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Effects of Blended and Urea Fertilizer Rates on Yield and Yield Components of Bread wheat (*Triticum aestivum* L.) at Banja District, North Western Ethiopia

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Abstract: A field experiment was carried out in 2017 to 2019 main cropping seasons in Banja District of Awi Administrative Zone, Amhara Regional State, Ethiopia with the objective to determine optimum blended and Urea fertilizer rate for wheat production. Twelve treatments combination from three levels of urea and four levels blended (NPSB) 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 three farmers' fields. Application of different NPSB blended and Urea fertilizers rates had significantly influenced yield and yield components of wheat in all years. Application of (100kg NPSB and 350 kg of urea ha^{-1}), (150 kg NPSB and 350 kg of urea ha^{-1}) and (250kg NPSB and 350 kg of urea ha^{-1}) fertilizer rates had increased biomass yield by about 202.5, 275 and 203.7% as compared to the control (no input) in 2017, 2018 and 2019 years, respectively. Application of blended fertilizer and urea rates (100 kg NPSB and 350 kg Urea ha^{-1}) and (250 kg NPSB and 350 kg Urea ha^{-1}) had increased grain yield by about 231.5, 428.8 and 188.7 % as compared to the negative control in 2017, 2018 and 2019 years, respectively. Both biological and economic analysis showed that application of blended 100 kg NPSB and 350 kg Urea ha^{-1} fertilizers was optimum for wheat production and could be recommended for the study area and similar agro ecologies.

Key words: Blended Fertilizer · Wheat · Urea

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most staple foods and economically important widely used cereal crop in Ethiopia next to teff and maize CSA [1]. However, production of wheat in Ethiopia falls under low fertility soils Yihenew [2]. Similarly, Woldeyesus *et al*. [3] investigated that low wheat productivity was obtained in the highland of Ethiopia due to low soil fertility. Low soil fertility is one of the bottlenecks to sustainable agricultural production and productivity in Ethiopia Wakene *et al*. [4], on the use and application of nitrogen and phosphorous fertilizers in the form of Di-ammonium phosphate (DAP) (18-46-0) and Urea (46-0-0) or blanket recommendation for the major food crops. Continuous application of nitrogen (N) and phosphorus (P) fertilizers without due consideration of other nutrients led to the depletion of other important nutrient elements such as potassium (K), magnesium (Mg), calcium (Ca), sulfur (S) and micronutrients.

In Ethiopia, fertilizer use trend has been focused mainly in soils Abiye *et al*. [5]. Balanced fertilization is the key to sustainable crop production and maintenance of soil health. It has both economic and environmental consideration. An imbalanced fertilizer uses results in low fertilizer use efficiency leading to less economic returns and a greater threat to the environment Abiye *et al*. [5]. Moreover, recently balanced fertilizers containing N, P, K, S, B and Zn in blend form have recommended ameliorating site specific nutrient deficiencies and thereby increasing productivity. The need for site-specific fertilizer prescriptions is increasingly apparent, however, fertilizer trials involving multi-nutrient blends that include micronutrients are rare in Ethiopian context.

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Although there is general perception that the new fertilizer blends better than the traditional fertilizer recommendation (urea and DAP), their comparative advantages not explicitly examined and understood under various production environment.

As long as the agriculture sector remains as the livelihood means of more than 85 per cent of the population, using all sorts of modern technology is essential to beat top most problem of the nation, i.e., poor agricultural productivity. The fertilizer blending project which is set to be put in place recently is believed to bring tangible results, as the blended fertilizer will be produced and used based on specific crop and soil demands unlike DAP and Urea. Blended fertilizer is customized to specific type of soils and crops as well. This helps to feed crops that Urea and DAP have not managed to nourish. And in the long run, instead of DAP and Urea, blended fertilizer shall be distributed to smallholder farmers which own farm lands with deficiency in some important nutrients. Here, the right rate of recommended blended fertilizer for the specific soil, ecology and crop type is important. Hence, the objectives of this study are: to determine optimum blended fertilizer rate for wheat in yield and yield component at Banja district and to assess economic feasibility of different blend fertilizers rate

MATERIALS AND METHODS

Study Site: A field experiment was carried out in (2017 to 2019) main cropping seasons in Banja District of Awi Administrative Zone, Amhara Regional State, Ethiopia. The district is located at latitude of 10°57'17" to 11° 03'05" north and longitude of 36°39'09" to 36°48'25" east, an altitude ranges between 1870 and 2570 masl and 122 km far from the regional city Bahir Dar to south and 447 km north to Addis Ababa (Figure 1).

The mean annual minimum and maximum temperatures of the study area were 7.5 and 24.1 °C, respectively. The mean annual rainfall is 2097 mm with main wet season from May to September usually continued with a less pronounced wet period up to November (Figure 2).

Experimental Design and Procedures: Four levels of blended NPSB (100, 150, 200 and 250 kg ha^{-1}), three levels of urea (150, 250 and 350 kg ha^{-1}) were factorial combined and tested with control and recommended NP fertilizer rate and total of 14 treatments. The experiment was laid out in randomized complete block design with factorial arrangement in three replications. According, to Ethio-SIS [6], nutrients level in 100 kg of NPSB (18.1N - 36.1 P_2O_5 – 0.0 K_2O + 6.7 S + 0.0 Zn + 0.71B). Sowing was done manually at a seed rate of 120 kg/ha using manual row maker with a spacing of 20 cm between rows. The blended fertilizers and DAP were basal applied once at planting. To minimize losses and increase efficiency, all the N fertilizer (urea) was applied in the row in two applications: half at planting and the other half 40 days after planting, during the maximum growth period of the crop at full tillering stage, after first weeding and during light rainfall to minimize loss of N to the atmosphere.

Data Collection: Plant height was measured from ground surface to the tip of the panicle at maturity from ten randomly sampled plants. Spike length was measured from the bottom of the spike to the tip of the spike excluding the awns from ten randomly spikes. The grain yield was determined from each experimental plot and adjusted to constant moisture levels of 12%. Harvest index was calculated from the ratio of grain yield to biological yield.

Soil Analysis: Initial Representative composite surface soil samples were collected from 0-20 cm depth at each experimental unit just before sowing were analyzed for texture, pH, organic carbon, total nitrogen, available phosphorus, exchangeable acidity and cation exchange capacity. Soil texture was determined using the hydrometer method Bouyoucos [7]. The USDA textural triangle was used when classifying textural classes. Soil pH was determined by potentiometric methods at a 1: 2.5 soil to water ratio as described by Carter [8]. Soil organic carbon was determined by the Walkley-Black oxidation method Walkley and Black [9]. Total nitrogen was determined by Kjeldahl digestion method Bremner and Mulvaney [10]. Exchangeable acidity was determined by saturating the soil samples with 1M KCl solution and titrating with 0.02M NaOH as described by Rowell [11]. The cation exchange capacity (CEC) was determined by extraction with ammonium acetate Chapman [12]. Available P was determined by the Bray II method Bray and Kurtz [13].

Economic Analysis: The partial budget analysis was employed for economic analysis of blended NPSB and urea fertilizers rates application for each treatment combination. Analysis of marginal rate of return (MRR %) was carried out for non-dominated treatments and the MRRs were compared to a minimum acceptable rate of return (MARR) of 100% in order to select the optimum

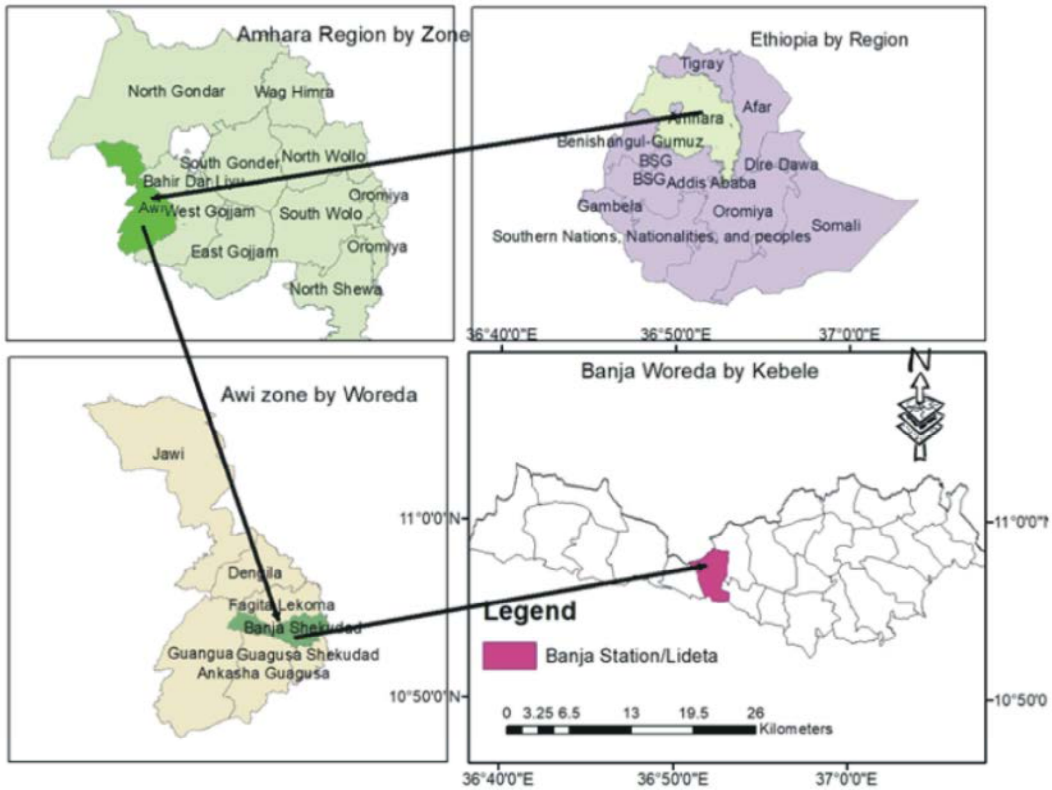

Fig. 1: Location map of the study area, Banja district, north western Ethiopia

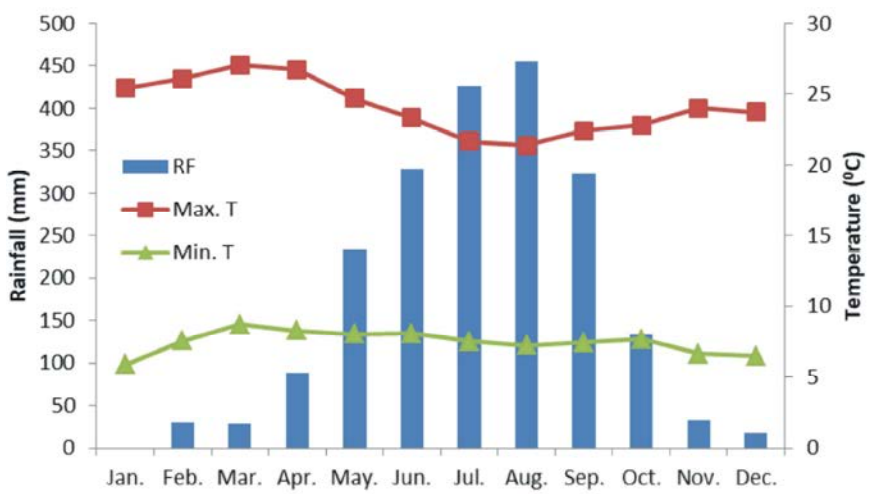

Fig. 2: Mean monthly rainfall and mean monthly maximum and minimum temperatures of the study area

treatment CIMMYT [14]. The net benefit per hectare for each treatment is the difference between the gross benefit and the total variable costs. The average yield was adjusted downward by 10% to reflect the difference between the experimental field and the expected yield at farmers' fields and with farmer's practices from the same treatments CIMMYT [14].

Statistical Analysis: Analysis of variance (ANOVA) was performed using SAS statistical software 9.3 version SAS [15]. Whenever the ANOVA detected significant differences between treatments, mean separation was conducted using least significant difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

Plant Height: Results showed that application of different rates of NPSB blended and Urea fertilizer had highly significant (P<0.01) effect on plant height in 2017 and 2018 cropping years (Tables 1 and 2). Application of combination blended fertilizer and urea rates (150 kg NPSB and 350 kg Urea ha^{-1}) and (200 kg NPSB and 350 kg Urea ha^{-1}) significantly increased plant height as compared to the control in 2017 and 2018 cropping years, respectively. The highest plant height (84.47 and 83.57 cm) recorded in applications of (150 kg NPSB and 350 kg Urea ha^{-1}) and (200 kg NPSB and 350 kg Urea ha^{-1}) fertilizers rates whereas the lowest plant height (66.03 and 53.63 cm) obtained from negative control (no input) treatment in 2017 and 2018 years, respectively. Similarly, Sofonyas *et al.* [16] reported that application of NPSZn rates ranging from 100 to 300 kg ha^{-1} showed statistically higher plant height than the recommended NP at Ofla site. Melkamu *et al*. [17] indicated that the maximum plant height (109.9 cm) was obtained from application of 200 NPSB kg ha^{-1} blended fertilizers.

Spike Length: Results showed that application of different rates of NPSB blended and Urea fertilizer had a significant (P<0.0001) effect on spike length only in 2017 cropping year. Hence, the highest spike length (8.17 cm) was recorded from the application of blended (150kg NPSB and 350 kg Urea ha^{-1}) rate whereas the lowest spike length (5.73cm) was in negative control treatment (Table 1). Sofonyas *et al.* [16] reported that the highest spike length was recorded from the application of 300 kg of NPSZn ha at both sites. Melkamu *et al*. [17] reported that the maximum spike length (7.1 cm) was obtained from application of 200 NPSB kg ha^{-1} blended fertilizers.

Number Kernel per Spike: The main effects of blended NPSB fertilizer and Urea rates were significantly ($p < 0.05$) affected on number of kerned per spike (Tables 1, 2 and 3). The highest number of kerned per spike (16.9, 32.7 and 19.1) of wheat was obtained from applications of (250 kg NPSB ha^{-1} and 350 kg Urea ha^{-1}), (200 kg NPSB ha^{-1} and 350 kg Urea ha^{-1}) and (250 kg NPSB ha^{-1} and 150 kg Urea ha^{-1}) in 2017, 2018 and 2019 cropping years. Conversely, the lowest number of kerned per spike (11.8, 12.1 and 14.5) was perceived in control plot. Also, Sofonyas *et al.* [16] reported that application of different rates of NPSZn blended fertilizer significantly influenced yield and yield components of wheat. Similarly, Melkamu *et al.* [17] found that the maximum number of kernels per spike (53) was obtained from application of 200 NPSB kg ha^{-1} blended fertilizers.

Biomass Yield: The results of the analysis of variance showed that the main effect of blended fertilizer and urea rates significantly affected the biomass yield (Tables 1, 2 and 3). Hence, the highest biomass yields (13444.5, 5555.6 and 10375.0 kg ha^{-1}) obtained from the applications of (100kg NPSB and 350 kg of urea ha^{-1}), (150 kg NPSB and 350 kg of urea ha^{-1}) and (250kg NPSB and 350 kg of urea ha^{-1}) fertilizers rates while, the lowest biomass yield was recorded from treatments that receive 0 kg of fertilizer (control) in 2017, 2018 and 2019 years, respectively. Similarly, application of (100kg NPSB and 350 kg of urea ha^{-1}), (150 kg NPSB and 350 kg of urea ha^{-1}) and (250kg NPSB and 350 kg of urea ha^{-1}) fertilizer rates had increased biomass yield by about 202.5, 275 and 203.7% as compared to the control (no input) in 2017, 2018 and 2019 years, respectively. Similar, the maximum aboveground biomass (12.63 t ha^{-1}) was obtained from 200NPSB kg ha^{-1} of blended fertilizer application Melkamu *et al*. [17]. This result agrees with the finding of Woubshet *et al.* [18] who found that application of 150 kg ha^{-1} NPSB blended fertilizer with compost increased the biomass by 11.5 t ha^{-1}. Similarly, Tolera *et al.* [19] indicated that application of NPSZnB and Urea fertilizer was significantly improved the production of the dry biomass yield.

Grain Yield: The mean grain yield of wheat was significantly (<0.001) affected by application of blended (NPSB) and Urea fertilizer rates in all years (Tables 1, 2 and 3). The highest grain yields (5999.7 and 1601.2 kg ha^{-1}) were obtained from applications of (100 kg NPSB and 350 kg Urea ha^{-1}) in 2017 and 2018 years, respectively. Also, the highest grain yields 3730.3 kg ha^{-1} was obtained from applications of (250 kg NPSB and 350 kg Urea ha^{-1}) in 2019 year. Conversely, the lowest grains yield (1809.9, 302.8 and 1292.0 kg ha^{-1}) was perceived in control plot in 2017, 2018 and 2019 years, respectively. Similarly, Tolera *et al.* [19] significantly lower mean grain yield (984 kg ha^{-1}) of wheat was obtained from control.

Application of blended fertilizer and urea rates (100 kg NPSB and 350 kg Urea ha^{-1}) and (250 kg NPSB and 350 kg Urea ha^{-1}) had increased grain yield by about 231.5, 428.8 and 188.7 % as compared to the negative control in 2017, 2018 and 2019 years, respectively.

Table 1: Effect of blended and Urea fertilizers rates on yield and yield component of wheat in 2017 cropping season

Urea (kg ha^{-1})	NPSB (kg ha^{-1})	Plant height (cm)	Spike length (cm)	Number kernel spike^{-1}	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvesting Index (%)
150	100	73.87bc	7.33b	14.8d	8166.7d	3384.4dc	40.3
150	150	78.07ab	7.33b	15.1cd	8500.0dc	3540.4dc	40.9
150	200	77.67ab	7.37b	15.4bcd	9277.8bdc	3952.9bc	40.7
150	250	82.03ab	8.23a	16.4abc	10833.3bdac	4435.3bac	41.9
250	100	79.20ab	7.83ab	15.9abcd	10500.0bdac	4413.9bac	40.5
250	150	80.93ab	7.97ab	16.0abcd	12444.5ba	5775.9ba	42.2
250	200	82.33ab	7.73ab	16.0abcd	11722.2bac	5282.4bac	46.3
250	250	77.37ab	7.67ab	15.5bcd	11111.1bdac	4510.7bac	45.0
350	100	82.53a	7.80ab	16.5ab	13444.5a	5999.7a	40.5
350	150	84.47a	8.17a	16.7ab	13111.1a	5800.9ba	44.6
350	200	82.33ab	7.97ab	16.4abc	13666.7a	5852.8ba	43.9
350	250	80.03ab	8.03ab	16.9a	13111.1a	5645.8ba	42.1
0	0	66.03c	5.73c	11.8e	4444.4e	1809.9d	42.7
LSD (0.05)		8.5531	0.7457	1.3609	3382.4	2043.4	ns
CV (%)		6.4	5.8	5.2	18.5	26.1	9.7
Significance		**	***	***	***	**	ns

Note: *** Significant at $P < 0.001$, ** significant at $P < 0.01$, ns – no significant difference at $P < 0.05$. Means along the column with the same letter are not significantly different.

Table 2: Effect of blended and Urea fertilizer rates on yield and yield component of wheat crop in 2018 cropping season

Urea (kg ha^{-1})	NPSB (kg ha^{-1})	Plant height (cm)	Spike length (cm)	Number kernel spike^{-1}	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvesting Index (%)
150	100	74.00b	7.0	26.0ab	3518.5ab	982.7bac	28.4
150	150	78.87ba	5.8	25.8ab	4000.0ab	1157.1bac	29.2
150	200	80.00ba	6.0	28.4ab	4074.1a	1230.2ba	30.2
150	250	82.83ba	6.4	27.8ab	5740.7a	1587.9ba	28.7
250	100	78.10ba	6.7	27.4ab	4555.6a	1235.5ba	27.7
250	150	76.17ba	6.2	30.5ab	3629.6ab	1101.8ba	30.2
250	200	78.43ba	6.6	30.8ab	3703.7ab	944.0bac	24.4
250	250	81.00ba	6.7	31.7a	5111.1a	1439.0ba	26.6
350	100	79.13ba	6.0	28.8ab	5481.5a	1601.2a	28.7
350	150	81.00ba	6.6	28.4ab	5555.6a	1497.4ba	27.1
350	200	83.57a	6.8	32.7a	5555.5a	1611.0a	29.5
350	250	78.40ba	6.4	30.2ab	4814.8a	1622.7a	36.4
150	100 NP	76.23ba	6.9	23.1b	3407.4ab	839.9bc	23.6
0	0	53.63c	6.4	12.1c	1481.5b	302.8c	21.0
LSD (0.05)		9.1889	ns	8.5636	2536.9	761.21	ns
CV (%)		7.1	16.4	18.6	34.9	37.0	17.8
Significance		***-	ns	**	*	*	ns

Note: *** Significant at $P < 0.001$, ** significant at $P < 0.01$, * significant at $P < 0.05$, ns – no significant difference. Means along the column with the same letter are not significantly different.

Table 3: Effect of blended fertilizer and Urea rates on yield and yield component of wheat crop in 2019 cropping season

Urea (kg ha^{-1})	NPSB (kg ha^{-1})	Plant height (cm)	Spike length (cm)	Number kernel spike^{-1}	Biomass yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvesting Index (%)
150	100	83.90	7.50	15.9bc	7166.7ba	2629.8ba	36.6
150	150	85.33	7.63	16.8abc	7916.7a	2976.4a	37.6
150	200	82.10	7.40	17.1ab	6916.7ba	2627.6ba	38.0
150	250	84.53	10.20	19.1a	7500.0a	2570.1ba	35.2
250	100	85.07	7.60	17.9ab	7833.3a	2815.9a	36.0
250	150	88.27	7.77	16.4bc	9625.0a	3376.9a	35.2
250	200	89.30	7.67	16.8abc	9291.7a	3532.1a	38.1
250	250	88.10	7.73	17.6ab	9041.7a	3288.6a	36.8
350	100	87.43	7.83	18.5ab	8791.7a	3136.0a	35.9
350	150	87.57	7.53	18.3ab	8791.7a	3334.7a	38.5
350	200	87.07	7.80	17.5ab	9416.7a	3276.2a	34.9
350	250	89.10	7.90	18.5ab	10375.0a	3730.3a	35.7
150	100	87.63	7.53	18.2ab	7166.7ba	2754.0ba	38.2
0	0	74.90	6.23	14.5c	3416.7b	1292.0b	37.1
LSD (0.05)		ns	ns	2.5497	4020.4	1480.9	ns
CV (%)		7.0	7.5	8.7	29.6	29.8	4.9
Significance		ns	ns	*	*	*	ns

Note: * significant at $P < 0.05$, ns – no significant difference. Means along the column with the same letter are not significantly different

This result agrees with the finding of Tolera *et al.* [19] indicated that application of 250 kg NPSZnB ha^{-1} and 350 kg Urea ha^{-1} gave the higher grain yield 4888 kg ha of bread wheat. Sofonyas *et al.* [16] reported that application of different rates of NPSZn blended fertilizer significantly influenced yield and yield components of wheat. Similarly, Mulugeta *et al.* [20] 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.

Table 4: Economic analysis of blended and urea fertilizer rates on wheat over three combined cropping seasons

Blended Fertilizer (kg ha^{-1})	Urea (kg ha^{-1})	Grain Yield (kg ha^{-1})	Gross Field Benefit (ETB)	Total Cost (ETB)	Net Benefit (ETB)	Marginal Rate of Return (%)
0	0	1021.41	25024.55	0.00	25024.55	-
100 NPSB	150	2099.07	51427.22	3978.50	47448.72	563.6
100 DAP	150	1078.17	26415.17	3978.50	22436.67	D
150 NPSB	150	2302.17	56403.17	4854.00	51549.17	3325.2
100 NPSB	250	2539.59	62219.96	5463.50	56756.46	854.4
200 NPSB	150	2343.21	57408.65	5729.50	51679.15	D
150 NPSB	250	3076.38	75371.31	6339.00	69032.31	2847.1
250 NPSB	150	2577.99	63160.76	6605.00	56555.76	D
100 NPSB	350	3221.07	78916.22	6948.50	71967.72	4486.7
200 NPSB	250	2927.55	71724.98	7214.50	64510.48	D
150 NPSB	350	3189.90	78152.55	7824.00	70328.55	954.6
250 NPSB	250	2771.49	67901.51	8090.00	59811.51	D
200 NPSB	350	3222.00	78939.00	8699.50	70239.50	1710.9
250 NPSB	350	3299.64	80841.18	9575.00	71266.18	117.3

Economic Benefit: Table 4 show economic analysis data of benefit, cost and marginal rate of return of treatments using partial budget techniques. Treatments that produced lower NFBs were not worth for investment. Similarly, some of the treatments did not realize economically viable returns. However, results of the partial budget analyses revealed that maximum net benefit of 71, 967.72 ETB ha^{-1} with an acceptable marginal rate of returns (MRR) 4486.7 % was recorded in the treatment that received of blended and Urea fertilizer (100 kg NPSB and 350 kg Urea ha^{-1}) rate (Table 4). This combination generated 46, 943.17 ETB ha^{-1} more compared to the negative control treatment and 49, 531.05 ETB ha^{-1} more compared to the positive control (100 kg DAP and 150 kg Urea ha^{-1}) treatment. High net return from the foregoing treatments could be attributed to the high yield whilst the low net returns to low yield. From the economic point of view, it was apparent from the above results that combined application of blended and Urea fertilizer (100 kg NPSB and 350 kg Urea ha^{-1}) rates is more profitable than the rest of treatment combinations.

CONCLUSION

Application of different NPSB blended and Urea fertilizers rates had significantly influenced yield and yield components of wheat in all cropping years. Similarly, Application of (100kg NPSB and 350 kg of urea ha^{-1}), (150 kg NPSB and 350 kg of urea ha^{-1}) and (250kg NPSB and 350 kg of urea ha^{-1}) fertilizer rates had increased biomass yield by about 202.5, 275 and 203.7% as compared to the control (no input) in 2017, 2018 and 2019 years, respectively. Application of blended fertilizer and urea rates (100 kg NPSB and 350 kg Urea ha^{-1}) and (250 kg NPSB and 350 kg Urea ha^{-1}) had increased grain yield by about 231.5, 428.8 and 188.7 % as compared to the negative control in 2017, 2018 and 2019 years, respectively. Both biological and economic analysis showed that application of blended 100 kg NPSB and 350 kg Urea ha^{-1} fertilizers was optimum for wheat production and could be recommended for the study area and similar agro ecologies.

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