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Effect of Blended NPSB and Urea Fertilizers Rate on Yield and Yield Component of Wheat on Nitisols at Welmera Districts, Central Highlands of Ethiopia

Zeleke Obsa, Matias Dejene, Girma Chala

Holeta Agricultural Research Center, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia

Email address:
zaleobsi@gmail.com (Z. Obsa)

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Abstract: Wheat productivity in Ethiopia is low due to nutrient deficiency, low chemical fertilizer usage, and poor management practices are among the major constraints. Now adays, proper and balanced fertilizer recommendations is a principal in order to increase the crop productivity in Ethiopia. Taking this in a Point of view, a field experiment was conducted from 2017 to 2019 cropping season at Welmera districts to determine optimum blended NPSB and urea fertilizer rate for wheat production. The experiment was laid out in RCBD with three replications. The treatment consists of four NPSB rate (100, 150, 200, 250 kg/ha) with three rates of urea (150, 250, 350kg/ha) were tested with one Recommended NP (60N/69P_2O_5) kg/ha as standard check and one treatment negative control having 14 treatments used for experiments. Grain yield and biomass yields recorded on plot basis were converted to kg ha^{-1} for statistical analysis. The results revealed that yield and yield componets of wheat affected by application of NPSB and urea fertilizer rates. The highest biomass yield (16,875 kg ha^{-1}) and highest grain yield (4984.3 ha^{-1}) were obtained from application of 250 kg NPSB with 350 kg urea ha^{-1}, while the lowest biomass yield and grain yield were recorded from control plot. Whereas based on partial budget analysis application of 100 kg NPSB ha^{-1} with 350 kg urea ha^{-1} provided relatively with high net benefit and hence these could be the best rate to apply.

Keywords: Blended Fertilizer, Grain Yield, NPSB Rate

1. Introduction

Soil fertility is one of the biggest challenges to achieving food security and poverty reduction in Ethiopia [1, 2]. To increase yield, fertilizer use trend has been focused mainly on the use and application of nitrogen and phosphorous fertilizers as blanket recommendation for the major food crops [3, 4]. The previous result indicated fertilizer recommendations in Ethiopia are based on a single recommendation for all crops are the only fertilizer sources that have been in use for the past four decades in the country [5]. Additionally, the nutrients in the blanket recommendation are not well balanced agronomically and its continued use will slowly deplete soil nutrient reserves [6]. Therefore, neither yields nor profits can be sustained using imbalanced application of fertilizers, as the practice outcomes in expanding deficiencies of other soil nutrients [7]. Since absence of one or more nutrients likewise N and P can reduce yield significantly. This could explain, in part, the uncertain crop yield improvements detected over the last few decades in contrast to significant increases in fertilizer use in the country. Currently, in addition to N and P, other nutrients S, B and Zn deficiencies are widespread in Ethiopian soils, while some soils are also deficient in K, Cu, Mn and Fe [8]. Soil test-based application of plant nutrient rather than the blanket recommendation of urea and DAP, especially those containing sulfur, boron, and other nutrients is recommended in preventing problems caused due to nutrient deficient soil [1].

Therefore, the use of balanced fertilizers containing both macro and micronutrients, which is based on the site-specific soil fertility assessment, is believed to be one of the solutions for reducing such production constraints. Although nutrient content of the fertilizer that suits the needs and the productivity of the crops, in most part of Ethiopia, particularly, Welmera district farmers have limited information on the impact of balanced fertilizer types and rates except only urea and DAP which are source of N and P. However, new blended fertilizer such as NPSB and currently being used by the farmers in the study area based on the soil fertility map of the area [1]. Thus, there is a need to test the blended NPSB fertilizer by supplementing it with urea fertilizer for optimum productivity of wheat. Therefore, the present study was undertaken with the following objectives:

1. To determine optimum blended NPSB and urea fertilizer rate for wheat production.
2. To assess economic feasibility of blended NPSB and urea fertilizer rate for wheat production.

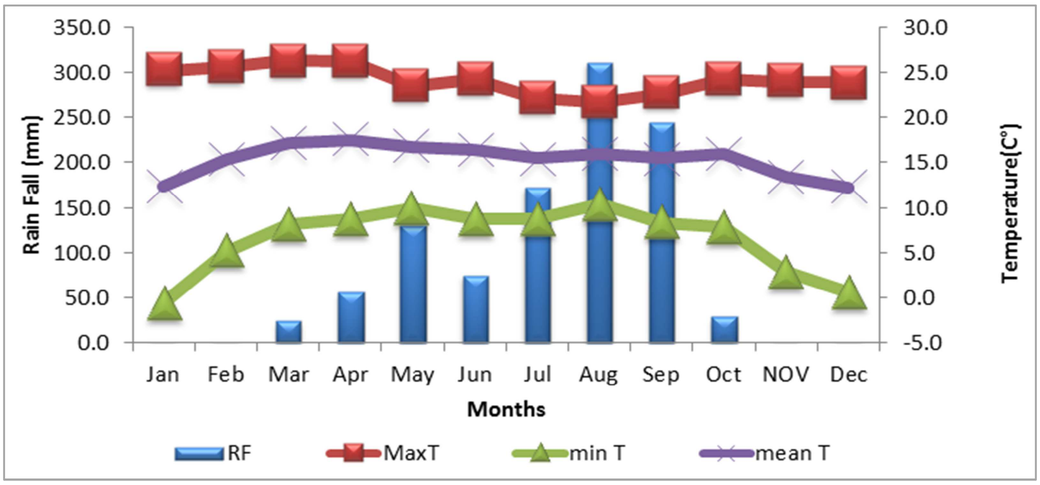

Figure 1. *Mean monthly rainfall, minimum and maximum temperature (°C) of Holetta 2018/2019 G.C.*

2. Materials and Methods

2.1. Description of the Study Site

The experiment was conducted in Welmera districts of West Shewa Zone of Oromia Regional State for three consecutive cropping seasons (2017 -2019). The experiment site is located at 09° 03′ N latitude and 38° 30′ E longitude, 30km west of Addis Ababa, at an altitude of about 2400 m above sea level. The mean annual rainfall of the study area was 1100 mm, of which about 85% falls from June to September and the rest from march to may and the mean annual temperature was about 14.3°C, with the mean maximum and minimum temperatures of 21.7°C and 6.9°C, respectively and mean relative humidity of 60.6% [9] (Figure 1). The environment is seasonally humid and the major soil type is Nitisols [10].

2.2. Experimental Design and Treatments

The experiment was laid out in RCBD with three replications. NPSB fertilizer was applied as basal application at planting and urea was applied in split form. The treatments consisted of five four levels of blended (100, 150, 200, and 250 kg NPSB ha^{-1}) and three rates of urea (150, 250, 350kg ha^{-1}), and as positive control (standard check) recommended NP (kg 60N/69P_2O_5) ha^{-1} fertilizers was used.

2.3. Soil Sampling and Analysis

Soil samples (0-20 cm) were collected randomly by Auger in a zigzag pattern before sowing the crop from the entire experimental field and composited into one sample. From this composite sample, a sample weighing 1.0 kg was taken. Air dried soil sample was ground with a pestle and mortar under shading. The sample was sieved through a 2 mm sieve mesh. The soil analysis was done for soil textural class, soil pH, organic carbon, total N, available P, cation exchange capacity (CEC) and, available S. The soil analyses were done at Holeta agriculture research center Soil and Water Analysis Laboratory.

Soil textural Class was determined by Bouyoucos Hydrometer Method [11]. Soil pH was determined in 1:2.5 soils: water ratio using a glass electrode attached to a digital pH meter [12]. Organic carbon was estimated by the wet digestion method [13] after air-dried soil was ground to pass a 0.2 mm sieve. To determine the cation exchange capacity (cmol kg^{-1} soil), the soil sample first was leached using 1 M ammonium acetate, washed with ethanol and the adsorbed ammonium was replaced by sodium (Na). Then, the CEC was determined titrimetrically by distillation of ammonia that was displaced by Na [14]. Total nitrogen (%) was determined using the Kjeldhal method [15]. Available phosphorus (ppm) was determined by Bray II method [16]. Available sulfur (S) was determined by mono-calcium phosphate extraction method [17].

2.4. Data Collection

Agronomic parameters collected were plant height and spike length (cm), was measured by taking five randomly selected plants per plot as the distance in cm from the soil surface to the top most growth point of aboveground at full maturity. Grain and biomass yield were measured based on plant samples taken from ten central rows at full maturity stage. Grain yield and biomass yields recorded on plot basis were converted to kg ha^{-1} for statistical analysis.

2.5. Statistical Analysis

Differences between treatments were determined by analysis of variance (ANOVA) using SAS software [18]. The result interpretations were made following the procedure of [19]. Mean separation were done using the Fishers' protected Least Significant Difference (LSD) test at 5% level of significance.

2.6. Partial Budget Analysis

The economic advantages of applied blended NPSB and urea fertilizers were carried out using partial budget analysis. In this experiment, the costs that vary were calculated by adding costs of fertilizer. The costs of blended NPSB and urea were 15 ETB kg^{-1} and 13 ETB kg^{-1}, respectively. The average grain was adjusted by 10%. Following the CIMMYT partial budget analysis methodology, total variable costs (TVC), gross benefits (GB), and net benefits (NB) were calculated. To identify treatments with maximum return to the farmer's investment marginal analysis was performed on non-dominated treatments. For a treatment to be considered as a worthwhile option to farmers, the marginal rate of return (MRR) needs to be at least between 50% and 100% [20]. However, other researchers suggested a MRR of 100% as realistic [21].

3. Result and Discussion

3.1. Soil Physico-Chemical Properties

The results of the soil laboratory analyses indicated that the soil of experimental site was 52.75% clay, 30% silt and 17.25% sand (Table 1). Thus, the texture class of the soil was clay according to [11] classification. In clay soil high rain fall in the field causes yield reduction in most crops. The pH of the soil was 5.2 (Table 1) which was acidic in reaction [22]. The organic carbon (OC) analysis indicated that the experimental field had 0.6% organic carbon (Table 1) it was found in Low range as per [22]. The total nitrogen of experimental soil was 0.25%, which was low according to [23]. The available phosphorus content of the soil was 8.12 ppm found in low range as per rated [1].

Table 1. *Selected Soil physico- chemical characteristics of the study site.*

Soil parameters	Value	Rating	Reference
Particle size			
Sand (%)	17.25	-	
Silt (%)	30.00	-	[11]
Clay (%)	52.75	-	
Textural class		Clay	
Soil pH	5.2	Acidic	[22]
Organic carbon (%)	0.6	Low	[22]
Total, N (%)	0.25	Low	[23]
Available P (ppm)	8.12	Low	[1]
Exchangeable k ($cmol^+$ /kg)	0.56	Medium	[24]
Available S ($cmol^+$ /kg)	8.63	Very low	[1]
CEC ($cmol^+$ /kg)	11.02	Low	[25]

The analysis for available sulfur indicated that the experimental soil had value of 6.18 ppm of available sulfur which is rated under very low according [1]. Thus, it is essential to apply sulfur sources fertilizer to improve yield and quality of wheat [26].

3.2. Response of NPSB and Urea on Growth Parameters

Combined application of blended NPSB and urea fertilizer rates showed significant on spike length (Table 1). The shortest spike length (cm) exhibited in control (unfertilized plot), whereas the longest mean spike length (10.89 cm) was recorded at a combined application of 100 NPSB, 250 NPSB with 350 kg urea and this was statistically at par. The current result indicated that, spike length of wheat increased obviously with each increase of combined application of blended NPSB and urea fertilizers rates even though the results were not consistent. The decreasing spike length with increasing supply of nitrogen fertilizer might be due to excessive application of N (urea) fertilizer causing high tissue N concentration which might have toxic effect on wheat growth resulting in stunted growth and reduced spike length [27].

Table 2. *Spike length and plant height in response to NPSB and urea fertilizer rate.*

NPSB (kg/ha)	Urea rate kg/ha	SL (cm)	PH (cm)
0	0	8.67c	86.22 c
100	150	10.50ab	99.56ab
150	150	10.17ab	100.72ab
200	150	10.28ab	101.44ab
250	150	10.50ab	101.56ab
100	250	10.11ab	100.50ab
150	250	10.39ab	100.06ab
200	250	9.78b	97.94ab
250	250	10.39ab	100.89ab
100	350	10.89a	102.17ab
150	350	10.61ab	101.67ab
200	350	10.89a	102.33ab
250	350	10.83a	103.72a
Recommended NP (kg 60N/69P_2O_5) ha^{-1}		10.22ab	97.72b
	Mean	10.30	99.75
	LSD (0.05)	1.025	5.97
	CV (%)	15.16	9.12

Means followed by the same letters on the same column are not significantly different at 5% probability level.

Analysis of variance revealed that application of blended NPSB and urea fertilizer rates were highly significant ($P < 0.01$) on plant heigh (Table 2). Application of 250 kg NPSB with 350 kg urea ha^{-1} fertilizer rate showed the highest plant height (103.72cm) and it was at par with plant height recorded from other application at rates of NPSB with kg urea ha^{-1}. The shortest plant height (86.22 cm) was recorded in unfertilized plot (Table 2).

3.3. Response of NPSB and Urea on Yield of Wheat

Biomass significantly ($p<0.05$) affected by the application of blended fertilizer and urea rates. As the rates of blended fertilizers and urea rate increased the biomass yield and grain yield were increased. The highest biomass yield (16,875 kg ha^{-1}) was recorded from plants supplied with blended fertilizer of 250 kg NPSB ha^{-1} combined with 350 kg urea ha^{-1}, which was statistically at par to 200/350, 250/350 kg NPSB/urea ha^{-1} fertilizer rates. The lowest total biomass yield (9022kg ha^{-1}) was obtained from the control (unfertilized) plot. At each blended NPSB fertilizer rate, biomass yield considerably increased with the increasing supply of urea fertilizer from 100 to 350 kg urea ha^{-1}. Application of NPSB fertilizer rate improves the production of biomass yield. Similarly, the study of Bezuayehu *et al* [28] reported that increasing rates of blended NPSB combined with N, increase in biomass yield might be due to enhanced crop growth rate. Consistent with this result, [29, 30] reported that aboveground dry biomass yield of cereal was significantly influenced by the blended fertilizers.

Table 3. *Biomass and yield in response to NPSB and urea fertilizer rate.*

NPSB (kg/ha)	Urea rate kg/ha	BY (kg/ha)	GY (kg/ha)	TSW (g)
0	0	9022g	2666.7c	47
100	150	13032f	3942.5b	44
150	150	14213ef	4371.7ab	43
200	150	14485cdef	4356.9ab	45
250	150	14850bcde	4680.3ab	45
100	250	14531cdef	4487.3ab	45
150	250	14948bcde	4441.4ab	46
200	250	14873bcde	4635.3ab	47
250	250	15885abc	4603.8ab	46
100	350	15289abcd	4831.1a	45
150	350	15451abcd	4658.4ab	45
200	350	16389ab	4909.8a	43
250	350	16875a	4984.3a	46
Recommended NP (kg 60N/69P_2O_5) ha^{-1}		13378ef	4018.6b	43
	Mean	14516	4399.2	42
	LSD (0.05)	1640.2	777.9	NS
	CV (%)	17.21	26.93	6.5

Means followed by the same letters on the same column are not significantly different at 5% probability level.

Combined analysis of variance overt three years showed that the mean grain yield of wheat was significantly influenced by blended NPSB and urea fertilizer rates, except thousand seed weight (TSW) (table 3). The highest grain yield (4984.3 ha^{-1}) was obtained from application of 250 kg NPSB with 350 kg urea ha^{-1}, while the lowest grain yield (2666.7 kg ha^{-1}) was recorded from control plot. However, grain produced with combined application of the higher blended NPSB across urea fertilizers rates (100/250, 150/150, 200/150, 100/250, 200/250, 250/250 and 150/350 kg blended NPSB/urea ha^{-1}) were statistically remained at par with the grain yield obtained from combined application of 250/350 kg NPSB/urea ha^{-1} fertilizers. In general, combined application of 250 kg blended NPSB with 350kg urea ha-1 gave more yield than negative control. This is due to the positive effect of NPSB with urea fertilizer that had increased yield and yield components of wheat. This result was in agreement with the findings of [31] who reported that the highest yield was recorded as of NPSB nutrients level increased.

4. Partial Budget Analysis

Wheat production under fertilizer management involved different costs, which affected the total production cost that varied within each treatment (Table 4).

Table 4. *Partial budget analysis of blended fertilizer with urea rate for wheat production.*

	Fertilizer rate (kg/ha)	GY (kg/ha)	ADGY (kg/ha)	TVC (ETB)	GFB (ETB)	NB (ETB)	MRR
1	Negative control (0)	2666.7	2400	20	48001	47981	-
2	100 kg NPSB + 150 kg urea ha^{-1}	3942.5	3548	3470	70965	67495	565.6
14	Rec. NP (60N/69P_2O_5) ha^{-1}	4018.6	3617	3623	72335	68712	798.2
3	150 kg NPSB +150 kg urea ha^{-1}	4371.7	3935	4220	78691	74471	963.7
6	100 kg NPSB + 250 kg urea ha^{-1}	4487.3	4039	4770	80771	76001	278.3
4	200 kgNPSB + 150 kg urea ha^{-1}	4356.9	3921	4970	78424	73454	D
7	150 kgNPSB + 250 kg urea ha^{-1}	4441.4	3997	5520	79945	74425	D
5	250 kgNPSB + 150 kg urea ha^{-1}	4680.3	4212	5720	84245	78525	2050.1
10	100 kg NPSB + 350 kg urea ha^{-1}	4831.1	4348	6070	86960	80890	675.5
8	200 kg NPSB + 250 kg urea ha^{-1}	4635.3	4172	6270	83435	77165	D
11	150 kg NPSB + 350 kg urea ha^{-1}	4658.4	4193	6820	83851	77031	D
9	250 kg NPSB + 250 kg urea ha^{-1}	4603.8	4143	7020	82868	75848	D
12	200 kg NPSB + 350 kg urea ha^{-1}	4909.8	4419	7570	88376	80806	D
13	250 kg NPSB + 350 kg urea ha^{-1}	4984	4486	8320	89717	81397	78.8

Where, ADGY=adjusted grain yield, TVC=total variable cost, GFB= growth field benefit, NB=Net benefit, MRR= marginal rate of return, D=dominated, costs of NPSB and urea were 15 ETB kg^{-1} and 13 ETB kg^{-1}.

The economic analysis showed that combined application of 100 kg blended fertilizer ha^{-1} additional with 350 kg urea ha^{-1} provided relatively high net benefit and hence these could be the best rate to apply. The highest mean net benefit (80890 ETB ha^{-1}) with conditional total cost and acceptable MRR 675.5) were obtained at application of 100/350 kg blended NPSB/urea ha^{-1} fertilizers. In contrast the lowest mean net benefit (47981 ETB ha^{-1}) was obtained from the control (unfertilized) plot. Therefore, on economic grounds, application of 100 kg NPSB ha^{-1} with supplement of 350 kg urea ha^{-1} would be economical best rewarding for production of wheat in the study area.

5. Conclusion

The result revealed that blended NPSB /urea fertilizer significantly affected most of the yield and yield components. Combined analysis of the results revealed that spike length, plant height, biomass yield and grain yields were significantly affected by NPSB and urea fertilizer. The highest grain yield was obtained at combined application of 250 blended NPSB with 350 kg urea. Whereas based on partial budget analysis, application of 100 kg NPSB with 350 kg urea ha^{-1} gave economic benefit. Therefore, it could be concluded that application of 100 kg blended NPSB ha^{-1} with addition of 350 kg urea ha^{-1} fertilizer rates are the fertilizer rates producing economically profitable grain yield of wheat to study area.

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