tillers were recorded from zero kg NPS rates. Maximum number of total tiller recorded at highest fertilizer as compare to control. Phosphorus fertilization has great influence on wheat yield and its deficiency has been reported as one of the main reasons for reduced number of tillers (Prystupa *et al*., 2003).

Number of productive tillers

The analysis of variance indicated that number of productive tillers was highly significantly ($P < 0.01$) affected by the main effect of NPS fertilizer as well as the interaction effect of NPS with seed rates. The more number of productive tillers (631.7 m^{-2}) was observed at NPS fertilizer rate of 150 kg NPS ha^{-1} with seeding rate of 150 kg ha^{-1} and the statistically less (485 m^{-2}) was from 100 kg ha^{-1} seeding rate and 0 kg NPS) (Table 5). Productive tillers are the most important because of the contribution in final yield. The NPS nutrients increased number of productive tillers significantly as compared to control. This might be due to N feed as NPS and also top-dressing of N fertilizer applied at time of tillering initiations. The number of spikes per unit area is set before stem elongation (Li C *et al*., 2001) so N fertilization in tillering stage has a significant impact. Increase in number of tiller per unit area is due to increased seeding rate (Ahmad *et al*., 2000, Otteson *et al*., 2008). Similarly, nitrogen fertilization also contributed in increasing tiller production up to an optimum level (Singh *et al*., 2002, Islam *et al*., 2002). Above optimum, the decrease in tillers might be due to the competition for nutrient, light and space. (Tanner *et al*., 1991) reported that, a seed rate of 125 kg ha^{-1} was sufficient for optimum yield with drilling of either the early maturing cultivars or late maturing. The result is similar with (Jemal *et al*., 2015) who reported that maximum effective tiller number was reported from the higher seed rate than the lower seed rate. However, this result was in contrast with (Alemayehu, 2019) who reported that maximum productive tiller from minimum seed rate and vice versa. Lower seed rate (125 kg ha^{-1}) significantly produced maximum tillers (439 m^{-2}) (Ghulam *et al*., 2011). Higher seed rate produced many number of tillers but it might not produce many numbers of effective tillers per unit area due to competition of tillers for growth factors that lead to the production of low numbers of productive tillers per unit area (Baloch *et al*., 2002).

Table: 4 Main effects of NPS fertilizers and seed rate on total tiller (TT), productive tiller (PT), grain per spike (GS) and thousand grain weight (TGW) of bread wheat in 2019/20.

Treatments	TT			PT			GS			TGW		
	Location			Location			Location			Location		
NPS rates (kg ha$^{-1)}$	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume
0	655.0	537.8a	316 a	581.1 a	493.9a	289 a	42.22 a	35.78 a	29.67 a	37.47	34.74	33.87 a
50	683.9	535.0a	351 ab	602.2 ab	495.6a	323 ab	48.22 bc	42.00 b	36.11 b	38.26	34.27	38.03 b
100	693.3	563.9ab	364 ab	606.1 ab	532.8 bc	336 ab	44.89 ab	42.33 b	38.11 b	37.72	34.01	38.31 b
150	688.3	601.1c	431 b	663.3 c	567.2c	403 b	50.89 c	43.33 b	38.22 b	38.23	34.56	38.01 b
200	690.6	582.8bc	403 b	631.7 b	551.1bc	376 ab	45.67 abc	42.00 b	37.11 b	37.36	34.39	38.63 b
250	675.6	563.3 ab	411 b	614.4 ab	529.4b	386 b	45.00 ab	44.00 b	38.22 b	39.24	35.77	38.94 b
LSD (0.05)	NS	33.94***	80.5*	30.87***	33.43***	80.5*	5.22*	4.04***	3.96***	NS	NS	1.34***
Seed rates (kg ha^{-1})												
100	677.5	548.6	343	612.8	515.3	315	47.00	41.17	36.17	37.28 a	34.57	37.87
125	686.1	563.3	398	613.9	523.6	371	44.72	42.61	36.72	36.82 a	34.82	37.43
150	679.7	580.0	397	622.8	546.1	371	46.72	40.94	35.83	40.04 b	34.48	37.60
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.18 ***	NS	NS
CV (%)	5.8	5.4	23.1	5.4	5.3	24.8	12.2	9.9	9.9	4.1	4.8	3.3

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; NS= non-significant, Means in column followed by the same letters are not significantly different at 5% levels of Significance

Table 5. Interaction effect of NPS fertilizers and seed rate on productive tillers of bread wheat in 2019/20 at Dugda location

Blended NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	485.0 ab	503.3 abcd	493.3 abc
50	506.7 abcd	505.0 abcd	475.0 a
100	513.3 abcde	540.0 bcdef	545.0 cdef
150	533.3 bcdef	536.7 bcdef	631.7 g
200	550.0 def	535.0 bcdef	568.3 f
250	503.3 abcd	521.7 abcdef	563.3 ef
LSD(0.05)	46.66 **		
CV (%)	5.3		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Number of grains per spike

The analysis of variance showed that the main effect of NPS fertilizer rates was highly significant ($P < 0.01$) and as well as the interaction effects was highly significant. The highest number of grains per spike (50.89, 44, and 38.2) was counted at Adami Tulu, Dugda and Lume with the main effect of NPS fertilizer level of 150, 150 and 250 kg ha^{-1} respectively (Table 4). The maximum number of grains per spike (40.67) was recorded from both 250 kg NPS ha^{-1} fertilizer rate of with seeding rate of 100 kg ha^{-1} and 200 kg NPS ha^{-1} with seeding rate of 150 kg ha^{-1} at Lume (Table 6). While the minimum number of grains per spike (25) was recorded from 0 kg NPS with seeding rate of 150 kg ha^{-1}) at Lume. Increased number of grains per spike could be due to optimum crop stand with better nutrition of NPS fertilizer. Better nutrition enhanced the source capacity to better fill of the sink. Nitrogen is the most important nutrient which affects the assimilate production and distribution and also affecting directly and indirectly the source-sink relation (Aynehband *et al.*, 2010). (Usman *et al.*, 2020) Showed that the highest number of grains per spike (48.3) was recorded from NPSB fertilizer rate of 150 kg ha^{-1}. (Maqsood *et al.*, 2002) also found that application of 150 kg N ha^{-1} gave the maximum number of grains per spike.

Thousand grains weight (g)

Analysis of variance revealed that the interaction effects of NPS fertilizer rate and seed rate were highly significant ($P < 0.01$) at Lume (Table 7). The maximum number of Thousand grains weight (39.73) was recorded from 200 kg NPS with seeding rate of 100 kg ha^{-1} followed by (39.70) was recorded from 200 kg NPS with seeding rate of 150 kg ha^{-1} at Lume in 2019/20 respectively (Table 7). (Maqsood *et al.*, 2002) Concluded that thousand grains weight significantly increased with increasing nitrogen levels. Studies have shown that N in wheat mainly represents N accumulated in the vegetative parts until anthesis and translocated to grains during the reproductive phase. This is mainly due to a reduction in available N when soil N mineralization is not enough to fulfill the crop demand (Fernando *et al.*, 2009). (Kinaci *et al.*, 2000) reported that the thousand kernels weight was increased with increase in phosphorus level. The result is in agreement with (Baloch *et al.*, 2010) and (Laghari *et al.*, 2011) who reported that the higher seed rate in bread wheat resulted in decreased 1000-kernel weight. Grains weight differs in their responses to temperatures and locations suggesting that wheat grain filling is closely related to optimum nutrient, temperature and locations. Lower 1000-grain weight was found in late sowing due to high temperature at growth stage, especially in grain filling stage (Akbar Hossain *et al.*, 2011). Delayed sowing shortens the duration of each development phase, which ultimately reduces grain filling period and lowers the grain weight (Spink *et al.*, 2000).

Table 6. Interaction effects of NPS fertilizers and seed rate on grain per spike of bread wheat in 2019/20 at Lume location

Blended NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	33.67 bcd	30.33 ab	25.00 a
50	35.00 bcd	34.67 bcd	38.67 d
100	38.67 d	39.33 d	36.33 bcd
150	37.67 cd	38.00 cd	39.00 d
200	31.33 bc	39.33 d	40.67 d
250	40.67 d	38.67 d	35.33 bcd
LSD(0.05)	5.98 **		
CV (%)	9.9		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Table 7. Interaction effect of NPS fertilizers and seed rate on thousand grain weight of bread wheat in 2019/20 at Lume location

Blended NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	35.87 b	32.43 a	33.30 a
50	37.83 bc	38.27 c	38.00 bc
100	37.90 bc	39.50 c	37.53 bc
150	38.03 bc	37.37 bc	38.63 c
200	39.73 c	37.73 bc	38.43 c
250	37.87 bc	39.27 c	39.70 c
LSD(0.05)	2.04 **		
CV (%)	3.3		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Aboveground dry biomass (kg ha^{-1})

Biological yield represents overall growth performance of the plants as well as the crop. The analysis of variance showed that the main effect of NPS fertilizer rates had highly significant ($P < 0.01$) at three locations (Table 8).

The highest aboveground dry biomass yield (11451, 9102, 7176 kg ha^{-1}) was recorded from 200, 250 and 150 NPS kg ha^{-1} from three location of Adami Tulu, Dugda and Lume respectively. While the lowest aboveground dry biomass yield was recorded from zero NPS kg ha^{-1} (Table 8). The increased in biomass production might be due to the higher NPS fertilizer rates application. In conformity with this result, (Jasemi *et al.*, 2014) reported vegetative growth and biological yield has much dependence to consumption of chemical fertilizers.

Grain yield (kg ha^{-1})

The analysis of variance showed that the main effect of NPS fertilizer rates had highly significant ($P < 0.01$) at three locations on grain yield of bread wheat (Table 8). The highest grain yield (4765.78, 3667, 2797 kg ha^{-1}) was obtained from Adami Tulu, Dugda and Lume at NPS fertilizer rates of 150 kg NPS ha^{-1} respectively. While the lowest grain yields were recorded from zero fertilizer applications at three locations (Table 8).

Table: 8. Main effects of NPS fertilizers and seed rate on above dry biomass (ADB), adjusted grain yield (Ad.GY), straw yield (SY) and harvest index (HI) of bread wheat in 2019/20

Treatments	ADB			Ad.GY			SY			HI		
	Location			Location			Location			Location		
NPS rates (kg ha^{-1})	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume
0	9165 a	5679 a	2639a	3694.71 a	2095 a	1110a	5470a	3584a	1529a	40.25	37.19a	43.87ab
50	10623 b	8395 b	4812b	4329.87 b	3177 b	1949b	6293ab	5218bc	2863b	40.88	37.96a	42.13ab
100	10806 b	8164 b	5586bc	4325.89 b	3287 bc	2373bc	6480b	4877bc	3213bc	40.20	41.15ab	44.58b
150	10741 b	8272 b	7176d	4765.78 b	3667 c	2797c	5976ab	4605b	4379d	44.78	44.59b	39.09ab
200	11451 b	8410 b	5787bc	4608.97 b	3511 bc	2250b	6842b	4899bc	3537bcd	40.30	41.78ab	39.16ab
250	10891 b	9102 b	6191cd	4394.33 b	3427 bc	2322b	6496b	5675 c	3870cd	40.58	37.69a	37.39a
LSD (0.05)	1152.9 ***	1011.2 ***	1155.8 ***	477.67 ***	378.62***	437.58 ***	NS	812.2 ***	820.75***	NS	4.26***	NS
Seed rates (kg ha^{-1})												
100	10473	7591	5045	4327.54	2998.07	2144.18	6145.59	4593	2900.58	41.53	39.58	44.40 b
125	10878	8110	5488	4376.07	3283.85	2071.13	6501.73	4826	3416.52	40.29	40.72	38.75 a
150	10487	8310	5563	4356.16	3300.25	2185.30	6130.93	5010	3378.01	41.68	39.88	39.97 a
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	4.21* *
CV (%)	11.9	12.4	22.5	11.5	11.0	21.1	15.1	16.8	26.0	8.4	10.6	13.2

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; NS= non-significant, Means in column followed by the same letters are not significantly different at 5% levels of Significance

The balanced plant nutrition is one of the most important factors that increase plant production. Balanced supplementation of NPS nutrition is one of the greatest production inputs for crops in high land and low land areas. Maximum grain yield might be attributed to the improvement in number of productive tillers, spike length, kernels per sipke and thousand kernels weight. It could also due to, top-dressing of N fertilizer applied at time of tillering initiations where bread wheat needs in high amount N (60-70%) at this stage for grain production significantly increased grain yield. At higher N application rates, top-dressing of N fertilizer significantly increased grain yield, improved grain protein content, and grain N uptake (Mohammed *et al*., 2013). Nitrogen is an essential nutrient in creating the plant dry matter, as well as many energy-rich compounds that regulate photosynthesis and plant production (Nahed and Darwesh, 2015).

The synergetic effects of those three NPS nutrients convey the enhanced yield components and yield. This might be due to; phosphorus has the role of structural, energy transfer and improvement of root growth and also adjusts the effect of extra nitrogen in maturity delay (Mostafa *et al*., 2012). It is widely found that increasing P as a fertilizer promotes reproductive yields (Egle *et al*., 1999) and inflorescence production (Besmer and Koide, 1999) Sulphur, an essential secondary plant nutrient, plays a vital role in biosynthesis of primary metabolities for improving yield and quality of oil seed crops and for accruing better yield under balanced fertilization (Anwar *et al*., 2002). So an insufficient S supply can affect both yield and quality of the crops (Inal *et al*., 2003).

Straw yield (kg ha^{-1})

Analysis of variance showed that the straw yield of bread wheat was highly significantly ($P < 0.01$) affected by the main effects of NPS fertilizer rates at Dugda and Lume (Table 8). The highest straw yield (5675 and 4379 kg ha^{-1}) was obtained from 250 and 150 kg NPS ha^{-1} fertilizers at Dugda and Lume respectively. While the lowest straw yields was recorded from zero fertilizer rates at both locations (Table 8). This might be due to balanced supplied of NPS nutrients lead to more vegetative growth and more dry matter accumulation which directly related to an increment in straw yield.

Harvest index

Harvest index is an ability of a cultivar to convert the dry matter into economic yield. The higher the harvest index value, the greater the physiological potential of the crop for the converting dry matter to grain yield. The analysis of variance revealed that the main effects of NPS fertilizer rates had highly significant ($P < 0.01$) at Dugda (Table 8). While the non significant effect observed at both locations. The significant effect of ($P < 0.05$) was recorded on the interaction effect of NPS fertilizer rates and seed rate on harvest index of bread wheat at Lume (Table 9). The highest harvest index (50.35%) was obtained from 150 kg NPS ha^{-1} with seeding rates of 150 kg ha^{-1} followed by (44.30%) from 250 kg NPS ha^{-1} fertilizer with seeding rates of 100 kg ha^{-1} whereas the lowest harvest index (38.01%) was recorded from100 kg NPS ha^{-1} with seeding rates of 125 kg ha^{-1} (Table 9). (Usman *et al*., 2020) reported that the highest harvest index of (48.5%) from king bird variety was recorded.

Table 9. Interaction effect of NPS fertilizers and seed rate on Harvest index of bread wheat in 2019/20 at Adami Tulu location

Blended NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	38.41 a	40.48 a	41.87 a
50	41.33 a	43.24 a	38.07 a
100	42.70 a	38.01 a	39.89 a
150	43.51 a	40.50 a	50.35 b
200	38.93 a	40.05 a	41.91 a
250	44.30 a	39.46 a	37.99 a
LSD(0.05)	5.71 *		
CV (%)	8.4		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Hectoliter weight (HLW)

The result showed a highly significant ($p<0.01$) main effect of fertilizer rates on Hectoliter weight at Lume, while the interactions effects of NPS fertilizer rates and seed rates were significant ($P<0.05$) at Adami Tulu (Table 11) and Lume (Table 12). The highest HLW (82.53) was obtained from 100 kg NPS ha^{-1} fertilizer rate with 125 kg seed rates ha^{-1} while the lowest HLW (78.87) was obtained from 0 kg NPS ha^{-1} fertilizer rate with 125 kg seed rates ha^{-1} at Adami Tulu respectively and the highest HLW (82.20) was obtained from 200 kg NPS ha^{-1} fertilizer rate with 150 kg seed rates ha^{-1} (Table 12) while the lowest HLW (76.73) was obtained from 0 kg NPS ha^{-1} fertilizer rate and 125 seed rates kg ha^{-1} at Lume respectively. This result is in line with that of (Behera *et al.*, 2010) who reported that hectoliters weight increased significantly with application of NPK fertilizer and was the highest with application of 125 kg NPK ha^{-1}.

Grain protein content (%)

The protein content in flour is the main quality criterion for wheat, especially for bread making (Triboi *et al.*, 2006). The highest protein contents of bread wheat due to optimum N application are for bread making and low protein for feed and other uses. Grain protein content was significantly ($p<0.01$) affected by main effect of NPS fertilizer rates at three locations (Table 10) and the interaction between the two factors was highly significant ($p<0.01$) at Adami Tulu (Table 13) and Lume (Table 14). The highest GPC (16.26) was obtained from of 200 kg NPS ha^{-1} fertilizer rate with 100 kg seed rates ha^{-1} while the lowest GPC (14.14) was obtained from 0 kg NPS ha^{-1} fertilizer rate with 125 kg seed rates ha^{-1} at Adami Tulu respectively (Table 13). The highest GPC of (12.72) was obtained from 250 kg NPS ha^{-1} fertilizer rate with 150 kg seed rates ha^{-1} while the lowest GPC of (10.60) was obtained from 0 kg NPS ha^{-1} fertilizer rate with 125 kg seed rates ha^{-1} at Lume respectively (Table 14). Nitrogen in the NPS nutrient is the most recognized element in plant for its presence in the structure of the protein molecule. The increase in grain N uptake and protein content led to an improvement in wheat grain quality (Mohammed *et al.*, 2013). Nitrogen fertilization contributes significantly to protein content, especially when fertilizer rates satisfy the requirements of both yield and protein formation (Woyema *et al.*, 2012). The grain protein content is directly connected with the overall available nitrogen, both from mineral fertilizers and from mineralization processes in soil (Renata *et al.*, 2013). Application of 105 kg N ha^{-1} gave the highest mean values of all yield and its components compared as control treatment such increments might be attributed to the favorable role of nitrogen in encouraging in catabolic processes in wheat plants (Gomaa *et al.*, 2015).

Table: 10. Main effects of NPS fertilizers and seed rate on hectoliter weight (HLW) and grain protein content (GPC) of bread wheat in 2019/20

Treatments	HLW			GPC		
	Location			Location		
NPS rates (kg ha^{-1})	A/Tulu	Dugda	Lume	A/Tulu	Dugda	Lume
0	81.01	79.79	78.29a	14.43a	12.59a	10.77a
50	81.18	79.61	80.63b	15.21b	14.17b	11.76b
100	81.22	79.46	81.52b	15.08b	14.25b	11.61b
150	81.58	79.76	81.66b	15.19b	14.03b	11.71b
200	80.46	79.46	81.49b	15.64b	13.74b	11.77b
250	81.67	80.24	81.60b	15.45b	13.88b	12.01b
LSD (0.05)	NS	NS	1.21***	0.51***	0.55***	0.57***
Seed rates (kg ha^{-1})						
100	81.04	79.51	80.62	15.14	13.63	11.63
125	80.92	79.84	80.98	15.05	13.99	11.58
150	81.59	79.81	81.00	15.31	13.71	11.61
LSD (0.05)	NS	NS	NS	NS	NS	NS
CV (%)	1.0	1.1	1.4	3.0	3.9	4.6

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; NS= non-significant, Means in column followed by the same letters are not significantly different at 5% levels of Significance

Table 11. Interaction effect of NPS fertilizers and seed rate on hectoliter weight of bread wheat in 2019/20 at Adami Tulu location

Blended NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	82.30 fg	78.87 a	81.87 defg
50	80.50 bcd	80.63 bcde	82.40 fg
100	80.13 abc	82.53 g	81.00 cdefg
150	81.83 defg	81.57 cdefg	81.33 cdefg
200	79.30 ab	81.00 cdefg	81.07 cdefg
250	82.17 efg	80.93 cdef	81.90 defg
LSD(0.05)	1.31 ***		
CV (%)	1.0		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Table 12. Interaction effect of NPS fertilizers and seed rate on hectoliter weight of bread wheat in 2019/20 at Lume location

Blended NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	79.73 bcd	76.73 a	78.40 ab
50	79.60 bc	81.33 cde	80.97 cde
100	80.60 cde	82.63 e	81.33 cde
150	81.30 cde	81.77 cde	81.90 de
200	80.60 cde	81.67 cde	82.20 e
250	81.87 de	81.73 cde	81.20 cde
LSD(0.05)	1.89 **		
CV (%)	1.4		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Table 13. Interaction effect of NPS fertilizers and seed rate on grain protein content of bread wheat in 2019/20 at Adami Tulu location

Blended NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	14.74 abc	14.14 a	14.42 ab
50	15.35 cd	15.05 bcd	15.22 bcd
100	14.41 ab	14.94 abc	15.87 de
150	14.96 abc	15.26 bcd	15.35 cd
200	16.26 e	15.31 cd	15.36 cd
250	15.09 bcd	15.62 cde	15.63 cde
LSD(0.05)	0.75 ***		
CV (%)	3.0		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Table 14. Interaction effect of NPS fertilizers and seed rate on grain protein content of bread wheat in 2019/20 at Lume location

Blended NPS (kg ha^{-1})	Seed rate (kg ha^{-1})		
	100	125	150
0	10.92 abc	10.60 a	10.81 ab
50	11.70 bcdef	12.15 defgh	11.43 abcde
100	11.59 abcde	11.72 bcdefg	11.51 abcde
150	11.87 cdefgh	11.55 abcde	11.71 bcdef
200	12.46 efgh	11.37 abcd	11.49 abcde
250	11.22 abcd	12.08 defgh	12.72 fh
LSD(0.05)	0.89 **		
CV (%)	4.6		

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation

Table 15. Summary of economic analysis of the effects of NPS fertilizer rates and seed rates on bread wheat at three locations in 2019/20 cropping season

Treatments		AGY (kg ha^{-1})			Income (ETB ha^{-1}) Grain yield			GFB (ETB ha^{-1})			TVC (ETB ha^{-1})	NB (ETB ha^{-1})			MRR (%)		
Seed rate	Fert	AT	DG	LM	AT	DG	LM	AT	DG	LM		AT	DG	LM	AT	DG	LM
100	0	3068.5	1636.0	1217.4	49095.65	26175.74	19478.59	49095.65	26175.74	19478.59	1600	47496	24576	17878.4			
100	50	4083.5	2905.7	1598.3	65336.26	46490.69	25572.67	65336.26	46490.69	25572.67	3074	62262	43417.2	22498.8	1001.8	1278	313
100	100	4340.9	2380.5	2436.4	69455.09	38088.43	38982.53	69455.09	38088.43	38982.53	4548	64906.4	33540	34434.4	179.4	D	810
100	150	3957.9	3073.0	2466.3	63327.17	49167.5	39460.61	63327.17	49167.5	39460.61	6022	57304.4	43146	33438.8	D	652	D
100	200	3906.9	3076.0	1568.0	62510.69	49216.46	25088.69	62510.69	49216.46	25088.69	7496	55014.4	41720	17592	D	D	D
100	250	4010.9	3118.4	2292.1	64174.9	49894.42	36673.78	64174.9	49894.42	36673.78	8970	55204.4	40924.4	27703.6	12.9	D	686
125	0	3414.7	2114.6	803.8	54634.61	33834.38	12860.78	54634.61	33834.38	12860.78	2000	52635.2	31833.6	10860.8	36.9	130	242
125	50	3931.1	2924.9	1860.0	62898.05	46797.98	29760.62	62898.05	46797.98	29760.62	3474	59423.6	43324.4	26286	460.5	780	1046
125	100	3749.4	3298.5	1916.4	59991.12	52775.57	30662.35	59991.12	52775.57	30662.35	4948	55042.4	47828	25714.4	D	306	D
125	150	4262.4	3192.9	2314.5	68198.69	51085.73	37032.62	68198.69	51085.73	37032.62	6422	61776.4	44664.4	30610	456.9	D	332
125	200	4345.6	3213.8	2359.3	69529.54	51420.67	37748.59	69529.54	51420.67	37748.59	7896	61633.6	43524.8	29852.8	D	D	D
125	250	3927.5	2988.2	1930.0	62840.59	47810.45	30880.37	62840.59	47810.45	30880.37	9370	53470	38441.2	21510	D	D	D
150	0	3492.6	1906.7	975.9	55881.5	30507.7	15613.78	55881.5	30507.7	15613.78	2400	53481.6	28107.2	13214.4	D	148	119
150	50	3676.0	2746.9	1803.5	58816.08	43950.1	28856.45	58816.08	43950.1	28856.45	3874	54942	40076.4	24982	99.1	812	798
150	100	3589.5	3194.7	2054.4	57432.1	51115.97	32870.3	57432.1	51115.97	32870.3	5348	52084	45767.2	27522.4	D	386	172
150	150	4647.2	3634.9	2772.1	74355.7	58158.43	44353.3	74355.7	58158.43	44353.3	6822	67533.2	51336.4	37531.6	1048.1	378	679
150	200	4191.7	3191.0	2148.7	67067.42	51055.92	34379.14	67067.42	51055.92	34379.14	8296	58771.2	42760	26083.2	D	D	D
150	250	3926.2	3147.1	2046.1	62819.71	50353.78	32736.96	62819.71	50353.78	32736.96	9770	53049.2	40583.6	22967.6	D	D	D

Where, AT= Adami Tulu, DG=Dugda, LM=Lume, AGY = adjusted grain 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. Market price of wheat = 16.00 ETB kg^{-1}; Cost of NPS= 14.96 kg^{-1}; Cost of Urea =14.52 ETB kg^{-1}.

Partial Budget Analysis

Partial budget analysis is important to identify experimental treatments with an optimum return to the farmer's investment and to develop recommendation for the agronomic data. Experimental yields are often higher than the yields that farmers could expect using the same treatments; hence in economic calculations, yields of farmers are adjusted by 10% less than that of the research results CIMMYT (1988). As indicated in Table 15, the partial budget analysis showed that the highest net benefit of (67533.2, 51336.4 and 37531.6) Birr ha^{-1} with marginal rate of return (1048.1, 378 and 679 %) was obtained for seed rates of (150 kg ha^{-1}) bread wheat that received (150 kg NPS ha^{-1}) at Adami Tulu, Dugda and Lume respectively. However, the lowest net benefits of (47496, 24576 and 10860.8) Birr ha^{-1} were obtained from the seed rate of (100, 100 and 125 kg ha^{-1}) bread wheat that received zero fertilizer at Adami Tulu, Dugda and Lume respectively.

The economically feasible combination indicated that application of (150, 150, 150 kg NPS ha^{-1}) fertilizer rates with similar seeding rates of (150, 150, 150 kg ha^{-1}) at Adami Tulu, Dugda and Lume respectively. Therefore, as compared to overall treatments of highest net benefits (150 kg NPS ha^{-1}) fertilizer rates with combination of (150 kg ha^{-1}) seed rates were economical and recommended for production of bread wheat with supplemented 73 kg N ha^{-1} fed as urea of ½ at sowing time and ½ top dressed at tillering stage of the crop for Adami Tulu, Dugda and Lume respectively and other areas with similar agro ecological condition. In general, from the recommended 150 NPS and 73 N supplemented each combined elemental rate of 101.5% N, 57 % P, and 10.5 % S were used.

Conclusions and Recommendation

As conclusions, in respect to the above results on the responses of bread wheat to seeding rates and NPS nutritional levels under different environmental conditions would be very useful in planning of our seeding system and NPS rates for increasing of productions in the specific study area. Seed rate did not bring significant effect on most of the yield and yield components at all locations. However, its interaction with seeding rate and fertilizer rates attributes had significant effect on yield component parameters.

The higher economically feasible seeding and NPS fertilizer rates was the soil nourished with 150 kg seed ha^{-1} and 150 kg NPS ha^{-1} with supplemented 73 kg N ha^{-1}(159 kg Urea ha^{-1}) of ½ at sowing time and ½ top dressed at tillering stage for Adami Tulu, Dugda and Lume respectively was suggested to the wheat producers.

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