Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.8, No.11, 2018

Effect of Blended NPS Fertilizer Supplemented with Nitrogen on Yield Components and Yield of Bread Wheat (Triticum aestivum L.)

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Abstract
This experiment was conducted to assess the effect of blended NPS fertilizer supplemented with N and to estimate the economically feasible fertilizer rate for higher yield of bread wheat. The experiment consisted of three levels of NPS (100,150 and 200 kg ha^{-1}) each supplemented with five levels of N (0, 23, 46, 69 and 92 kg N ha^{-1}) and control. Randomized Complete Block Design in factorial arrangement with three replication was used. The results showed that the days to heading, grain filling period, aboveground dry biomass (AGB) and 1000-kernels weight significantly affected by main effect of NPS and N. The highest (17129 and 16822 kg ha^{-1}) AGB were obtained due to 200 kg blended NPS ha^{-1} and 92 kg N ha^{-1}, respectively. Also the interaction of NPS with N rate had significant effect on most parameters. The highest grain yield (6832 kg ha^{-1}),highest number of kernels per spike and highest harvest index were obtained from application of 200 kg NPS ha^{-1} with 92 kg of SN ha^{-1}. The results of the economic analysis showed that the maximum net return was obtained due to the application of 200 kg NPS ha^{-1}+ 46 kg N ha^{-1}. In conclusion, a combined application of 200 kg NPS ha^{-1}supplemented with 46 kg N ha^{-1} are recommended to achieve sustainable bread wheat. However, the experiment was conducted only in one location for one season, so further studies at different locations for several years should be conducted in the study area before giving a conclusive recommendation.
Keywords: blended NPS fertilizer; bread wheat; grain yield; inorganic N fertilizer

1. NTRODUCTION

Wheat (*Triticum* spp.*)* is one of the world's most important staple foods for about one third of the world's population (Hussain *et al*, 2006). Among many wheat plants, only three species are commercially important. These are bread wheat (*Triticum aestivum)*, durum wheat (*Triticum durum)* and emmer wheat (*Triticum compactum)* (Gooding and Davies, 1997). Ethiopia is the second largest producers of wheat in sub-Saharan Africa with an estimated area of 1.6 million ha (CSA, 2015). However, the Ethiopia government is forced to import wheat ever year because of high demand than supply (World Fact Book, 2012).

Nutritionally, bread wheat grain is high in carbohydrates: whole grain wheat flour contains roughly 70% carbohydrate, 11.5% protein (varying from 8-15%), 2% fat, 2% fibre, 1.5% ash, and 13% water (Hoveland, 1980). Wheat production in the country is adversely affected by low soil fertility and suboptimal use of mineral fertilizers in addition to diseases, weeds, erratic rainfall distribution in lower altitude zones, and water-logging in the Vertisols areas (Amanuel *et al*., 2002).

In Ethiopia, N and P are the most important nutrients limiting wheat growth and yield. Most of the fertilizer studies on bread wheat have been conducted using NP fertilizers. To alleviate the soil fertility problem in the area, the Office of Agricultural and Natural Resources of the Woreda has introduced chemical fertilizer blended with NPS fertilizer which contains nutrients N: P: S:: 19:38:7 and urea fertilizer in each Kebele of the Woreda. However, the NPS fertilizer rate which is being used by farmers is blanket recommendation (100 kg ha^{-1}) along with 46 kg N ha^{-1} through urea in the Distinct. This fertilizer (blended NPS) which may or may not be sufficient to meet the crop requirement in the area. In the study area experiment has not been conducted on effect of NPS fertilizer with nitrogen rates of bread wheat. Thus, it is imperative to conduct location specific study on the response of one of the popular varieties with the newly introduced blended fertilizer in conjunction with nitrogen fertilizer that will help farmers to increase the yield of the crop. This study was conducted to assess the effect of blended NPS fertilizer supplemented with inorganic N on yield components and yield and to estimate the economically feasible NPS and N rate for higher yield of bread wheat.

2. MATERIALS AND METHODS

2.1 Area Description

The on-farm field experiment was conducted during 2016 main cropping season at Soro District, Southern Ethiopia in farmer field and the site is located on geographic coordinates of 7° 35' 00''N latitude, 37°30' 00''E longitudes and 2134 meter above sea-level. The rainfall of the area is characterized by bimodal distribution pattern and the main rainy season (*Meher)* is between June and end of September and short rainy season (*Belg*) is from late February to early April. Wheat is grown during the main season from June to September. The average annual rainfall is 1250 mm. The average annual minimum and maximum air temperature is 14°C and 28°C, respectively.

2.2 Experimental Materials

A bread wheat variety named *Danda'a*, which was released by Kulumsa Agricultural Research Centre in 2010 (MoA, 2010) was used as a test crop. Urea (46% N) and blended of NPS (19-38-7) fertilizers were used as source of nutrients.

2.3. Soil Sampling and Analysis

Before sowing, the composite soil sample was analyzed for the determination of soil texture, soil pH, organic carbon, total nitrogen, available phosphorus and cation exchange capacity (CEC) analysis using standard laboratory procedures.

2.4. Treatments, Experimental Design:

The treatment consists of three levels of NPS (100, 150 and 200 kg ha^{-1}) each supplemented with five levels of nitrogen (0, 23, 46, 69 and 92 kg ha^{-1}) and control (Table 1).The experiment was laid out in a randomized complete block design (RCBD) in factorial arrangement with three replications.

Table 1. Details of Fertilizer Rates and their Composition

Treatments	Applied Fertilizer kg ha^{-1}		Composition of the applied fertilizer		
	NPS	N in urea	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	S (kg ha^{-1})
1	0	0	0	0	0
2	100	0	19	38	7
3	100	23	42	38	7
4	100	46	65	38	7
5	100	69	88	38	7
6	100	92	111	38	7
7	150	0	28.5	57	10.5
8	150	23	51.5	57	10.5
9	150	46	74.5	57	10.5
10	150	69	97.5	57	10.5
11	150	92	120.5	57	10.5
12	200	0	38	76	14
13	200	23	61	76	14
14	200	46	84	76	14
15	200	69	107	76	14
16	200	92	130	76	14

2.5. Management of the Experiment

The experimental plots were maintained to have 10 rows each spaced 20cm. Spacing of 1m and 0.5m was maintained between adjacent blocks and plots, respectively. Seeds were sown using a seed rate of 125 kg ha^{-1} in a plot size of 3 m x 2 m (6 m^2), by drilling. Fertilizers were applied based on the treatments. Full rate of blended NPS as per the treatment and one-third N was applied in form of urea at sowing time. The remaining two-third of N alone was side dressed at the mid-tillering crop stage. The middle 8 rows were used to collect data on growth and yield parameters. The outermost one row from each side of a plot and 25 cm from each end of the rows was considered as border, thus the net plot size was 2.5 m x 1.6 m.

2.6 Data collection and evaluation parameters

Days to 50% heading: Days to heading was recorded as the number of days from the date of sowing till spikes emerged in 50% of the plants in each net plot.

Days to 90% physiological maturity: Days to maturity was recorded as the number of days from date of sowing till in 90% of the plants changed their green color to yellowish, in each plot.

Grain filling period: was determined the number of days from anthesis to physiological maturity, *i.e.* the number of days to maturity minus the number of days to heading.

Plant height (cm): Plant height was measured from the soil surface to the tip of a spike (awns excluded) of 10plants, randomly taken 5 plants each from two 0.5 m row length in net plot area at physiological maturity

Total number of tillers: Total tillers were counted from two randomly taken rows of 0.5 m in length from the net plot area at physiological maturity.

Number of productive tillers: The number of productive tillers bearing spikes was counted at physiological maturity by counting all spikes from two randomly taken rows of 0.5 m in length from the net plot area.
Number of kernels per spike: Number of kernels per spike was determined from the ten randomly sampled spikes from the net plot.
Thousand kernels weight (g): It was determined based on the weight of 1000 kernels sampled from the grain yields used to determine of each treatment, using an electric seed counter, weighing with an electronic balance and adjusted to 12.5% moisture level.
Aboveground dry biomass yield: The plants in the net plot area were harvested at ground level, sun dried for about 10 days until constant weight attained and weighed to obtain the total biomass yield and expressed in kg ha^{-1}.
Grain yield: The grain yield was taken by harvesting and threshing the grain yield from net plot area and converted to kg ha^{-1}. The yield was adjusted to 12.5% moisture.

$$\text{Grain yield (kg ha}^{-1}\text{) at 12.5\% moisture base} = \text{Yield obtained (kg ha}^{-1}\text{)} \times \frac{(100-\%MC)}{(100-12.5)}$$

Where, MC= grain moisture content.
Harvest Index (HI): It was calculated as the ratio of grain yield per to the aboveground dry biomass yield per plot expressed as a percentage.

$$\text{HI (\%)} = \frac{Grain\ yield/plot}{Above\ ground\ dry\ biomass/plot} \times 100$$

2.7 Data Analysis

The data were subjected to analysis of variance (ANOVA) as per the experimental design test GenStat 15thedition software (GenStat, 2012). The significant differences between treatment means were separated using Duncan's multiple range Tests at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Soil Properties before Planting

The physical and chemical properties of the soil of the experimental field are indicated in Table 2. The soil textural class of the experimental site is loam. The soil of experimental field is moderately acidic in pH (5.5), low in total N (0.173%), very low in available phosphorus (2.2 mg $kg^{-1)}$, and medium in CEC (23.68Cmol+ /kg). From the results of soil analysis it can be depicted both nitrogen and phosphorus may be yield limiting for wheat production in the area.

Table 2. Soil properties of the experimental site

Physical properties	Content	Rating
Soil texture:		
Sand (%)	51	High
Silt (%)	32	Moderate
Clay (%)	17	Low
Textural class		Loam
Chemical properties		
pH (1:2.5 H_2O)	5.5	Moderately acidic
Organic carbon (%)	2.00	High
Total N (%)	0.1731	Low
Available P (mg/kg)	2.2	Very low
CEC Cmol+/kg of soil	23.68	Medium

CEC=Cation exchange capacity, ma=moderately acidic

3.2. Crop Phenology and Plant Height

The main effects of supplemental nitrogen rate was significantly (P<0.01) affected days to heading. However, the main effect of blended NPS fertilizer rates and interaction effect did not significantly affect days to 50% heading of the bread wheat. This result is in line with the findings of Ayoub *et al.,* (1994). Days to physiological maturity was highly significantly (P < 0.01) affected due to the main effect of blended NPS fertilizer and supplemental N rate and significantly (P < 0.05) by the interaction. The result is in conformity with the findings of Gurmessa (2002); and Getachew (2004). The main effects of blended NPS rate had significant (P<0.01) effect on grain filling period; but the main effect of supplemental N rate as well as their interaction effect did not significantly affect this. The current result is supported by Gupta and Sharma (2000) findings.

The plant height was significantly (P<0.01) affected by the main effects of blended NPS, supplemental nitrogen and interaction effect. This study is in agreement with the findings of Melesse Harfe (2007).

3.3. Yield Components and Yield

Both total and productive number of tillers were highly significantly (P<0.01) affected by the main effect of blended NPS fertilizer and supplemental N rate and significant (P <0.05) by the interaction. These results are supported by the findings of Firehiwot (2014). Number of kernels per spike was highly significantly (P<0.01) affected by the main effects of blended NPS fertilizer application and supplemental N fertilizer rate as well as by the interaction. In line with this result, Zhao*et al.* (1999).The main effects of blended NPS fertilizer and supplemental nitrogen rate had highly significantly (P < 0.01) effect on both aboveground dry biomass and thousand kernels weight .However, the interaction effect were not significant. These results are supported by the findings of Iqtidar *et al.*(2006); and Melesse Harfe (2007). Grain yield of wheat highly significantly (P< 0.01) due to the main effects of blended NPS and supplemental N rates and significantly (P< 0.05) due to the interaction. The result is supported by (Minale *et al*., 2005; Melesse Harfe, 2007). The highest grain yield was obtained due to 200 kg blended NPS ha^{-1} supplemented with 92, but was not statistically different than the rate of 200 kg blended NPS ha^{-1} supplemented with 46 kg supplemental N ha^{-1}. Harvest index was highly significantly (P< 0.01) affected by main effects of blended NPS and supplemental N rates and significantly (P< 0.05) by the interaction. This result is supported by the findings of Mengel and Kirkby (2001).

Table 3. Main Effect of Blended NPS Fertilizer and Supplemental Nitrogen on some parameter of bread wheat

SN (kg)	DH	GFP	TK W(g)	AGB
0	63.00^{d}	29.67	45.17^{c}	15567^{b}
23	64.33^{c}	31.00	45.62^{c}	16585^{a}
46	65.44^{b}	30.56	47.30^{b}	16822^{a}
69	66.33^{b}	30.22	48.53^{ab}	16728^{a}
92	67.78^{a}	29.56	49.93^{a}	16855^{a}
LSD (0.05)	0.956	0.956	1.529	719.1
NPS (kg)				
100	65.07	29.00^{b}	45.26^{c}	16130^{b}
150	65.27	30.53^{a}	48.97^{a}	16275^{b}
200	65.80	31.07^{a}	47.70^{b}	17129^{a}
LSD (0.05)	0.740	1.068	1.184	557.0
CV (%)	1.5	4.7	3.3	4.5
Treated × Control				
LSD (0.05)	2.057	2.629	4.800	2868.255
CV (%	0.9	2.6	3.2	6.9

SN=supplemental nitrogen; DH=Days to 50% heading; GFP= Grain filling period; TKW=Thousand kernels weight; AGB=Above ground biomass; CV= coefficient of variance; LSD= Least Significant Difference at 5% level.

Table 4. The Interaction Effect of Blended NPS Fertilizer Supplemented with Nitrogen on days to 90% physiological maturity and plant height of bread wheat

SN (kg ha^{-1})	Blended NPS (kg ha^{-1})					
	90% PM					
	100	150	200	100	150	200
0	92.33^{i}	93.33^{hi}	92.33^{i}	74.87^{j}	83.60^{h}	81.07^{i}
23	93.67^{ghi}	95.67^{de}	96.67^{bcd}	84.52^{hg}	85.23^{gh}	92.40^{d}
46	94.00^{fgh}	96.00^{de}	98.00^{ab}	86.63^{fg}	89.53^{e}	97.17^{c}
69	95.00^{efg}	96.33^{cde}	98.33^{a}	88.23^{ef}	94.67^{cd}	102.50^{b}
92	95.33^{def}	97.67^{abc}	99.00^{a}	92.53^{d}	96.60^{c}	106.27^{a}
Treated mean		95.58A			90.39A	
Control mean		89.33B			63.53B	
NPS ×N LSD (0.05)		Treated ×Control		NPS ×N LSD (0.05)	Treated ×Control	
1.458		1.339		2.455	16.4	
CV (%) 0.9		0.4		CV (%) 1.6	6.1	

SN=supplemental nitrogen; PM= Physiological maturity; PH= Plant height; CV= coefficient of variance; LSD= Least Significant Difference at 5% level

Table 5. The Interaction Effect of Blended NPS Fertilizer Supplemented with Nitrogen on total number of tillers and productive number of tillers of bread wheat

SN (kg ha^{-1})	Blended NPS (kg ha^{-1})					
	TNT			PNT		
	100	150	200	100	150	200
0	5150000^{defg}	4166667^{g}	6300000^{abcd}	4926833^{def}	3986000^{f}	5961333^{abcd}
23	4733333^{fg}	5700000^{bcdef}	5083333^{efg}	4528667^{ef}	5435833^{bcde}	4880000^{def}
46	5650000^{bcdef}	5650000^{bcdef}	6400000^{abc}	5367500^{bcde}	5388833^{bcde}	6082333^{abc}
69	5433333^{cdef}	6000000^{abcde}	6483333^{abc}	5180333^{cde}	5718667^{abcd}	6199000^{abc}
92	5633333^{bcdef}	6766667^{ab}	7066667^{a}	5331667^{bcde}	6449333^{ab}	6738333^{a}
Treated mean		5757778A			5478311A	
Control mean		3316667B			2466667B	
NPS ×N		Treated ×Control		NPS ×N	Treated ×Control	
LSD (0.05) 1040408.4		2174158		LSD (0.05) 989456.2	1638732.5	
CV (%) 10.8		13.7		CV (%) 10.7	11.7	

SN=supplemental nitrogen; TNT= Total number of tillers; PNT= Productive number of tillers; CV= coefficient of variance; LSD= Least Significant Difference at 5% level

Table 6. The Interaction Effect of Blended NPS Fertilizer Supplemented with Nitrogen on grain yield and harvest index of bread wheat

SN (kg ha^{-1})	Blended NPS (kg ha^{-1})					
	GY(kg ha^{-1})			HI (%)		
	100	150	200	100	150	200
0	4023^{d}	4949^{bc}	5375^{bc}	0.284^{c}	0.323^{bc}	0.319^{bc}
23	4581^{cd}	5533^{b}	5305^{bc}	0.283^{c}	0.335^{bc}	0.318^{bc}
46	5180^{bc}	5199^{bc}	6810^{a}	0.316^{bc}	0.321^{bc}	0.377^{ab}
69	5290^{bc}	5506^{b}	5816^{b}	0.319^{bc}	0.333^{bc}	0.349^{ab}
92	5396^{bc}	5453^{bc}	6832^{a}	0.324^{bc}	0.325^{bc}	0.400 ^{a}
Treated mean		5417A			0.33A	
Control mean		2093B			0.28B	
NPS ×N		Treated ×Control		NPS ×N	Treated × Control	
LSD (0.05) 791.6		1347.5		LSD (0.05) 0.034	0.043	
CV (%) 8.7		10.2		CV (%) 6.3	4.0	

SN=supplemental nitrogen; GY= Grain yield; HI= Harvest index; CV= coefficient of variance; LSD= Least Significant Difference at 5% level.

3.4. Partial Budget Analysis

The partial budget analysis showed that the maximum net benefit with an acceptable MRR was obtained from 200 kg blended NPS ha^{-1} fertilizer supplemented with 46 kg SN ha^{-1} application. The net benefit obtained by the use of improved bread wheat with rates of 200 kg NPS ha^{-1}+ 46 kg SN ha^{-1} were found to be greater than the benefit of applying blended NPS and SN at the blanket recommendation rates (100 kg NPS ha^{-1} + 100 kg SN ha^{-1}).Therefore, the net positive benefit obtained with application of 200 kg blended NPS ha^{-1} + 46 kg SN ha^{-1}to bread wheat are economically profitable application rates and can be recommended for farmers in study area and other areas with similar agro-ecological conditions.

Table 7. Marginal analysis of bread wheat yield as influenced by blended NPS fertilizer supplemented with nitrogen rate

NPS (kg ha^{-1})	SN (kg ha^{-1})	Average Yield (kg ha^{-1})	Adjusted Yield (kg ha^{-1})	GB (Birr ha^{-1})	TVC (Birr ha^{-1})	NB (Birr ha^{-1})	MRR (%)
0	0	2093	1883.7	11302.2	0	11302.2	0
100	0	4023	3620.7	21724.2	1822	19902.2	472
100	23	4581	4122.9	24737.4	2412.37	22325.03	410.39
150	0	4949	4454.1	26724.6	2608	24116.6	915.79
100	46	5180	4662	27972	3002.74	24969.26	216
150	50	5533	4979.7	29878.2	3198.37	26679.83	874
200	0	5375	4837.5	29025	3394	25631	D
100	69	5290	4761	28566	3593.11	24972.89	D
150	46	5199	4679.1	28074.6	3788.74	24285.86	D
200	23	5305	4774.5	28647	3984.37	24662.63	192.59
100	92	5396	4856.4	29138.4	4183.48	24954.92	146.8
150	69	5506	4955.4	29732.4	4379.11	25353.29	203.63
200	46	6810	6129	36774	4574.74	32199.26	3499.45
150	92	5453	4907.7	29446.2	4969.48	24476.72	D
200	69	5816	5234.4	31406.4	5165.11	26241.29	901.99
200	92	6832	6148.8	36892.8	5755.48	31137.32	829.32

SN= supplemental nitrogen; ETB= Ethiopian Birr; GB= Gross benefit; TVC = Total variable cost; NB = Net benefit; D=Dominated treatment's, MRR = Marginal rate of return.

4. CONCLUSION AND RECOMMENDATION

Nitrogen and phosphorus are known as the most yield limiting nutrients constraining cereal productivity including wheat in Ethiopia. Though there were some evidences on the effect of blended NPS fertilizer supplemented with nitrogen on wheat productivity, a comprehensive work in scanty in loam soil like the case of Soro distinct. The results of this experiment revealed that all parameters were significantly affected by the main effect of blended NPS and SN, except days to 50% heading and grain filling period. Similarly, all parameters were significantly affected by the interactions of blended NPS x SN, except days to 50% heading, grain filling period, thousand kernels weight and aboveground dry biomass. Use of higher blended NPS fertilizer with supplemental N rates is the realistic approach to address the problem of low productivity of bread wheat in the study area. In general, it can be concluded that use of 200 kg blended NPS ha^{-1} supplemented with 46 kg SN ha^{-1} produced highest grain yields, together with the best economic benefit or profitability. Therefore, this treatment can be recommended to increase bread wheat production on loam soil in the study area.

5. ACKNOWLEDGEMENTS

This research was funded by grants from Soro Woreda Agricultural Development Office for supporting me financially during the period of the study. The administrations of Gimbichu High School are highly acknowledged to allowing me use their land for this study. I express my deepest thanks and honest thankfulness to my research advisors, Dr. Ketema Belete and Dr. Tamado Tana for his professional involvement, and continuous encouragement, guidance and valuable suggestions in every step of the research work and write-up of this Thesis.

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