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Response of Bread wheat (*Triticum aestivum* L.) for Different Application Rates of Blended Fertilizer (NPSZnB) and Urea on Nitisols of Ejere District, Central Highlands of Ethiopia

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Abstract: Field experiment was conducted on Nitisols in Ejere district of Oromia regional state of Ethiopia for three successive years since 2018 to evaluate the response of combined application rate for blended fertilizer (NPSZnB) with supplementary Nitrogen as urea on bread wheat (*Triticum aestivum* L.) by using CRBD with three replication. Several growth parameters, yield and yield component data was collected and analyzed for their response of blended fertilizer application. It's possible to obtain statistically significant difference ($P<0.05$) between treatments on most of collected data accordingly, maximum grain yield 4247.9kg ha^{-1} was harvested from combined use of 200 kg NPSZnB ha^{-1} and 161 kg N ha^{-1} followed by 150 kg NPSZnB by 115 kg N, maximum Biomass yield 14.7 ton ha^{-1} was resulted from 150 NPSZnB by 115 kg N on the other hand most economical result with maximum Net benefit and higher marginal rate of return were resulted from 150 kg NPSZnB blended fertilizer combined with 69 kg Nitrogen ha^{-1} as a 2nd alternative using 150 NPZnB with 115 Nitrogen gave competitive result with all parameters.

Key words: Nitisols · NPSZnB · *Triticum aestivum* L. · Marginal Rate of Return · Net Benefit

INTRODUCTION

The declining agricultural crop productivity is primarily allied to the depletion of soil fertility due to continuous nutrient mining of crops, low fertilizer uses and insufficient organic matter incorporation [1]. The growth of the global food production is projected to demands increased use of chemical fertilizers, but since the current environmental impact of agriculture and fertilizer use has reached its global boundaries [2], the nutrient use efficiency of fertilizers should be increased dramatically. The current yield trends are insufficient to meet forecasted food demands [3], which implies an intimidating challenge to limiting the use of fertilizers and increasing yields. This problem reveals the great potential to increase the nutrient use efficiency and consequently, yield levels by considering all essential plant nutrients (macronutrients N, P, K, Ca, Mg and S and micronutrients Cl, Fe, B, Mn, Zn, Cu, Mo and Ni) in fertilizer products and fertilization strategies [4, 5].

In Ethiopian dominant use of chemical fertilizers like di-ammonium phosphate (DAP) and Urea to improve major crop yields for about five decades and this did not consider soil fertility status and crop requirement. Although a soil fertility survey conducted by Murphy [6] found no K deficiency in Ethiopian soils, However, Astatke *et al.* [7] and Haile and Boke [8] reported the deficiency of K in some Ethiopian soils. Moreover, the soil fertility mapping project in Ethiopia reported the deficiency of K, S, Zn, B and Cu in addition to N and P in major Ethiopian soils and thus recommend application of customized and balanced fertilizers [9]; Moreover, Habte *et al.* [10], Bellete [11], Laekemariam [12] and Habtamu *et al.* [13] reported that S content in the soils they studied were found to be very low in some Ethiopian soils. Consequently, holistic soil fertility enhancements which consider those nutrients were crucial for sustainable soil productivity.

Bread wheat (*Triticum aestivum* L.) is one of the major cereal crops grown in the highlands of Ethiopia and

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this region is considered as the largest wheat producer in Sub-Saharan Africa. It is mainly grown in the highlands of Ethiopia, which lie between 6 and 16° N latitude and 35 and 42° E longitude, at altitudes ranging from 1500 to 2800 meters above sea level [14]. Its production in such potential areas were considerably constrained from soil fertility problem and un appropriate use of fertilizer like other major crops so it's important to look forward the balanced plant nutrition through incorporating other essential soil nutrients than N and P which becomes limiting for crop production in central high lands of Ethiopia.

MATERIALS AND METHODS

Field trial was conducted at Ejere districts of "FinfineZuria" special zone in Oromia regional states of Ethiopia, located at latitude 9°02'36" N and longitude 38°25'45.5" E DMS. For three consecutive years (i.e. 2018, 2019 and 2020). Based on the Ethiosis, 2014 digital soil map the study area are located on the NPSZnB (formula-IV) blended fertilizer spotted location of digital soil fertility map grid. Composition of formula-IV (NPSZnB) blended fertilizer includes 16.5% N, 33.8% P_2O_5, 7.3 % S, 2.23% Zn and 0.54% B. Bread wheat (*Triticum aestivum* L.) improved variety "*Alidoro*" was used as a test crop for the experiment with 150 kgha^{-1} seed rates planted in row planting.

Randomized completed block design (RCBD) was used with three replications. Treatments includes different rate of blended fertilizer (NPSZnB) at 100, 150, 200 and 250 kg ha^{-1}. which factorially combined with 150, 250 and 350 kg ha^{-1}of urea (46% N) arranged as shown in Table1.TSP and urea were used as standard control treatment with conventionally recommended N and P rate (60 Kg N Ha^{-1} Vs 69 kg P_2O_5Ha^{-1} respectively) for bread wheat crop on Nitisols (WBR, 2015) [26] reference soil group of central Ethiopian highland. All fertilizer treatment except urea were applied at planting with band application whereas the urea fertilizer was applied in to two splits half at planting and the remaining was applied at tillering crop growth stage of wheat.

Statistically Analysis: Collected bread wheat crop growth parameter and yield (grain yield and above ground dry biomass yield) data were subjected to statistical data analysis by using SAS software version 9.0 at (p<0.05) for the variants which show statistically significant difference on different factors means were separated by using LSD (least significant difference) procedure.

Table 1: Treatments setup of blended fertilizer and urea rate study on bread wheat at Ejere district

No.	Treatments	N	P_2O_5	S	Zn	B
1	Control (no fertilizer)	0	0	0	0	0
2	100 NPSZnB + 150 urea	85.5	33.8	7.3	3.35	0.46
3	150 NPSZnB + 150 urea	93.8	50.7	11.0	3.35	0.51
4	200 NPSZnB + 150 urea	102.0	67.6	14.6	3.35	0.56
5	250 NPSZnB + 150 urea	110.3	84.5	18.3	3.35	0.60
6	100 NPSZnB + 250 urea	131.5	33.8	7.3	5.58	0.71
7	150 NPSZnB + 250 urea	139.8	50.7	11.0	5.58	0.76
8	200 NPSZnB + 250 urea	148.0	67.6	14.6	5.58	0.80
9	250 NPSZnB + 250 urea	156.3	84.5	18.3	5.58	0.85
10	100 NPSZnB + 350 urea	177.5	33.8	7.3	7.81	0.96
11	150 NPSZnB + 350 urea	185.8	50.7	11.0	7.81	1.01
12	200 NPSZnB + 350 urea	194.0	67.6	14.6	7.81	1.05
13	250 NPSZnB + 350 urea	202.3	84.5	18.3	7.81	1.10
14	Rec NP (69 P_2O_5 Vs 60 N)	60	69	0	0	0

where treatment 14 is used as standard check which used recommended N and P rates at 60 by 69 kg ha^{-1} from urea and TSP fertilizers

Simplified Economic data analysis (partial budget; total variable cost, net benefit, marginal cost, marginal net benefit and marginal rate of return MRR%) is computed by using [15] procedure to determine economically profitable and feasible fertilizer input application rates for optimal wheat crop productivity under Ejere and similar soil, agro-ecologic Zones of the country.

RESULTS AND DISCUSSION

From three years aggregated data analysis result application of blended fertilizer (NPSZnB) with different rate were significantly affect the plant height and spike length (P<0.05) on the other hand thousand seed weight and hectoliter weight were not affected significantly at (P<0.05) level (Table 2). Accordingly, the highest plant height (ph) result 102.6 cm was recorded from the treatment # 13 which have 250 kg ha^{-1} NPSZnB supplemented with 350 kg ha^{-1}urea followed by competent treatment # 11 (i.e. 150 NPSZnB + 350 urea) 102.4 cm. the least result was recorded from negative control treatment which do not receive any fertilizer input. Significant spike length difference (P<0.05) between treatment were recorded on the over year mean data analysis accordingly the highest result was attained from the treatment 11 (150 NPSZnB + 350 urea) followed by treatment 12 which have received 200 kg ha^{-1} of NPSZnB with 350 kg ha^{-1} Urea (Table 2).

Effects of Blended Fertilizer on Grain and Biomass Yields: Aggregate results of three successive study years reveals that different application rates of blended fertilizer

Table 2: Three years collective growth parameter and yield components of wheat result as affected by the application rate of blended fertilizer (NPSZnB) and urea at Ejere

		2018				2019				2020				Average			
No.	Treatments	ph	spk	tsw	hlw	ph	spk	tsw	hlw	ph	spk	tsw	hlw	ph	spk	tsw	hlw
1	Control (no fertilizer)	84.3	7.0	38.5	81.3	74.0	6.9	35.1	75.3	76.8	7.3	39.3	79.1	78.4C	7.1E	37.6	78.6
2	100 NPSZnB + 150 urea	108.7	10.3	38.4	80.9	92.3	9.4	41.6	80.1	97.4	9.1	41.7	78.4	99.5AB	9.6ABCD	40.6	79.8
3	150 NPSZnB + 150 urea	109.7	10.0	37.7	81.4	91.7	8.4	40.0	79.3	99.1	9.5	41.6	78.8	100.2AB	9.3CD	39.8	79.8
4	200 NPSZnB + 150 urea	109.0	10.7	36.9	81.4	93.7	8.5	40.3	79.3	95.6	8.5	40.5	78.7	99.4AB	9.2CD	39.2	79.8
5	250 NPSZnB + 150 urea	110.7	10.7	36.1	80.9	92.3	9.6	40.4	77.9	98.8	9.6	41.1	77.0	100.6AB	10.ABC	39.2	78.6
6	100 NPSZnB + 250 urea	108.7	9.7	34.0	80.9	95.3	8.5	41.2	79.4	94.9	9.5	41.3	78.5	99.6AB	9.2CD	38.8	79.6
7	150 NPSZnB + 250 urea	107.0	9.7	32.7	81.0	93.3	9.4	40.4	79.1	102.3	9.1	40.8	79.0	100.9AB	9.4BCD	38.0	79.7
8	200 NPSZnB + 250 urea	112.7	9.7	35.1	81.3	81.7	7.6	39.7	79.0	100.5	10.0	40.7	77.3	98.3AB	9.07D	38.5	79.2
9	250 NPSZnB + 250 urea	113.0	9.7	32.3	80.4	89.0	8.5	40.9	79.4	100.5	9.2	41.1	79.3	100.8AB	9.1CD	38.1	79.7
10	100 NPSZnB + 350 urea	106.3	10.0	31.5	80.1	93.0	9.9	41.1	80.0	101.3	9.3	42.1	78.9	100.2AB	9.7ABCD	38.2	79.6
11	150 NPSZnB + 350 urea	107.7	10.3	32.8	80.3	93.7	10.0	39.6	79.5	106.0	10.5	40.9	78.6	102.4A	10.3A	37.8	79.5
12	200 NPSZnB + 350 urea	110.3	10.7	35.1	80.5	93.7	10.3	40.4	78.7	102.7	9.7	40.9	79.1	102.2A	10.2AB	38.8	79.5
13	250 NPSZnB + 350 urea	110.0	10.3	33.7	79.8	95.0	9.5	40.1	79.7	102.7	10.1	40.4	78.4	102.6A	10.ABC	38.1	79.3
14	Rec NP (69 P_2O_5 Vs 60 N)	101.5	10.9	37.5	80.9	91.0	9.8	40.4	80.3	95.2	9.1	40.1	78.1	95.9B	9.9ABCD	39.4	79.8
Lsd	6.26	1.37	4.13	1.74	13.3	1.96	2.93	3.68	9.23	1.45	2.11	2	5.7	0.89	1.9	1.56	
Cv %	3.49	8.15	6.99	1.28	8.73	13	4.36	2.78	5.61	9.32	3.1	1.52	3.5	5.66	2.94	1.17	
ANOVA	**	**	*	ns	ns	ns	*	*	**	*	ns	ns	**	**	ns	ns	

where ph plant height in cm, spk spike length in cm, tsw thousand seed weight in gram and hlw is hectoliter weight in gm. means with the same letter were do not have statistically difference value

(NPSZnB) and urea were significantly affecting the grain yield (GYD) and above ground dry biomass yield (BMS) (Table 3) at (P<0.05) level of statistically significant difference between variants. From over three-years aggregate data analysis results the highest mean grain yield (GYD) 4247.9 kg $ha^{-1}$was recorded under treatment # 12 (Table 3) which is the combination of 200 kg ha^{-1} NPSZnB fertilizer with 350 kg ha^{-1} urea. Which have got 202% grain yield increments over the control. Correspondingly treatment # 3 (150 NPSZnB + 150 urea) and# 7 (i.e. 150 NPSZnB + 250 urea) also can gave a statistically competent result with the highest BMS yield with least rate of fertilizer application. Whereas treatment # 12 was got 37.6% yield increment over the standard control i.e. Conventional recommended NP application 60 N and 69 P_2O_5 from urea and TSP sources. It was also reported that the highest wheat grain yield was attained from application of blended fertilizer, 250 kg ha^{-1} NPSZnB and 350 kg ha^{-1} urea at Ambo district [16]. Likely, maximum grain yield of Maize crop was gained by applying 200/350 kg ha^{-1} urea and NPSZnB at 'Toke Kuyaye' district of west Shoa Zone [17].

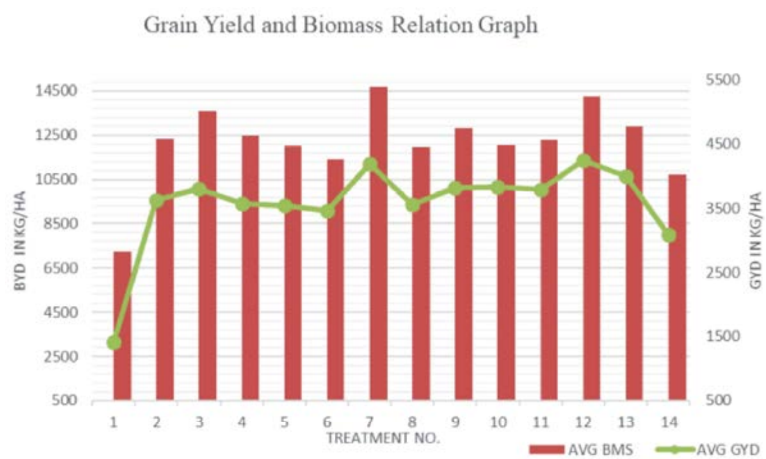
While maximum above ground plant biomass (BMS) yield 14.7ton ha^{-1} was found at treatment # 7 (Table 3) which have got 161.2% and 37.2% statistically significant biomass yield advantage over negative and standard controls respectively. Similarly studies of blended fertilizer (NPSB) on durum wheat confirmed that NPSB and N interaction result showed that above ground biomass (BMS) and other related growth parameters was significantly affected by its application, accordingly maximum result was recorded at combined application of 150 blended fertilizer (NPSB) with 250 kg urea ha^{-1} [18].

Relatively improved grain yield (GYD) and biomass yields (BMS) were attained from NPSZnB than standard control NP due to the incorporated soil deficient essential nutrients like Sulfur (S), Zink (Zn) and Boron (B) which is vital for wheat crop metabolic and enzymatic involvement on its growth and productivity [19-21] specially on specific soils which have indicated on EthioSIS [9] soil fertility map and similar soil fertility status. From those results as we exceed the application rate of 250 kg NPSZnB ha^{-1} grain yield increment become limited (Graph 1) whereas the biomass yield reduced relatively in some extent as a result the harvest index starts to fall (Table 4) its due to excessive combined effects of trace elements like Zn and B. Subsequently it becomes antagonizing beyond crop specific nutrient requirements specially on low pH or acidic *Nitisols*. As soil pH falls, Zn concentration in the soil solution and plant uptake increase and the potential for Zn phyto-toxicity is more severe [22-24] control progressive concentration effects on acidic soils, phytotoxicity is indicated by Zn-induced Fe-deficiency-chlorosis (typical phytotoxic level is 500 ppm DW in diagnostic leaves), or beyond 1ppm for soil Zn level [25] consequently wise monitoring and balanced fertilization with the optimal rate of NPSZnB blended fertilizer were crucial to improve both productivity and quality of wheat crop with soil health maintenance aspects.

Table 3: Grain and Biomass yield of bread wheat as affected by application rate of blended fertilizer (NPSZnB) and urea at Ejere district for three growing successive years

		GYD (kg ha^{-1})				BMS (kg ha^{-1})			
No.	Treatment	2018	2019	2020	AVG	2018	2019	2020	AVG
1	Control (no fertilizer)	1598.5	1015.4	1611.4	1408.4D	6061.7	5937.5	4869.5	5622.9F
2	100 NPSZnB + 150 urea	4292.2	2978.0	3625.0	3631.7ABC	14967.6	11145.8	10833.3	12315.6BCDE
3	150 NPSZnB + 150 urea	4407.2	2713.0	4286.4	3802.2ABC	16755.8	11562.5	12361.1	13559.8ABC
4	200 NPSZnB + 150 urea	4287.9	2891.8	3514.6	3564.8ABC	14796.9	11666.7	10972.2	12478.6BCDE
5	250 NPSZnB + 150 urea	4656.5	3101.4	2863.9	3540.6ABC	16641.4	11666.7	8602.7	12303.6CDE
6	100 NPSZnB + 250 urea	3774.7	3809.6	2785.1	3456.5BC	12902.9	12708.3	8611.1	11407.5DE
7	150 NPSZnB + 250 urea	4525.0	3642.3	4390.3	4185.9AB	17402.6	13750.0	12916.7	14689.8A
8	200 NPSZnB + 250 urea	4029.7	3687.3	2944.0	3553.7ABC	13935.3	13125.0	8888.9	11983.1CDE
9	250 NPSZnB + 250 urea	3716.8	3774.9	3960.8	3817.5ABC	13403.3	13541.7	11527.8	12824.3ABCD
10	100 NPSZnB + 350 urea	3569.7	4427.8	3505.1	3834.2AB	11770.4	14375.0	10000.0	12048.5CDE
11	150 NPSZnB + 350 urea	4160.7	4219.7	2993.6	3791.3ABC	14016.0	14062.5	8750.0	12276.2CDE
12	200 NPSZnB + 350 urea	4568.5	4633.7	3541.5	4247.9A	16602.3	15416.7	10694.4	14237.8AB
13	250 NPSZnB + 350 urea	3652.4	4751.9	3601.8	4002.0AB	13002.2	16458.3	9166.7	12875.7ABCD
14	Rec NP (69 P_2O_5 Vs 60 N)	3599.2	3302.5	2359.0	3086.9C	12083.3	11562.5	8472.2	10706.0E
LSD		1031.4	763.92	1824.5	793.29	3133.6	2022.5	5119.9	2108.5
CV		15.69	13.02	18.68	12.21	13.45	9.53	17.18	9.81
ANOVA		**	**	ns	**	**	**	ns	**

where GYD is grain yield in kg/ha, BMS is above ground dry biomass in kg/ha, means with the same letter do not have statistically significant difference



where: primary vertical axis value for biomass yield and secondary vertical axis for the grain yield represented by line kg unit used for both.

Graph 1: Grain yield and above ground biomass yield relation graph on blended fertilizer study

Significantly higher harvest index results 31.8 was attained from application of blended fertilizer (NPSZnB) rate at treatment # 10 (Table 4) which is 100 kg ha^{-1} NPSZnB with 350 kg ha^{-1}Urea per hectare followed by similarly competent result of 31.1 from treatment 13 which have 250 NPSZnB with 350 kg ha^{-1} urea fertilizer the least result was obtained from negative control treatment with 19.5 ratio value.

Economic Analysis (Partial Budget): From partial budget analysis result the highest Net benefit 2501.92$ USD were attained from treatment # 12 (200 NPSZnB + 350 urea kg ha^{-1}) followed by 2457.45$ USD competent treatment # 7 (150 NPSZnB + 250 urea kg ha^{-1}) on the other hand treatment # 7 got the higher Marginal rate of return (MRR) percentage (Table 5) as both of them are dominant treatment with higher net economic benefits it's preferable than other treatments on the other hands treatment # 3 (i.e. 150 NPSZnB + 150 urea kg ha^{-1}) can be presented as economically beneficial alternative.

From the marginal rate of return percentage highest result were computed under treatment # 2 (100 NPSZnB + 150 urea) whereas while comparing with the net benefit and other biological productivity results the first

Table 4: Over year Harvest index result of bread wheat as affected by application rates of blended fertilizer and urea at Ejere

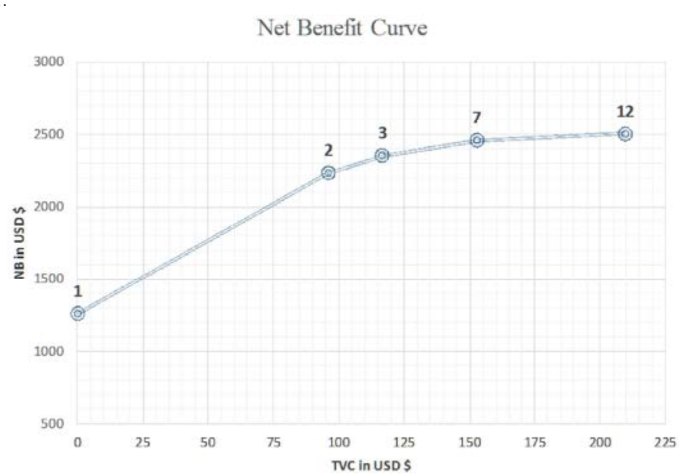
No.	Treatments	Harvest Index (HDX) 2018	2019	2020	AVG
1	Control (no fertilizer)	26.4	17.1 E	16.6	19.5 C
2	100 NPSZnB + 150 urea	28.7	26.7 ABCD	33.5	29.5 AB
3	150 NPSZnB + 150 urea	26.3	23.5 D	34.7	28.0 B
4	200 NPSZnB + 150 urea	29.0	24.8 CD	32.0	28.6 B
5	250 NPSZnB + 150 urea	28.0	26.6 BCD	36.8	29.4 AB
6	100 NPSZnB + 250 urea	29.3	30.0 AB	32.3	30.3 AB
7	150 NPSZnB + 250 urea	26.0	26.5 BCD	34.0	28.5 B
8	200 NPSZnB + 250 urea	28.9	28.1 ABC	33.1	29.7 AB
9	250 NPSZnB + 250 urea	27.7	27.9 ABCD	34.4	29.8 AB
10	100 NPSZnB + 350 urea	30.3	30.8 A	35.1	31.8 A
11	150 NPSZnB + 350 urea	29.7	30.0 AB	34.2	30.9 AB
12	200 NPSZnB + 350 urea	27.5	30.1 AB	33.1	29.8 AB
13	250 NPSZnB + 350 urea	28.1	28.9 ABC	39.3	31.1 AB
14	Rec NP (69 P_2O_5 Vs 60 N)	29.8	28.6 ABC	27.8	28.8 AB
CV %		6.79	9.36	19.4	6.29
LSD		3.22	4.25	10.84	3.06
ANOVA		ns	**	ns	**

where means with the same letter do not have statistically significant difference. AVG three years computed average HDX values

Table 5: Partial budget and Marginal rate of return (MRR%) as affected by the application of different rates of blended fertilizer with urea at Ejere

No.	Treatments	T.V.C in USD $	GFB in USD $	NB in USD $	Dominance	MRR %	Marginal cost (C)	Marginal Net Benefit (B)	B:C ratio
1	Control	0.00	1258.44	1258.44					
2	100 NPSBZn + 150 urea	95.83	2327.73	2231.90		1015.9	95.83	973.46	10.16
14	Rec NP	105.15	2019.36	1914.21	Dominated				
3	150 NPSBZn + 150 urea	116.73	2468.97	2352.24		575.69	11.58	438.03	37.83
6	100 NPSBZn + 250 urea	131.84	2354.75	2222.91	Dominated				
4	200 NPSBZn + 150 urea	137.63	2333.76	2196.13	Dominated				
7	150 NPSBZn + 250 urea	152.74	2610.19	2457.45		292.13	15.11	261.31	17.29
5	250 NPSBZn + 150 urea	158.53	2392.20	2233.67	Dominated				
10	100 NPSBZn + 350 urea	167.85	2543.81	2375.96	Dominated				
8	200 NPSBZn + 250 urea	173.65	2316.89	2143.25	Dominated				
11	150 NPSBZn + 350 urea	188.76	2565.41	2376.65	Dominated				
9	250 NPSBZn + 250 urea	194.55	2508.68	2314.13	Dominated				
12	200 NPSBZn + 350 urea	209.66	2711.58	2501.92		78.14	15.11	187.79	12.43
13	250 NPSBZn + 350 urea	230.56	2661.87	2431.30	Dominated				

where T.V.C is total variable cost, GFB is gross field benefit, NB is net benefit, MRR marginal rate of return. All the cash data were presented in US dollar. With exchange rate of 36 Eth. Birr.



Graph 2: Net benefit curve of blended fertilizer and urea fertilizer rate study on bread wheat at Ejere district of central Ethiopian highland

preference will be treatment # 7 (150 NPSZnB + 250 urea kg ha^{-1}) followed by treatment # 12 (200 NPSZnB + 350 urea kg ha^{-1}) and as an alternative with the most economically productive treatment #3 (150 NPSZnB + 150 urea kg ha^{-1}) with 2352.3 $ net benefit with relatively 575.7% MRR can economically be best alternative for poor farmers otherwise using treatment # 7 (150 NPSZnB + 250 urea kg ha^{-1}) is more preferable than other treatments in all aspects. Similar study on durum wheat also revealed that application of 100 kg blended NPSB ha^{-1} with supplement of 92 kg N ha^{-1} fertilizer rates are the fertilizer combinations and rates producing economically profitable grain yield (GYD) of durum wheat in central highlands of Ethiopia [16].

CONCLUSION AND RECOMMENDATIONS

Using blended fertilizer sources depending on the soil fertility status map developed by EthioSIS, 2014 is vital to improve current productivity of wheat crop by addressing most deficient essential nutrients in addition to nitrogen and phosphorus which were widely exploited before. Combined application of Blended fertilizer and urea at 200 NPSZnB with 350 urea kg ha^{-1} (161 kg N ha^{-1}) rate is important to assure maximum crop productivity likewise 150 kg rate of blended fertilizer combined with 115 kg N ha^{-1} can gave competitive grain yield result with even superior above ground biomass yield.

On the economics point of view application of 150 kg blended fertilizer with 69 kg N ha^{-1} gave the most preferable result with highest MRR, Net economic benefit as well as competent biological productivities with other superior treatments as an alternative using 150 kg rate of blended fertilizer combined with 115 kg N ha^{-1} can gave competent economical advantage.

As a vital approach to improve the soil nutrient balance its important to continual improvements of those blended fertilizers in terms of their quality and composition by improving the level of primary major nutrients like N and P also by incorporating Calcium oxides to improve soil acidifying effects for such types of soils. Continuous monitoring and inspection on those trace elements which might easily exceed their critical concentration to prevent further toxicity or antagonizing effects from repeated application for prolonged time. As a future research direction, it is important to consider the integrated application of such fertilizers with improved organic sources like vermicompost for optimal and economical inorganic fertilizer utilization.

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