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Blended Fertilizers as Sources of Balanced Nutrients for Growth and Yield of Wheat at Hulla District in Southern Ethiopia

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Abstract
Although a number of blended fertilizers, which contain multi-nutrients, were formulated to be used in different areas of the country, they were not evaluated for their effectiveness in different soils and agro-ecologies. This study was conducted in Hulla district to evaluate two types of blended fertilizers for their effectiveness in boosting wheat yield in the area. The experiment consists of nine treatments including recommended NP (69 kg N + 40 kg P/ha), 200 kg BF1/ha, 200 kg BF2/ha, 200 kg BF1/ha + N adjusted to the recommended rate, 200 kg BF1/ha + P adjusted to the recommended rate, 200 kg BF1/ha + NP adjusted to the recommended rate, 200 kg BF2/ha + N adjusted to the recommended rate, 200 kg BF2/ha + P adjusted to the recommended rate and 200 kg BF2/ha + NP adjusted to the recommended rate. The experiment was laid out in RCB design replicated across five farmers. Wheat (variety Ogolcho), was drilled in rows spaced 20 cm apart. Data including plant height, spike length, total biomass and grain yields (kg ha^{-1}) were collected and analyzed using the SAS statistical package program version 9.0 and means were separated with LSD. Economic analysis was performed to investigate the economic feasibility of the new blended fertilizers for wheat production. Results of data analyses showed that application of BFs alone or with recommended amounts of N and P produced higher results in all parameters as compared to the recommended N and P alone indicating the need for balanced nutrients for wheat production at Hulla. Application of balanced nutrients from blended fertilizers (BF1) by adjusting N and P to the recommended amounts could significantly improve wheat production at Hulla compared to the recommended N and P alone. However, the use of these fertilizers was not economical and as a result 200 kg BF-2 is recommended for wheat production at Hulla.
Keywords: blended fertilizers, recommended NP, balanced nutrients, wheat production, nutrient content

Introduction

Ethiopia is one of the Sub-Saharan African countries where severe soil nutrient depletion restrains agricultural crop production and economic growth. The annual per-hectare net loss of nutrients is estimated to be at least 40 kg N, 6.6 kg P and 33.2 kg K (Scoones and Toulmin, 1999). Continuous cropping, high proportions of cereals in the cropping system, and the application of suboptimal levels of mineral fertilizers aggravate the decline in soil fertility (Tanner *et al.,* 1991; Hailu *et al.,* 1991; Workneh and Mwangi, 1992).

In addition, locally available organic matter inputs have also become more limiting due to increasing demand for fuel and fodder, as well as lower biomass production—driven by declining soil fertility and competing uses (Selamyihun et al., 2005 and Nigussie et al., 2007). Livestock through grazing and crop residue consumption remove over 3 million tons of nutrients (NCS, 1992, FAO 1984). In turn, livestock produces dung equivalent to 1.4 million tons of N, P2O5 and K2O (Hawando, 1995), though very small fraction goes back to the soil due to its other competitive uses. Nutrient loss due to biomass energy consumption of dung and crop residues which otherwise added to the soil is equivalent to the total amount commercial fertilizer use in the country (PIF, 2010). Harvesting total crop residue also removes cations and organic materials, which help neutralize soil acidity and critical to maintain soil productivity. Similarly, the aforementioned problems are very common in SNNPRS.

Farmers in the country, in general and in the region, in particular use inorganic and organic inputs to counteract the production and productivity problems. However, despite significant rise in total fertilizer import from 250,000 tons in 1995 to 500,000 tons in 2012 (CSA, 2012), the intensity of the fertilizer use has increased only marginally over the past decade from 31 kilograms per ha in 1995 to 36 kilograms per ha in 2008 which is still less than the blanket recommendation (Alem et al., 2008; Fufa and Hassen 2005); whereas fertilizer factor productivity declined by 63% during the same period. The main reasons encompass lack of basic data on crop nutrient requirements, climatic and soil conditions at trial sites.

Nutrient mining due to sub optimal fertilizer use in one hand and unbalanced fertilizer (only N and P) uses on other have favoured the emergence of multi nutrient deficiency in Ethiopian soils (Abyie et al., 2003, Beyene, 1984; Wassie et al., 2011); that in part may contributed to fertilizer factor productivity decline experienced over recent past. The national soil inventory data also revealed that in addition to nitrogen and phosphorus, sulphur, boron and zinc deficiencies are widespread in Ethiopian soils, while some soils are also deficient in potassium, copper, manganese and iron (Ethiosis, 2013), which all potentially hold back crop productivity despite continued use of N and P fertilizers as per the blanket recommendation. Future gains in food grain production will be more difficult and expensive considering the increasing problem of multi nutrient deficiencies.

New fertilizer materials with value addition/ fortification with secondary and micronutrients would be required to ensure balanced fertilizer use involving all or most of the nutrients required by crops. Experience in Malawi provides a striking example of how N fertilizer efficiency for maize can be raised by providing appropriate micronutrients on a location-specific basis. Supplementation by S, Zn, B, and K increased maize yields by 40% over the standard N-P recommendation alone (John *et al.,* 2000). The work of Wassie and Shiferaw (2011) in southern Ethiopia provides a striking example of how fertilizer use efficiency of potato can be raised when NP fertilizers are combined with K on a location-specific basis. In this study supplementation of K increased potato tuber yields by 197% over the standard N-P recommendation alone. Therefore, it is high time to investigate nutrient dynamics in major production systems and establish site /AEZ, crop and soil specific balanced fertilizer recommendation.

Blanket applications of 100 kg DAP and 100 kg Urea were used almost all over the country irrespective of the climate, soil type, crop species and variety, and Agro-ecological Zones (AEZ). The need for site-specific fertilizer prescriptions is increasingly apparent. However, fertilizer trials involving multi-nutrient blends that include micronutrients are rare. This is believed to be the causes for the highest gap between the potential and the actual yield. The results of recent study to map Ethiopian soil indicates that there are a wide spread of nutrient deficiencies. A number of formulae in which these nutrients are included are also formulated for different areas of the country. However, before making use of these formulae they should be evaluated for their effectiveness with different crops and soils. Therefore, this study was initiated to provide site and crop specific balanced fertilizer recommendations for better wheat production and in return to enhance house hold income.

Materials and Methods

On farm study was conducted at Hulla district of Southern Nations Nationalities and Peoples Regional State (SNNPRS) in 2014 and 2015 main cropping seasons. The experimental site was located between 06.28645N latitude and 038.34884E longitude at an altitude of about 2694 meter above sea level. Two blended fertilizer types namely BF1 (14N, 21P_2O_5 15K_2O 6.5 S 1.2 Zn and 0.5 B) and BF2 (23N, 23P_2O_5 0 K_2O 8S and 1.3 Zn) were used for they were recommended to the area. The experiment consists of nine treatments including recommended NP (69 kg N + 40 kg P/ha), 200 kg BF1/ha, 200 kg BF2/ha, 200 kg BF1/ha + N adjusted to the recommended rate, 200 kg BF1/ha + P adjusted to the recommended rate, 200 kg BF1/ha + NP adjusted to the recommended rate, 200 kg BF2/ha + N adjusted to the recommended rate, 200 kg BF2/ha + P adjusted to the recommended rate and 200 kg BF2/ha + NP adjusted to the recommended rate.

The experiment was laid out in RCB design using 4 m by 4 m plot size and replicated across five farmers. The blended fertilizers and DAP were applied at planting and Urea was top dressed 45 days after planting. The test crop, wheat (variety Ogolcho), was drilled in rows spaced 20 cm apart and all management practices were applied equally for all treatments as per the recommendation developed for the crop.

Different agronomic data including plant height, spike length, total biomass and grain yields (kg ha^{-1}) were collected. To estimate biological and grain yield, the whole plot size ($16m^2$) was harvested and threshed manually. Analysis of variance for all data were performed using the SAS statistical package program version 9.0 (SAS institute Inc., 2002). Least significant difference (LSD) at 5% probability level was used to establish the difference among the means.

Economic analysis with partial budget, dominance and marginal analyses was performed to investigate the economic feasibility of the new blended fertilizers for wheat production. The average yield was adjusted downwards by 10%, assuming that farmers could get 10% less yield. The average open market price (Birr kg^{-1}) for wheat and the official prices of N, P and the new blended fertilizers were used for analysis. For a treatment to be considered a worthwhile option to farmers, 100% rate of return (MARR) was considered.

Results and Discussion

Results of data analyses showed that application of BFs alone or with recommended amounts of N and P produced higher results in all parameters as compared to the recommended N and P alone indicating the need for balanced nutrients for wheat production at Hulla. All parameters except spike length (Table 1) were significantly higher due to the application of BF-1 adjusted to the recommended NP compared to the recommended NP alone with yield advantage of 36.43%. when BF1 and BF2 fertilizers were applied alone (without adjusting to the recommended N and/or P), BF1 was found to be better in plant height and spike length than BF2, whereas BF1 was better in biomass and grain yields. Although BFs alone gave higher results in all parameters compared to the N and P alone, differences were not significant. On the other hand, when BF1 was applied adjusted to the recommended N and P, significant differences in all parameters were recorded as compared to the recommended N and P alone. BF1 adjusted to the recommended N and P resulted in significantly higher results in all parameters compared to all treatments except BF1, BF1 adjusted to the recommended N and BF2 adjusted to the recommended N. But BF2 did not bring significance difference compared to the recommended N and P in all parameters whether applied alone or adjusted to the recommended N and P though higher results in all parameters were recorded from BF2. This could be attributed to the unbalanced nutrient contents of the BF2 particularly the missing of K and B in this fertilizer. This also discloses that K and B are critical for wheat production at Bensa and they should be applied. From this result we can understand that the contents of the nutrients in BF2 are not as sufficiently balanced as required for wheat production at Hulla. On the other hand, BF1 contains well balanced contents of nutrients the production of the crop at the above mentioned location; however, its N and P contents should be adjusted to the recommended amounts. In both blended fertilizers, adjusting the recommended N gave better result than adjusting the recommended P, which might be due to the lower P requirement by wheat as compared to N, or the N content in the blended fertilizers is by far below the recommended one as compared to the P content.

Table 1.Effects of blended fertilizers application on plant height and spike length of wheat at Hula

No.	Treatments	Plant height	Spike length	Biomass t/ha	Grain yield kg/ha	Grain yield Mean
1	Recommended NP	91.667c	9.13	4.700c	1539.9c	2998.6b
2	200kg BF1	100.067abc	9.73	7.600bc	2865.0abc	3750.2ab
3	200kg BF2	93.667c	9.33	9.667ab	3129.2abc	3808.3ab
4	BF1 + N adjusted	104.333ab	9.60	10.200ab	3790.3ab	4062.3a
5	BF1 + P adjusted	95.000bc	9.80	8.567abc	3244.1abc	3813.6ab
6	BF1 +NP adjusted	106.000a	9.53	11.633a	4207.3a	4091.1a
7	BF2 + N adjusted	99.333abc	8.80	7.500bc	2568.8abc	3289.5ab
8	BF2+ P adjusted	95.000bc	9.13	7.333bc	2433.3bc	3482.1ab
9	BF2 +NP adjusted	95.667bc	9.80	7.500bc	2476.0abc	3150.0b
	LSD	9.5249	NS	3.9831	1738	841.87
	CV	5.67	7.37	15.40	12.78	13.61350

Economic analysis

The result of the dominance analysis revealed that except 200 BF-1 + 41N + 25K, the remaining ones were dominated by the alternatives with lower total cost that varied (Table 3). Since no beneficiary will prefer alternatives that give lower net benefit than net benefit of the alternative with low total costs that vary, the dominated treatments were eliminated from further economic analysis.

Table 2. Economic (Partial budget, Marginal rate of return, and Dominance) analysis of blended and PK fertilizers on wheat at Hulla

Treatment	BF (kg/ha)	N kg/ha	P kg/ha	NP kg/ha	K kg/ha	Av.yield	Adj. yield	TCTV (ETB/ha)	Revenue (EB/ha)	NB (ETB/ha)	MRR (%)
T3	200	0	0	0	0	3808.3	3427.47	2731.3	30847.23	28115.9	
T2	200	0	0	0	25	3750.2	3375.18	2704.8	30376.62	27671.8	D
T7	200	23	0	0	0	3289.5	2960.55	3030.1	26644.95	23614.8	D
T1	0	69	40	0	0	2998.6	2698.74	3354.7	24288.66	209340	D
T4	200	41	0	0	25	4062.3	3656.07	3798.0	32904.63	29106.7	
T8	200	0	19.92		0	3482.1	3133.89	4205.4	28205.01	23999.6	D
T5	200	0	21.66	0	25	3813.6	3432.24	4334.8	30890.16	26555.4	D
T9	200	0	0	23+19.92	0	3150	2835	4803.4	25515	20711.6	D
T6	200	0	0	41+21.66	25	4091.1	3681.99	5400.9	33137.91	27737.1	D

Yield adjustment=10%, Field price of wheat = 9/kg, MARR=100%, BF: blended fertilizer, Av.yield: average yield, Adj.yield: adjusted yield, TCTV: total cost that vary, NB: net benefit, MRR: marginal rate of return, D: dominated treatments

According to the partial budget analysis (Table 3) the highest net benefit (29106.66 Birr/ha) was obtained from the application of 200 kg BF1+ 41 kg N + 25K ha^{-1} whereas BF2 alone gave the lowest net benefit (28115.91Birr/ha).

However, the marginal rate of return from the non-dominated treatment was 92.88% (Table 3). This implies that for one Birr investment in wheat production with application of 200 kg BF1+ 41 kg N + 25K ha^{-1} the producer can get extra net benefit of Birr 9.288 compared to the application of BF2 alone. Since the minimum acceptable rate of return considered in this experiment was 100%, the treatment with application of 200 kg BF1+ 41 kg N + 25K ha^{-1} cannot give an acceptable marginal rate of return.

Table 3.Economic (Partial budget, Marginal rate of return, and Dominance) analysis of blended and NPK fertilizers on wheat at Hulla

Fertilizers (kg/ha)	Av.yield	Adj. yield	TCTV (EB/ha)	Gross field benefit	NB (EB/ha)	MRR (%)
200kg BF2	3808.3	3427.47	2731.3	30847.23	28115.91	
200 BF1 + 41N + 25 K	4062.3	3656.07	3798.0	32904.63	29106.66	92.88

Yield adjustment=10%, Field price of wheat = 9/kg, MARR=100%, Av.yield: average yield, Adj.yield: adjusted yield, TCTV: total cost that vary, NB: net benefit, MRR: marginal rate of return

Conclusion and Recommendation

This study indicated that application of balanced nutrients from blended fertilizers (BF1) by adjusting N and P to the recommended amounts could significantly improve wheat production at Hulla compared to the recommended N and P alone. Applying BF2 either alone or by adjusting the N and P to the recommended amounts could not improve the yield and yield parameters of wheat as compared to the recommended N and P alone. This clearly indicates that the nutrient contents in the BF2 are not sufficiently balanced to boost yields over the control (recommended N and P alone). Although the highest yield and net benefit (29106.66 EB/ha) were obtained from application of BF1 by adjusting the N and P to the recommended amounts (200 kg BF-1 + 41 N + 25 K kg/ha), the marginal rate of return (92.88%) of this treatment (fertilizer) is lower than the minimum acceptable rate of return (100%) indicating it is not economical to use this treatment. Therefore, as an alternative option, 200 kg BF-2 is recommended for wheat production at Hulla.

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