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Application of Blended (NPSB) and Urea Fertilizers Levels for Wheat Production across Soil Types and Agro-Ecologies of South-Eastern Ethiopia

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Abstract

For three cropping seasons, field experiment was carried out on different farm lands at Gedeb-Hasasa and Lemu-Bilbilo districts of Arsi zone of Oromia, South-eastern Ethiopia, to determine optimum NPSB and urea fertilizers rates for selected crop, soil and climatic conditions by varying levels of NPSB fertilizer (0, 100, 150, 200, 250 kg ha^{-1}), urea (0, 150, 250, 350 kg ha^{-1}) and recommended NP in combined RCBD with three replications on yield and yield components. The soil analysis result of experimental sites at post harvest indicated that, the application of treatments significantly ($p < 0.01$) affected pH, total N organic matter and available P for samples taken from experimental sites of wheat crop. Application of different fertilizer levels had significant effects on post-harvest pH and organic carbon contents. In a similar way, the application of treatments significantly ($p < 0.01$) affected total N organic carbon and available P for samples taken from experimental sites of wheat crop. Soil pH of wheat field was significantly ($p < 0.05$) affected by different fertilizer treatments. Different fertilizer treatments had significant effects on post harvest soil organic carbon content at Lemu-Bilbilo district. Combined levels of NPSB and urea fertilizers rates were significantly affected grain and above ground biomass yields at Gedeb-Hasasa and Lemu-Bilbilo districts. Agronomic maximum grain and above ground biomass yields (6170 and 13510 kg ha^{-1}) in 2017 and minimum (4038 and 10908 kg ha^{-1}) in 2018 cropping season were obtained, respectively, up on the application of NPSB and urea fertilizers, and significant grain and above ground biomass yield (6440 and 14846 kg ha^{-1}) were obtained from the application of 250 + 350 kg ha-1 NPSB + urea rates, respectively, at Gedeb-Hasasa district. The highest grain and above ground biomass yields (6584 and 12709 kg ha^{-1}) in 2019 and lowest (5229 and 10674 kg ha^{-1}) in 2018 cropping season were obtained, respectively, up on the application of NPSB and urea fertilizers rate, and significant grain and above ground biomass yield (6629 and 13372 kg ha^{-1}) were obtained from the application of 250 and 350 kg ha^{-1} NPSB and urea at Lemu-Bilbilo district.

Keywords: Experiment; NPSB; Urea; Fertilizer; Bread Wheat; Gedeb-Hasasa; Lemu-Bilbilo; Oromia; South-Eastern Ethiopia

Introduction

Wheat is one of the most important food crops in the world, providing 20 percent of humanity's dietary energy supply and serving as the main source of protein in developing nations [1]. Wheat is among most cereal crops ensuring food and nutrition security in developing countries like Ethiopia. The demand for wheat is projected as significantly increases mainly due to a rapidly population growth in the countries. Of the current total wheat production area 75.5% is located in Arsi, Bale, and Shewa regions [2]. The yield gap analysis shows that 61%, 55% and 46% of wheat yield gap existed when the national average yield was compared with that of the actual yield at research station, farmers' plot and potential yield at highland part of the country, respectively [3].

For many centuries until about 1800, the average grain yield was about 800 kg/ha, providing food only for a few people. The main problems were the low fertility of most soils (mainly caused by the depletion of nutrients) and the great yield losses from crop diseases and pests [4]. Fertilizers constitute an integral part of improved crop production technology [5]. Nitrogen (N) is major factor limiting yield of wheat [6]. Optimum N management to wheat is important for maximum yield, optimum water utilization and minimum contamination to environment [7]. The efficiency of wheat cultivars to N use has become increasingly important to allow reduction in N fertilizer use without decreasing yield. Phosphorus is another essential nutrient for enhancing seed maturity and seed development [8]. With adequate application of phosphorus, 20% more grain yield of wheat can be obtained [9]. N and P uptake could be enhanced with increased P applications [10].

Recently, with the emerging of agro-industries, cereal crops as a raw material, there is a high demand for bread wheat crop with higher grain yield and better end use quality. Several combinations of blended fertilizers which include vital elements such as N, P, K, S, B, Zn, Cu, Fe, etc. are developed for different agro-ecologies of the country [11]. However, there is limited information on the effect of blended fertilizer application rate on yield and grain quality of bread wheat varieties grown in Ethiopia. Moreover, the response of a crop to application of fertilizer varies with varieties, climatic conditions, soils, and agronomic practices. There is also a need to develop location and agro-ecology based recommendation on the blended fertilizer rates to increase the productivity and quality of bread wheat.

Therefore, this particular experiment was designed to investigate response of bread wheat to NPSB and Urea fertilizers with the specific objective to determine optimum NPSB and urea fertilizer rates for wheat crop, soil and climatic conditions.

Materials and Methods

Area descriptions

The experiment was carried out on farmers' fields and research stations for three cropping seasons during 2017-2019 at Gedeb-Hasasa and Lemu-Bilbilo districts in Arsi zone of Oromia, South-eastern Ethiopia. Geographically, the study area at Gedeb-Hasasa is located between 07^0 07' 10.1" to 07^0 03' 130" N, and 039^0 11' 54.8" to 039^0 07' 911" E with an elevation ranging from 2372-2407 meters above sea level; and Lemu-Bilbilo is located between 07^0 36' 870" to 07^0 27' 530" N, and 039^0 14' 270" to 039^0 15' 133" E with an elevation ranging from 2526-2873 meters above sea level.

The average weather data recorded on the weather station located near the study areas from the years 2017 - 2019 indicate that the total annual rainfall for Gedeb-Hasasa district were 496.1, 571.5 and 640.0 mm respectively, and the annual mean minimum and maximum daily air temperature for the consecutive years were (7.3, 6.9, 7.0 ^{0}C) and (17.9, 18.1, 21.0 ^{0}C) respectively. Similarly, the total annual rainfall for Lemu-Bilbilo district were 956.6, 803.5 and 990.6 mm respectively, and the annual mean minimum and maximum daily air temperature for the consecutive years were (4.7, 2.9, 3.3 ^{0}C) and (18.5, 20.3, 20.5 ^{0}C) respectively.

Design and Treatments

The experiment was set in combined RCBD by varying levels of NPSB fertilizer (0, 100, 150, 200, 250 kg ha^{-1}), urea (0, 150, 250, 350 kg ha^{-1}) and recommended NP with three replications. The size of each experimental gross plot was 2.6 m * 4 m (10.4 m^2). The bread wheat variety used for the experiment at Gedeb-Hasasa and Lemu-Bilbilo were Wane and Lemu, respectively. Both fertilizers which varied depending on treatments were applied as side banding at sowing time, urea was applied two times in split half at planting and the remaining at 35 days after planting, the other agronomic practices were kept uniform for all treatments.

Soil Sampling and Analysis

Surface soil, 0 - 20 cm depth, were collected from the entire experimental field before planting and after harvesting. The soil was daily air dried and made fine by using mortar and pestle. The fined soil was passed through 2mm sieve and the soil pH, Available P, Total N and Organic matter were determined at Kulumsa Agricultural soil Laboratory. Soil pH (H2O) was measured by using a pH meter in a 1:2.5 soil: water ratio. Soil organic carbon was estimated by the Walkley-Black wet oxidation method. Total nitrogen was determined by the micro-Kjeldahl digestion, distillation and titration method, and available P was determined using the standard Olsen extraction method. Accordingly, the soil analysis result taken before planting at Gedeb-Hasasa and Lemu-Bilbilo districts indicated that the pH value were 5.88 and 5.62 (moderate) [12], available phosphorus 14.36 (high) and 9.03 (medium) [13], total N 0.14 (medium) and 0.27 (high), and Organic matter 2.36 and 3.36 %, low [14], respectively (Table 1).

Location	pH (1:2.5)	Av.P (ppm)	Total N (%)	OC (%)	OM (%)
Gedeb-Hasasa	5.88	14.36	0.14	2.39	4.12
Lemu-Bilbilo	5.62	9.03	0.27	3.36	5.79

Table 1: Mean values of soil chemical properties sampled before planting of bread wheat from the experimental sites.

Yield Data Collection

Data of seedling density, tiller per plant, plant height, number of spike per 50cm, spike length, number of seed per spike, grain yield, above ground biomass, and thousand seed grain weight and hectoliter weight were collected from each plot. Grain and above ground biomass yield were analyzed gravimetrically by using sensitive balance and recorded in units of gram.

Statistical Analysis

The ANOVA procedure of statistical analysis system SAS Institute [15] was used for performing the significance of differences in grain and above ground biomass yields. A post hoc separation of means was done by least significant difference (LSD) test after main effects was found significant at $P < 0.05$.

Results and Discussions

Effect of Fertilizer Application on Soil Chemical Properties

The soil analysis result at post-harvest at Gedeb-Hasasa district showed that the application of treatments significantly ($p < 0.01$) affected pH, total N, organic matter, and available P for samples taken from experimental sites of wheat crop. Application of different fertilizer levels had significant effects on post-harvest pH and organic carbon contents. A significant improvement was not observed in soil chemical contents except available P and total N compared to the contents of the soil before treatment application (Table2).

NPSB + Urea (kg ha^{-1})	pH (1:2.5)	AvP (ppm)	Total N (%)	OC (%)	OM (%)
0 + 0	5.78	13.09	0.13	1.86	3.20
100 + 150	5.84	12.15	0.17	1.89	3.26
100 + 250	5.77	13.53	0.14	2.19	3.77
100 + 350	5.69	12.55	0.16	1.87	3.22
150 + 150	5.80	17.11	0.15	1.43	2.46
150 + 250	5.74	11.31	0.16	1.42	2.44
150 + 350	5.55	18.72	0.13	0.97	1.67
200 + 150	5.51	17.32	0.14	1.48	2.55
200 + 250	5.70	14.89	0.14	1.13	1.95
200 + 350	5.66	20.87	0.14	1.62	2.79
250 + 150	5.67	15.91	0.15	1.45	2.49
250 + 250	5.80	15.30	0.15	1.63	2.80
250 + 350	5.75	14.83	0.15	1.74	2.99
Mean	5.71	15.20	0.15	1.59	2.74
F-probability	***	***	**	***	***
$LSD_{0.05}$	0.05	1.53	0.02	0.05	0.28
CV (%)	0.51	6.04	6.85	5.96	6.01

, * = significant at $p < 0.01$ and $p < 0.001$

Table 2: Effect of fertilizer levels on soil chemical properties after harvesting wheat in Gedeb-Hasasa district.

Similarly, the soil analysis result after harvest revealed that the application of treatments significantly ($p < 0.01$) affected total N, organic carbon, and available P for samples taken from experimental sites of wheat crop. Soil pH of wheat field was significantly ($p < 0.05$) affected by different fertilizer treatments. Different fertilizer treatments had significant effects on post harvest soil organic carbon content. A significant decrement was observed in pH content of soil compared to the contents of the soil before treatment application at Lemu-Bilbilo district (Table 3).

NPSB + Urea (kg ha^{-1})	pH (1:2.5)	AvP (ppm)	Total N (%)	OC (%)	**OM (%)**
0 + 0	4.83	14.45	0.29	3.17	5.46
100 + 150	4.70	19.66	0.28	3.27	5.63
100 + 250	4.76	17.35	0.27	3.27	5.64
100 + 350	4.79	18.98	0.29	3.21	5.54
150 + 150	4.82	15.34	0.28	2.95	5.08
150 + 250	4.74	13.57	0.28	3.05	5.26
150 + 350	4.77	16.30	0.30	3.21	5.53
200 + 150	4.71	15.29	0.29	3.43	5.92
200 + 250	4.92	14.82	0.28	3.46	5.97
200 + 350	4.65	20.03	0.30	3.38	5.83
250 + 150	4.60	18.72	0.25	3.73	6.43
250 + 250	4.61	13.53	0.26	3.08	5.32
250 + 350	4.66	14.45	0.29	3.43	5.91
Mean	4.74	16.35	0.28	3.28	5.66
F-probability	*	***	***	***	***
$LSD_{0.05}$	0.18	2.72	0.02	0.39	0.68
CV (%)	3.34	14.61	8.11	10.61	10.60

*, **, *** = significant at $p < 0.05$, $p < 0.01$ and $p < 0.001$

Table 3: Effect of fertilizer levels on soil chemical properties after harvesting wheat in Lemu-Bilbilo district.

Effect of NPSB and Urea Fertilizers on Grain Yield and Yield Components of Wheat

Agronomic maximum grain and above ground biomass yield (6170 and 13510 kg ha-1) in 2017 and minimum (4038 and 10908 kg ha-1) in 2018 cropping season were obtained, respectively at Gedeb-Hasasa district up on the application of NPSB and urea fertilizers. Similarly, significant grain and above ground biomass yield (6440 and 14846 kg ha-1) were obtained from the application of 250 + 350 kg ha-1 NPSB + urea rate, respectively (Table 4).

	Gedeb-Hasasa		**Lemu-Bilbilo**	
Factors	GY (kg ha^{-1})	BY(kg ha^{-1})	GY (kg ha^{-1})	BY (kg ha^{-1})
Year				
2017	6170a	13510a	5939b	12667a
2018	4038c	10908c	5229c	10674b
2019	5725b	12529b	6584a	12709a
$LSD_{0.05}$	172.9	477.1	251.8	578.4
Fertilizers rate (NPSB + Urea), kg ha^{-1}				
0 + 0	3527i	7483h	3589f	7157f
100 + 150	4687h	10572g	5344e	10737e
100 + 250	5103g	11511fg	5659de	11564de

100 + 350	5441efg	13261bcd	6281abc	12729abcd
150 + 150	5397fg	12327def	5758cde	11738cde
150 + 250	5933cd	13828abc	6171abcd	12815abc
150 + 350	6014bc	13759abc	5939bcd	12050bcd
200 + 150	5551def	11984ef	6100bcd	12427abcd
200 + 250	5911cd	13119bcd	6460ab	13054ab
200 + 350	6144abc	14080ab	6372ab	12766abcd
250 + 150	5845cde	12899cde	6266abc	12942abc
250 + 250	6358ab	14092ab	6362ab	12863abc
250 + 350	6440a	14846a	6629a	13372a
CV(%)	10.3	12.3	13.5	15.3
$LSD_{0.05}$	414.4	1124.4	524.1	1204.0

Table 4: Grain (GY) and above ground biomass (BY) yield analysis result on effect of NPSB and urea fertilizers for bread wheat at Gedeb-Hasasa and Lemu-Bilbilo districts.

Agronomic maximum grain and above ground biomass yield (6584 and 12709 kg ha^{-1}) in 2019 and minimum (5229 and 10674 kg ha^{-1}) in 2018 cropping season were obtained, respectively at Lemu-Bilbilo district up on the application of NPSB and urea fertilizers. Similarly, significant grain and above ground biomass yield (6629 and 13372 kg ha^{-1}) were obtained from the application of 250 and 350 kg ha^{-1} NPSB and urea fertilizers rate (Table 4).

Maximum harvest index, HLW and thousand seed weight (44.8 %, 78.8 ghL-1 and 42.4 g) in 2017 and minimum (39.1 % and 75.6 ghL-1) in 2019, and (38.43 g) in 2018 cropping season were obtained, respectively at Gedeb-Hasasa district up on the application of NPSB and urea fertilizers. Similarly, significant value of harvest index and thousand seed weight (43.1% and 42.2g) were obtained from the application of (200, 150) and (250, 150) kg ha-1 NPSB and urea fertilizers respectively. HLW was not significantly different across the fertilizer rates (Table 5).

	Gedeb-Hasasa			Lemu-Bilbilo		
Factors	HI (%)	HLW (ghL^{-1})	TKW (gm)	HI (%)	HLW ($gmhL^{-1}$)	TKW (gm)
Year						
2017	44.8a	78.8a	42.4a	41.5b	83.8a	46.1a
2018	42.7b	76.8b	38.4c	45.1a	81.5b	46.8a
2019	39.1c	75.6c	41.3b	45.1a	78.2c	44.6b
$LSD_{0.05}$	1.0	0.7	0.6	0.6	0.4	0.8
Fertilizer rate (NPSB + Urea), kg ha^{-1}						
0 + 0	42.4a	76.8ab	40.8b	44.8a	81.3	46.3ab
100 + 150	42.2ab	77.3a	41.0ab	43.7abc	81.2	46.1ab
100 + 250	42.5a	77.1a	40.9ab	43.6bc	81.4	46.5a
100 + 350	40.0b	76.6ab	40.6b	44.3ab	81.0	45.7ab
150 + 150	41.2ab	77.1a	40.9ab	43.7abc	81.2	46.2ab
150 + 250	41.6ab	77.8a	41.0ab	43.4bc	81.2	46.1ab
150 + 350	42.0ab	77.3a	41.5ab	44.2ab	81.1	46ab
200 + 150	43.1a	77.6a	41.8ab	43.5bc	81.5	46.3ab
200 + 250	42.9a	77.5a	40.9ab	43.8abc	81.1	45.5ab

200 + 350	42.0ab	77.5a	41.0ab	44.3ab	81.0	45.5ab
250 + 150	42.4ab	77.4a	42.2a	42.7c	81.2	45.8ab
250 + 250	42.6a	75.5b	41.5ab	44.2ab	81.0	45.2ab
250 + 350	42.6a	77.0ab	40.9ab	44.2ab	81.0	44.9b
CV(%)	7.9	2.6	4.7	4.1	1.5	5.4
$LSD_{0.05}$	2.4	1.5	1.4	1.2	ns	1.6

Table 5: Harvest index (HI), hectoliter weight (HLW) and thousand seed weight (TKW) analysis result on effect of NPSB and urea fertilizers for bread wheat at Gedeb-Hasasa and Lemu-Bilbilo districts.

The highest value of harvest index (45.1%) in 2018 and 2019, HLW (83.8 ghL^{-1}) in 2017 and thousand seed weight (46.8 g) in 2018 and minimum (41.5%) in 2017, (78.2 ghL^{-1}) in 2019 and (44.6 g) in 2019 cropping season were obtained, respectively at Lemu-Bilbilo district up on the application of NPSB and urea fertilizers. Similarly, significant value of harvest index (44.8%) at the control and thousand seed weight (46.5 g) was obtained from the application of (100, 250) kg ha^{-1} NPSB and urea fertilizers respectively. The value of HLW was not significantly different across the fertilizer rates (Table 5).

Conclusions and Recommendations

The soil analysis result at post-harvest at Gedeb-Hasasa district showed that the application of treatments significantly ($p < 0.01$) affected pH, total N organic matter and available P for samples taken from experimental sites of wheat crop. Application of different fertilizer levels had significant effects on post-harvest pH and organic carbon contents. Similarly, the soil analysis result after harvest revealed that the application of treatments significantly ($p < 0.01$) affected total N organic carbon and available P for samples taken from experimental sites of wheat crop. Soil pH of wheat field was significantly ($p < .05$) affected by different fertilizer treatments. Different fertilizer treatments had significant effects on post harvest soil organic carbon content at Lemu-Bilbilo district.

Agronomic maximum grain and above ground biomass yields (6170 and 13510 kg ha^{-1}) in 2017 and minimum (4038 and 10908 kg ha^{-1}) in 2018 cropping season were obtained, respectively, at Gedeb-Hasasa district up on the application of NPSB and urea fertilizers. Similarly, significant grain and above ground biomass yield (6440 and 14846 kg ha^{-1}) were obtained from the application of 250 + 350 kg ha^{-1} NPSB + urea rates, respectively.

The highest grain and above ground biomass yields (6584 and 12709 kg ha^{-1}) in 2019 and lowest (5229 and 10674 kg ha^{-1}) in 2018 cropping season were obtained, respectively, at Lemu-Bilbilo district up on the application of NPSB and urea fertilizers. Similarly, significant grain and above ground biomass yield (6629 and 13372 kg ha^{-1}) were obtained from the application of 250 and 350 kg ha^{-1} NPSB and urea.

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