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Effects of Blended and Urea Fertilizer Rate on Yield and Yield Components of Wheat in Vertisols of Ambo District

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Abstract: Wheat (*Triticum aestivum L.*) is one of the most important cereal crops in Ethiopia but its yield was low because of depleted soil fertility which might be due to low levels of chemical fertilizer usage, limited knowledge on time and rate of fertilizer application and the unavailability of other modern crop management inputs. This in view a field experiment was conducted during 2018/19 and 2019/20 cropping seasons in Ambo District central Ethiopia with the objective to determine optimum blended and Urea fertilizer rate for wheat production in Vertisols. Twelve treatments combination from three levels of urea and four levels blended (NPSZnB) were used for the field experiment with one recommended NP and control. The experiment was laid out in randomized complete block design with factorial arrangement in three replications in four farmers' fields. Dry biomass and grain yield of wheat were significantly affected by application of blended (NPSZnB) and urea fertilizer rates. Significantly higher 4968 and 11369 kg ha^{-1} mean grain yield and dry biomass of bread wheat were obtained by application of 250 kg NPSZnB ha^{-1} and 350 kg Urea ha^{-1} while the lowest was from control. The highest mean grain yield of farm 1, 2, 3, 4 and combined mean gave yield advantages of wheat by 50.4, 80.2, 74.7, 73.1 and 65.9%, respectively as compared to control; and by 29.5, 46.3, 42.1, 35.6 and 33.9% as compared to recommended rate of NP respectively. The application of 250 kg NPSZnB ha^{-1} and 250 kg Urea ha^{-1} gave the higher grain yield 4888 kg ha^{-1} of bread wheat. The highest grain yield 4968 kg ha^{-1} was obtained with application of blended fertilizer, 250 kg NPSZnB ha^{-1} and 350 kg Urea ha^{-1}. Therefore, application of blended fertilizer NPSZnB 250 kg ha^{-1} and 350 kg ha^{-1} Urea can be recommended for highest yield, for farmers who are affordable to buy it. For those who are unable to buy such amount of fertilizer, application of 250 kg urea ha^{-1} and 250 kg NPSZnB ha^{-1} could be agronomical optimum and recommended for wheat production in Vertosols of Ambo district and similar agroecologies.

Key words: Biomass Yield · Blended Fertilizer · Urea · Grain Yield

INTRODUCTION

Wheat (*Triticum aestivum L.*) is one of the most important cereal crops globally and is a staple food for about one third of the world's population [1]. Bread wheat is one of the main essential food and a vital source of energy in human diet. It is one of the major significant and widely cultivated crops of the entire world in terms of area coverage and production and it is a major source of nourishment [2-5]. It is a principal food for more than 35% of the world's population and a source of food and livelihood for over one billion people in developing countries [6]. It is a major source of nutrition for humans and livestock, estimated to contribute as much as 60 million tonnes of protein per year [7]. Wheat is an annual grass growing to between 0.5 to 1.25 meters in height, with a long stalk that terminates in a tightly formed cluster of plump kernels enclosed by a beard of bristly spikes [8]. In Ethiopia wheat has become one of the most important cereal crops ranking fourth both in total grain production and area coverage next to teff, maize and sorghum [9]. Though Ethiopian agroclimatic condition is suitable for

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wheat production, the productivity is low (2.76 t ha^{-1}) [9] as compared world average about 3 t ha^{-1}. This is because of depleted soil fertility, low levels of chemical fertilizer usage, limited knowledge on time and rate of fertilizer application and the unavailability of other modern crop management inputs [10]. In addition to these, wheat production in the country is adversely affected by low soil fertility and suboptimal use of mineral fertilizers, diseases, weeds, erratic rainfall distribution in lower altitude zones and water-logging in the Vertisols areas [11].

Understanding plant nutrients requirement of a given area has vital role in enhancing crop production and productivity on sustainable basis. Nevertheless, little information is available on blended fertilizers requirement including macro and micro plant nutrients in the study area. Increasing yields through the application of nitrogen and phosphorus alone can deplete other nutrients [12]. However, crop productivity can also be limited because of toxicity and/or deficiency of essential plant nutrients.

Recent studies have indicated that elements like N, P, K, S and Zn levels as well as B and Cu are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country [13]. Most Ethiopian soils are deficit in macronutrients (N, P, K and S) and micronutrients (Cu, B and Zn) [14]. Lemi and Negash [15] found that significantly higher plant height (91cm), grain yield (5.28 tha^{-1}) and harvest index (54.33%) were recorded from Ogolcho wheat varieties with application of 100/100 kg NPSZnB/Urea ha^{-1}. Maximum grain yield of (5.77 t ha^{-1}), straw yield of (8.52 t ha^{-1}) and dry biomass (14.29 t ha^{-1}) were recorded from application Kg NPSBZn (175N + 125P_2O_5 +11.1S + 3.3B and 0.15Zn) ha^{-1} rate [16]. Significantly grain yield (2856 kg ha^{-1}) and straw yield (3917 kg ha^{-1}) of bread wheat were obtained by application of 300 kg NPSZn ha^{-1} [17]. Bereket *et al*. [18] found that significantly higher grain yield (2911 kg ha^{-1}), dry biomass (8200 kg ha^{-1}) and straw yield (5289 kg ha^{-1}) of bread wheat were recorded by application of blended fertilizer rate (300 kg NPSZnB ha^{-1}) though the yields were statistically at par with application rate of 100 kg ha^{-1} for grain and 200 kg ha^{-1} for biomass and straw yield of bread wheat in Hawzen district. Significantly higher (3580 and 6756 kg ha^{-1}) grain yields of bread wheat were obtained from the application of 200 kg NPSZn ha^{-1} in Ofla and Emba Alaje districts [19].

However, the farmers around study area have limited information on the impact of different types and rates of fertilizers except blanket recommendation of nitrogen (87 kg N ha^{-1}) and phosphorus (20 kg P ha^{-1}), i.e. 150 kg Urea and 100 kg DAP ha^{-1} for wheat for the district. Except blanket recommendation of nitrogen and phosphorus, the effect of other blended fertilizers on yield and yield components of wheat are unknown, even though new blended fertilizers such as NPSB and NPSZnB are currently available. Based on the soil analysis result the types of required blended fertilizers are identified for the district, optimum rates of blended fertilizer identified for the district were not determined for wheat production. The response of wheat to application of fertilizer varies with varieties, rainfall, soils, agronomic practices, expected yield etc. Thus, indeed in need to develop location specific recommendation of blended fertilizer rates to increase the productivity of wheat. Therefore, the objective was to determine optimum blended (NPSZnB) and urea fertilizer rate for wheat production in Vertisols of Ambo district.

MATERIALS AND METHODS

Description of the Experimental Site: The experiment was conducted in 2018/19 and 2019/20 cropping seasons at Bayo Kurbi and Amaro peasant association Ambo District, in West Shewa Zone, Oromia National Regional State. The site is located at 8°59'21.4" N latitude and 37°57'17.15"E longitude with an altitude of 2385 meter above sea level. The average annual rainfall of 2008 to 2017, the nearby metrological station is 829.5 mm with minimum and maximum temperatures of 11 and 25°C, respectively. The area was predominantly found to have clay textural class with a swelling and cracking nature of black colored pellic Vertisols weakly acid to neutral in reaction with a montmorillonitic clay content in excess of 50% [20, 21].

Treatments, Experimental Designs and Procedures: Three levels of urea (150, 250 and 350 kg ha^{-1}) and four levels of blended NPSZnB (100, 150, 200 and 250 kg ha^{-1}) were factorial combined and tested with control and recommended NP fertilizer rate and total of 14 treatments. The recommended fertilizer rate for wheat was 139/100 kg urea/DAP ha^{-1} for the area. The experiment was laid out in randomized complete block design in factorial arrangement with three replications. The plot size was 3m x 3m (9m^2). The spacing between rows, plots and blocks was 0.2 m, 0.5 m and 1.5 m respectively. Wheat variety Wane with 150 kg seed ha^{-1} was used and sown uniformly drilled into the rows made by hand hoe in July 2018. The full dose of all blended fertilizers and half of fertilizer N were applied uniformly within the rows at sowing. The remaining half N fertilizers were top-dressed on the inter-row spaces by hand at the mid-tillering stage. During the different growth stages of the crop, all the necessary field management practices were carried out as per the research recommended practices for wheat production. Net plot size 2 x 2.4= 4.8 m^2 was used for the data collection.

Soil Sampling and Analysis: Before sowing, surface soil samples (0-20 cm depth) were collected from the experimental field using Auger sampler in a zigzag pattern from five spots from each block and composited into one sample for initial soil nutrient analysis. The collected soil sample was air dried ground with a pestle and mortar. The sample was sieved through a 2-mm sieve for selected chemical and physical soil properties and analyzed based on the standard laboratory procedures at Holetta Agricultural Research Center soil and plant laboratory. Determination of soil particle size distribution was carried out using the hydrometer method [22]. Soil pH was measured using digital pH meter in 1:2.5 soil to solution ratio with H_2O. Exchangeable basis was extracted with 1.0 Molar ammonium acetate at pH7. Ca and Mg in the extract were measured by atomic absorption spectrophotometer while Na and K were determined using flame photometry [23]. Cation exchange capacity of the soil was determined following the modified Kjeldahl procedure [24] and reported as CEC of the soil. Percent base saturation was calculated from the sum of exchangeable basis as a percent of the CEC of the soil. Exchangeable acidity was determined by extracting the soil samples with M KCL solution and titrating with sodium hydroxide as described by McLean [25]. Organic carbon was determined following wet digestion methods as described by Walkley and Black [26] whereas kjeldahl procedure was used for the determination of total N as described by Jackson [27]. The available P was measured by Bray II method [28].

Agronomic Data Collection: Data on plant basis was recorded from the nine central rows (5.4 m2) out of the fifteen rows per plot. The crop data collected include, thousand seed weight, dry biomass yield, grain yield and harvest index of wheat. Measurements of yield attributes were taken at physiological maturity of the crop prior to harvest. The crop was harvested from the net plot areas manually using sickle at the ground level and dry mater yield of the above ground biomass was determined. Grain moisture content was determined and grain yield was adjusted to 10 % moisture content. Thousand seed weight was determined by counting 1000 seed and weighting. Harvest index was calculated as the percentage ratio of grain yield to the total biomass yield.

Data Analysis: The collected data was subjected to analysis of variance (ANOVA) as per the design used in the experiment SAS version 9.4 Statistical Software [29]. Comparisons among treatment means were made using List Significant difference (LSD) at 5% level of significance [30].

RESULTS AND DISCUSSION

Soil Physicochemical Properties of the Experimental Site: The soil of the study area is Vertisols with a particle size distribution of 67.46% clay, 20.36% silt and 12.18% sand (Table 1), which is of clay texture [31]. The high clay content may indicate better nutrient and water holding capacity of the soil. The pH of the soil of the experimental site is 6.45 which indicate the suitability of the soil reaction at the experimental site for optimum growth and yield of most crops including wheat. According to FAO [32] the suitable pH range for most crops is between 6.5 and 7.5 in which N availability is optimum. Wheat grows under a wide range of soil pH; with permissible ranges of 5.5-7.0 [33]. The cation exchange capacity of the soil is high (44 cmolc (+) kg^{-1} soil) and found in very high range [34]. Furthermore, the soil had a low organic matter (1.08%) content indicating low potential of a soil to supply N [35] and high in available Olsen P (12.42mg kg^{-1}) [36]. The total nitrogen content was 0.12% and found in low range [35].

Dry Biomass Yield: The analysis of variance was showed highly significant ($P<0.001$) differences on dry biomass yield of wheat due to application of blended (NPSZnB) and urea fertilizer rate (Table 2). The highest dry biomass yield (15444 kg ha^{-1}) of wheat in Farm 1 was recorded from application of 150 kg NPSZnB ha^{-1} and 350kg urea ha-1 in Farm 4 the highest (11746 kg ha^{-1}) dry biomass yield of wheat was recorded from application of 200 kg NPSZnB ha^{-1} and 250 kg urea ha^{-1}. Whereas in Farm 2, 3 and combined over years significantly higher dry biomass yield (11333, 9619 and 11369 kg ha^{-1}) respectively were recorded from application of 250 kg NPSZnB ha^{-1} and 350 kg urea ha^{-1}. The lowest dry biomass yield of wheat was recorded from the control in all farmers and combined over years (Table 2).

The dry biomass yield of (15444 kg ha^{-1}) of wheat obtained from Farm 1 with application of 150 kg NPSZnB and 350kg urea ha^{-1} was significantly different from

Table 1: Selected Soil physical and chemical characteristics of the study area before sowing

Soil Characteristic	Value
Clay (%)	67.46
Silt (%)	20.36
Sand (%)	12.18
pH-H_2O (1:2.5)	6.0
OC (%)	1.19
OM (%)	2.05
Total N (%)	0.12
CEC (cmol(+) kg soil)	36.56
P (ppm)	20.05

Table 2: Effects of blended and Urea Fertilizer rate on dry biomass yield of wheat in Vertisols of Ambo district

		Dry biomass (kg ha^{-1})				
Urea (kg ha^{-1})	NPSB (kg ha^{-1})	Farm 1	Farm 2	Farm 3	Farm 4	Combined mean
150	100	11556b	7484de	5619c	7683cd	8085e
150	150	12889ab	8095bcd	6746bc	9008bc	9185de
150	200	14555a	7460de	6508bc	10683ab	9801cd
150	250	13492ab	7794cd	7191abc	10579ab	9763cd
250	100	13206ab	7738cd	6413bc	10889ab	9562cd
250	150	14905a	9555abc	7222abc	9587abc	10317abcd
250	200	14492a	9905ab	6619bc	11746a	10690abc
250	250	14952a	9651abc	6873bc	11286ab	10690abc
350	100	14619a	8778bcd	5667c	9825abc	9722cd
350	150	15444a	9191bcd	6016bc	9889abc	10135bcd
350	200	15143a	10111ab	8270ab	11333ab	11214ab
350	250	13143ab	11333a	9619a	11381a	11369a
139	100	11143b	5555e	2921d	5603de	6305f
0	0	7206c	2508f	2492d	3524e	3932g
LSD (5%)		2671.6	2071.1	2509.6	2327.3	2226.1
CV (%)		11.93	15	23.74	14.59	16.25

Means followed by the same letter(s) within a column are not significantly different from each other using LSD at 5% probability level.

other rates fertilizer. On the other hand, the application of 200 kg NPSZnB and 150 kg urea ha^{-1}, 250 kg NPSZnB and 150 kg urea ha^{-1} and 100 kg NPSZnB with 350 kg urea ha^{-1} were statistically at par from each other (Table 2). As application of blended fertilizer rate increase, dry biomass yield of bread wheat also in all site increases. The application of NPSZnB and Urea fertilizer was significantly improved the production of the dry biomass yield. Similarly, Melkamu *et al*. [37] blended fertilizer supply had a marked effect on the dry biomass yield of wheat. Atsede *et al.* [38] found that significantly the highest dry biomass (11292 kg ha^{-1}) was obtained by application of 150 kg NPKSZnB ha^{-1} at Dibdbo. Also, Jasemi *et al*. [39] reported vegetative growth and biological yield has much dependence to consumption of chemical fertilizers, application of the fertilizers led to increasing biological yield of wheat.

Grain Yield: The mean grain yield of wheat was significantly (<0.001) affected by application of blended (NSZnB) and Urea fertilizer rates in all farmers (Table 3). Significantly lower mean grain yield (984 kg ha^{-1}) of wheat was obtained from control in farm 2 as compared with Farm 1, 3, 4 and combined over years. The highest grain yield (6778 kg ha^{-1}) of wheat was obtained from application of 150 kg NPSZnB ha^{-1} and 150 kg Urea ha^{-1} in Farm 1 as compared with the Farm 2, 3, 4 and combined over years. Significantly higher yield 4143 and 5127 kg ha^{-1} of wheat in Farm 3 and 4 were obtained from sapplication of 250 kg Urea ha^{-1} with 200 and 250 kg NPSZnB ha^{-1} respectively. Significantly higher yield 4968 kg ha^{-1} of wheat in Farm 2 and combined over years was obtained from application of 250 kg NPSZnB ha^{-1} and 350 kg Urea ha^{-1}. The highest mean grain yield of farm 1, 2, 3, 4 and combined mean gave yield advantages of wheat by

Table 3: Effects of blended and Urea Fertilizer rate on grain yield of wheat in Vertisols of Ambo district

		Grain yield (kg ha^{-1})				
Urea (kg ha^{-1})	NPSZnB (kg ha^{-1})	Farm 1	Farm 2	Farm 3	Farm 4	Combined Mean
150	100	4778bc	2667ef	2397de	3301bc	3286d
150	150	6778a	3222bcde	2968bcd	3873ab	4210bc
150	200	6429ab	3095cde	3222abcd	4047ab	4198bc
150	250	5500ab	3286bcde	2873cd	4571ab	4057c
250	100	5683ab	2952def	2873cd	4794a	4075c
250	150	6159ab	3698bcd	3032bcd	4381ab	4317abc
250	200	6143ab	4079abc	2500de	5127a	4462abc
250	250	6777a	4000abc	4143a	4635ab	4888a
350	100	6190ab	4143ab	2555de	4841a	4433abc
350	150	6571a	3603bcde	2571de	4762a	4377abc
350	200	6476ab	4079abc	3698abc	4738a	4748ab
350	250	6063ab	4968a	3873ab	4968a	4968a
139	100	5452ab	2032f	1636ef	2476cd	2899d
0	0	3365c	984g	1048f	1381d	1694e
LSD(5%)		1791.6	992.44	995.76	1334.5	659.81
CV (%)		18.14	17.68	21.08	19.22	20.21

Means followed by the same letter(s) within a column are not significantly different from each other at 5% probability level

Table 4: Effects of blended and Urea Fertilizer rate on thousand seed weight of wheat in Vertisols of Ambo District

		Thousand seed weight (g)				
Urea (kg ha^{-1})	NPSB (kg ha^{-1})	Farm 1	Farm 2	Farm 3	Farm 4	Combined Mean
150	100	43	47	37	38	41
150	150	41	44	37	38	40
150	200	43	43	37	39	41
150	250	44	45	36	38	41
250	100	45	45	39	40	42
250	150	42	45	36	40	41
250	200	45	47	38	40	43
250	250	43	46	39	36	41
350	100	43	48	40	40	43
350	150	44	42	38	38	40
350	200	40	48	39	39	42
350	250	43	43	38	35	40
139	100	41	46	34	38	39
0	0	43	43	37	38	40
LSD (5%)		NS	NS	Ns	NS	NS
CV (%)		6.04	6.5	4.04	4.86	5.81

Means followed by the same letter(s) within a column are not significantly different from each other at 5% probability level

50.4, 80.2, 74.7, 73.1 and 65.9%, respectively as compared to control; and by 29.5, 46.3, 42.1, 35.6 and 33.9% as compared to recommended rate of NP respectively.

Increasing the application of blended fertilizer rates increased the production of bread wheat in four sites. Fayera *et al.* [40] reported that the agronomic performance was improved through application of blend of macro with micronutrient in a suitable form in nutrient deficient soil; as a result, it improved nutrient use efficiency of teff which increased the grain yield. Likewise, Debnath *et al*. [41] also indicated that grain yield of wheat was significantly influenced by boron application, which increased the yield progressively up to 2.25 kg B ha^{-1} and thereafter declined at higher rate 3 kg B ha^{-1}. Bereket *et al*. [42]reported that increasing rate of nitrogen fertilization increased grain yield of wheat. Similarly, Mulugeta *et al.* [43] reported that application of nutrients like K, S, Zn, g and B significantly increased grain yield and yield component of bread wheat as compare to the control. Atsede *et al*. [38] found that significantly the highest grain yield (4163 kg ha^{-1}) was obtained by application of 150 kg NPKSZnB ha^{-1} at Dibdbo.

Table 5: Effects of blended and Urea Fertilizer rate on harvest index of wheat in Vertisols of Ambo district

		Harvest index (%)				
Urea (kg ha^{-1})	NPSZnB (kg ha^{-1})	Farm 1	Farm 2	Farm 3	Farm 4	Combined mean
150	100	41.16	35.67	42.82	42.46	40.55
150	150	51.86	39.67	43.68	43.03	44.59
150	200	44.19	41.67	50.04	38.23	43.56
150	250	40.62	42.02	39.80	43.10	41.47
250	100	42.94	38.33	44.76	44.07	42.54
250	150	41.47	39.05	42.05	45.55	42.03
250	200	42.39	40.67	38.24	43.57	41.21
250	250	45.33	41.66	77.81	41.0	51.45
350	100	42.30	47.87	44.92	49.06	46.04
350	150	42.55	39.55	43.37	47.83	43.33
350	200	42.67	40.23	44.80	39.92	41.90
350	250	46.77	43.65	40.35	43.98	43.67
139	100	49.56	36.52	59.13	44.13	47.34
0	0	46.86	40.03	41.82	39.49	42.05
LSD (5%)	NS	NS	NS	NS	NS	
CV (%)	13.8	9.63	36.58	9.06	22.05	

Means followed by the same letter(s) within a column are not significantly different from each other at the 5% probability level using LSD. Ns: Non-significant.

Thousand Seed Weight: Non-significant (P>0.05) difference was observed among application of blended (NPSZnB) fertilizer and Urea on thousand seed weight of bread wheat (Table 4). The result is consistent with Debnath *et al*. [41] who found that application of B fertilizer had no significant effect on thousand grain weight of wheat crop. Esayas [44] also reported that blended fertilizer (NPS, NPSB, NPSZnB) application had no significance effect on thousand grain seed weight of wheat. In contrary, Fayera *et al*. [40] reported that thousand grain weights had significant difference with application of micronutrients (zinc + boron) and macronutrients in blended form of fertilizer markedly increased thousand grain seed weight of teff crop.

Harvest Index: Harvest index is the relationship of the economic yield to the total or biological yield expressed as coefficient of effectiveness. Thus, harvest index of wheat was the balance between the productive parts of the plant and the reserves, which form the economic yield. Harvest index of wheat was showed non-significantly (P>0.05) affected by application of blended (NPSZnB) and urea fertilizer rates (Table 5). Likewise, Esayas [44] reported that, application of blended fertilizer has no significant effect on harvest index in wheat.

CONCLUSION

The soil analysis indicated that soil of the experimental field was clay in texture with a pH of 6.0 which was moderately acidic in reaction. Application of blended NPSZnB and recommended NP fertilizer significantly improved mean grain yield, dry biomass yield and harvest index of bread wheat. The highest grain yield (4848 kg ha^{-1}) was obtained with application of blended 250 kg NPSZnB ha^{-1} and 250 kg Urea ha^{-1}. Therefore, application of blended 250 kg NPSZnB ha^{-1} and 250 kg Urea ha^{-1} could be agronomical optimum and recommended for wheat production in Vertosols of Ambo district and similar agroecologies.

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