Evaluation of Togo blended fertilizer on Teff and bread wheat yields in the Amhara Highlands

[1]Adet Agricultural Research Center, P.O.Box. 08, Bahir Dar, Ethiopia.

[2]Amhara Regional Agricultural Research Institute, P.O.Box 527. Bahir Dar, Ethiopia.

[3]Water and Land Resource Center, Addis Ababa, Ethiopia

[4] Debere Birhan Agricultural Research Center, P.O.Box. , 112, Debre Birhan, Ethiopia

[5] Sirinka Agricultural Research Center, P.O.Box. 74, Weldia, Ethiopia

*First authors

Abstract

blended fertilizer on teff and bread wheat yields in the Amhara highlands, Ethiopia. The experiment was conducted on Vertisols and Nitisols and arranged in a randomized complete block design in three replications. Analysis of variance was implemented using SAS statistical software and LSD was used for the mean separation. The result revealed that there was significant difference among treatments on grain and biomass yields for both crops at all locations. The maximum teff grain yield was obtained from the blanket recommended nitrogen and phosphorus at Gonjikollela, Moretnajiru and Jamma and from Togo blended fertilizer at Enemay. The maximum grain and straw yields of bread wheat were also obtained from the plots that received from the blanket recommended nitrogen and phosphorus at all locations. From the multi location results it is visible/can be concluded/ that using this blend has no yield advantage over the blanket recommended nitrogen and phosphorus fertilizers. Thus, further studies shall be done for other blends based on soil test crop response.

Key words: Togo, blend, grain yield, nitrogen, phosphorus.

Introduction

Inorganic fertilizer is one of the best agricultural technologies that have immense potential for raising the productivity of poor smallholders, enabling them to increase income, accumulate assets, and set themselves economically on a pathway out of poverty. In Ethiopia enhancing the productivity of the agricultural sector by wisely exploiting its existing human and natural resources is critical option to avert the existing situation. 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 (Hailu et al., 1991; Amsal et al., 2000). The identification of the proper fertilizer mix is beneficial at the macroeconomic level by improving the efficiency of fertilizer procurement and resource allocation. It is generally understood that crop response to fertilizer inevitably declines, if nutrient applications are continually unbalanced. But if harvested nutrients are replaced, intensive agricultural systems can be sustained indefinitely, provided that measures are taken to halt soil erosion and to minimize detrimental changes in soil pH.

To address the problem of macro and micro nutrients imbalance, an experiment was conducted on blended fertilizers in the year 2010/2011cropping season in Amhara region, Ethiopia. Blended fertilizers have been available for much of this century but the early forms of fertilizers have left much to be desired. The practice of blending started in the early 1950s, and grew slowly at first, but then grew rapidly throughout the 1960s and into the 1970s. In 1980 blended fertilizer accounted for 40% of the finished fertilizer in the developed nations and now-a-days blended fertilizers accounted for 55% of the total dry compound fertilizers (unpublished working paper). Blending system incorporated the different raw materials into a multi-nutrient granule and mad one physically mixed product. The equipment to produce these mixed granules, however, was cumbersome and expensive and mixed granulated fertilizers were soon supplanted by bulk blends (unpublished working paper). Blended fertilizers are made by physically mixing fertilizer materials to give a desired grade. The individual particles remain separate in the mixture, and segregation may occur. This problem can be reduced by using materials with the same particle size. Blends are equal in agronomic efficiency as far as the blending of fertilizers is done

properly that can reduce segregation problem. Blends have the added advantage of allowing a very wide range of fertilizer grades, thus making it possible to match a fertilizer exactly to a soil test recommendation. Micronutrients can enhance plant growth and stress tolerance – if they are absorbed into the plant and transported where they can do their job. One of the blended fertilizers called Togo 26-11-11 N-$P_2O_5K_2O$ (Togo blend) was evaluated for a year in different districts of the Amhara region, Ethiopia. Therefore the objective of the experiment was to evaluate the effects of Togo 26-11-11 N-$P_2O_5K_2O$ (Togo blended) fertilizer on yields of bread wheat and teff.

Materials and Methods

Table 1. Description of the Study Area

parameters	Districts						
	YilmanaDensa	Gonjikollela	Enemay	Debre Elias	Moretinajiru	Jamma	Wereyilu

teff variety was used) and for the bread wheat TAY variety was used at Yilmana Densa, GonjiKollella and Debre Elias, Menzie variety at Moretnajiru and Dinkinesh variety at Wereyilu. Teff was broadcasted while bread wheat was drilled on 20 cm row spacing.

Data analysis

Analysis of variance was carried out for yield and yield components using SAS statistical package (SAS Institute, 2002) following statistical procedure appropriate for the experimental design. Whenever, treatment effects were found statistically significant, the means separation was done using Least Significant Difference (LSD) at 5% significant probability level.

Results and discussions

Effect of Togo blended fertilizer on Teff (*Eragerostis tef* (Zucor…) yield

The statistical analysis revealed that there was significant difference among the treatments on teff grain yield at all locations (Table 2). However, there was no statistically significant difference between the blanket recommended N and P (64/46 N/P_2O_5), Togo blend @ 200 kg ha^{-1}+ N adjusted to the blanket recommended N (64 kg N ha^{-1}) using urea and Togo blend @200 kg ha^{-1}+ N/P adjusted to blanket recommended N and P (64/46 kg N/P_2O_5 ha^{-1}) using urea and DAP respectively at Enemay, Moretnajiru and Jamma districts. However, at Gonjikollela Togo blend was inferior to the blanket recommended N and P when it was used alone and with N and NP adjusted to the blanket recommendations (Table 2).

Even though, there was no significant difference between the blanket recommended N and P and Togo blend @200kg ha^{-1} N and NP adjusted to blanket recommendation at Enemay, high yield was recorded using Togo blend @200 kg ha^{-1} + N and P adjusted to the blanket recommendation using using and DAP respectively. On the contrary high yield was obtained from the blanket recommended N and P in Gonji Koellela, Moretinajiru and Jamma. The lowest yield at all locations and soil types was obtained from the control plots (without fertilizer) (Table2). Togo blend @200 kg ha^{-1} alone gave lower yield compared to 64 kg ha N and 46 kg $ha^{-1}P_2O_5$ at all locations (Table 2).

Table 2. Effect of Togo blended fertilizer on teff grain yield (kg ha^{-1}) in different locations in 2010/2011

treatments	Grain yield kg ha^{-1}			
	Enemay	Gonjikollela	Moretnajiru	Jamma
Control (without any fertilizer)	496.7^{c}	176.7^{c}	784.1^{c}	507b
NP recommended (100/100 urea/DAP)	1215.0^{ab}	1770.0^{a}	1338.1^{a}	815a
Togo blend @ 200Kg/ha	950.0^{b}	1061.7^{b}	1151.0^{b}	758a
Togo blend @ 200Kg/ha + N adj	1351.7^{a}	1171.7^{b}	1249.3^{ab}	730a
Togo blend @200Kg/ha + NP adj	1446.7^{a}	1351.7^{b}	1247.6^{ab}	776a
CV (%)	14.95	14.50	14.4	12.4
LSD (0.05)	307.46	302.18	137.9	

Similarly, there was statistically significant difference ($P<0.05$) among the treatments in teff straw yield. At Gonji kollela and Moretnajiru the highest straw yield was obtained from blanket recommended N and P (64/46 N/P_2O_5) (Table 3). While, the highest straw yield was obtained from Togo blend @ 200 Kg ha^{-1} + N and P adjusted at Enemay and Jamma (Table 3). The lowest straw yield was obtained from the control (without fertilizer) at all locations (Table 3). However, there was no significant difference in straw yield among the blanket recommended N and P, Togo blend @ 200 Kg ha^{-1} + N adjusted to the blanket recommendation using urea and Togo blend @ 200 kg ha^{-1} adjusted with N and P in Moretnajiru and Jamma (Table 3).

Table 3. Effect of Togo blended fertilizer on teff straw yield (kg ha^{-1}) combined over locations.

Treatment	Straw kg ha^{-1}			
	Enemay	Gonjikollela	Moretnajiru	Jamma
Control (without fertilizer)	1166.7^{d}	350.0^{c}	2122.2^{c}	1902b
NP recommended (100/100 urea/DAP)	1833.3^{c}	5333.3^{a}	4167.2^{a}	2777a
Togo blend @ 200Kg/ha	2050.0^{c}	4000.0^{ab}	3421.7^{b}	2824a
Togo blend @ 200Kg/ha + adj N	3500.0^{b}	3666.7^{b}	3885.1a	2495ab
Togo blend @200Kg/ha +adj NP	5000.0^{a}	4666.7^{ab}	3925.1^{a}	2807a
CV (%)	12.77	22.39	13.1	12.4
LSD (0.05)	651.71	1519.6	378.8	

Effect of Togo blended Fertilizer on Wheat (*Triticum aestivum*) yield

The statistical analysis showed that there was significant difference in bread wheat grain yield among the treatments. Higher grain yield was obtained from the blanket recommended N and P (64/46 kg N/P_2O_5 ha^{-1}) at all locations (Table 4). However, there was no statistically significant

difference between the blanket recommendation (64/46 N/P_2O_5), Togo blend @ 200 Kg ha^{-1} + N adjusted using Urea and Togo blend @200Kg ha^{-1} +NP adjusted using urea and DAP at Morenajiru and Wereyilu (Table 4). On the contrary there was significant difference between the blanket recommended N and P and Togo blend@ 200 kg ha^{-1}, Togo blend @ 200 kg ha^{-1} + N adjusted to blanket recommendation using urea and Togo blend @ 200 kg ha^{-1} + NP adjusted to blanket recommendation using urea and DAP at Gonjikollela. At Debre Elias there was no significant difference between the recommended N and P fertilizer and Togo blend @200 kg ha^{-1} + NP adjusted. The highest grain yield was obtained from blanket recommended N and P in the aforementioned districts (Table 4).

Table 4. Effect of Togo blended fertilizer on wheat grain yield combined over locations in each district.

treatments	Grain yield (kg ha^{-1})			
	Gonjikollela	DebreElias	Moretnajiru	Wereyilu
Control (without any fertilizer)	929.7^{c}	1202.0^{bc}	838.8^{c}	4363b
NP recommended (100/100 urea/DAP)	2335.5^{a}	1726.3^{a}	2125.2^{a}	6004a
Togo 26-11-11 @ 200Kg/ha	1600.3^{b}	1128.9^{c}	1793.1^{b}	5030.5ab
Togo 26-11-11 @ 200Kg/ha + adjusted for N	1491.1^{b}	1224.6^{bc}	2112.4^{a}	5919.2a
Togo 26-11-17 @200Kg/ha +adjusted for NP	1683.5^{b}	1485.4^{ab}	2023.9^{a}	5586.4a
CV (%)	11.29		9.0	16.8
LSD (0.05)	273.94	287.85	132.7	

There was statistically significant difference among the treatments on straw yield. The highest straw was obtained from the blanket recommended NP (64/46 kg ha^{-1}) followed by Togo blend @200 Kg ha^{-1} + N and NP adjusted to the blanket recommendation using urea and DAP at Moretnajiru and Wereyilu while the lower straw yield was recorded from the control (without fertilizer) at all locations (Table 5). However, the result on mean straw yield indicated that there was no significant difference among the blanket recommendation, Togo blend @ 200 kg ha^{-1} with adjusted N and NP. However, these treatments were significantly different compared to Togo blend@ 200 kg ha^{-1} and the control (Table 5).

Table 5. Effect of Togo blended fertilizers on yield of wheat over locations.

Treatments	Straw yield (kg ha^{-1})			
	Gonjikollela	DebrElias	Enemay	Wereyilu
Control (without any fertilizer)	699.7^{d}	1631.3^{ab}	1966.0^{c}	4363b
Blanket recommended NP (100/100 urea/DAP)	2497.8^{a}	2148.7^{a}	5052.1^{a}	6004a
Togo blend @ 200Kg/ha	720.3^{cd}	1371.2^{b}	4228.4^{b}	5030.5ab
Togo blend @ 200Kg/ha + adjusted for N	1242.3^{c}	1567.0^{ab}	4975.9^{a}	5919.2a
Togo blend @200Kg/ha +adjusted for NP	1816.5^{b}	1931.2^{ab}	4873.5^{a}	5586.4a
CV (%)	20.08	20.75	8	16.8
LSD (0.05)	527.66	675.98	160.8	

Generally, Togo blend was not superior with or without N and P adjusted with urea and DAP to the blanket recommendation in all locations and soil types considered. Even though blended fertilizers have more nutrient composition and expected to give better yield than the straight fertilizers, the result was to the contrary. The lower yield from Togo blend @200 kg ha^{-1} with and without N and NP adjustment might be attributed to segregation in the blended fertilizer as reported by Miserquea and Pirard (2004). The yield obtained from the experiment for both crops (teff and wheat) as a whole at all locations and from all fertilizer types was lower and the crops didn't give higher yield to their potential (Table 2, 3, 4 and 5).

The reason for the lower yield from Togo blend @ 200 kg ha^{-1} with or without adjusted N or NP might be due to antagonistic effect of the nutrients in the blend as reported by Rietra *et al*., (2015) observing antagonistic effect between potassium and zinc nutrients when they were blended together or applied to the field at the same time. Similarly, Beegle (1985) and Leonard (1996) also reported that using urea and diammonium phosphate during planting as starter fertilizer with blend fertilizer can hinder seed germination and seedling growth. Hence, since in this experiment, Togo blend, urea and DAP were applied during planting this might cause antagonistic effect against each other that might resulted in lower yield (grain and straw) in Togo fertilizer with or without adjustment. Therefore, the negative effects like segregation and antagonism should be further studied in details through applying the blend, urea and DAP at the same and/or different time. The straw and grain yields were not proportional at all locations and this might be due to the fact that the experiment was implemented late and may lack proper

rainfall amount for full seed set and maturity. In addition, the amount of applied blanket recommended N and P fertilizer was so obsolete and didn't consider the area specific crop response fertilizer recommendation and hence might result in the lower yield. Therefore, before conducting on farm experiments, the blended fertilizers should be evaluated at laboratory and green house condition for appropriate formulation. Segregation of non-uniform particles can occur in a number of different aspects of manufacturing, distribution, transport and final spreading. Fertilizer flowing characteristics may vary and led to segregation within heaps in store depending on if tipped or use of elevators. Vibration may also lead to segregation in transport from ship to the site, or from site to the farm.

Conclusion and recommendations

Togo blended fertilizer with a composition of 26-11-11 N-P_2O_5 -K_2O + 3.5S + 0.15 B_2O_3 0.6 Zn did not outsmart urea and DAP fertilizers in all experimental sites and soil types. Even though the blanket recommended N and P (64/46 N and P_2O_5) was not the site specific recommendation, Togo blended fertilizer didn't give higher yield compared to this blanket recommendation which is widely recognized outdated in the potential wheat and teff growing areas of the Region. There might be different suggestions that need detailed research justifications and evidences like the status of potassium in those soils, the uniformity of size and shape of the blend and the antagonistic effect of different fertilizer compositions in the blend. Therefore, before conducting such country wide experiments detailed research should be conducted in laboratory and green house experiments to see whether there is segregation and or antagonistic effect on this blended fertilizers even though this procedure is time taking.

Generally, the experiment showed that Togo blended fertilizer with the composition of -11-11 N-P_2O_5 -K2O + 3.5S + 0.15 B_2O_3 0.6 Zn at 200 kg ha^{-1} with or without N and NP adjustment was unable to outsmart the blanket recommended N and P (64/46 kg N/P_2O_5) so as to replace the existing NP fertilizers. Though there was no significant yield difference between the blanket recommended N and P fertilizer Togo blend @200 kg ha^{-1} can't be used as an alternate fertilizer due to its bulkiness i.e. double in weight compared to the N and P and incurred transporaion cost. In addition, with no yield advantage it might have additional cost to N and P due to the blends

since the blend was adjusted by N and NP. Hence, it is advisable to study the biological requirement of the crops and the economics of using the additions.

References

Amsal Tarekegne, Tanner, D.G, Taye Tesema and Chanyalew Mandefro. 2000. Agronomic and economic evaluation of the on-farm N and P response of bread wheat grown on two contrasting soil types in central Ethiopia. pp. 239 - 252. The 11th Regional Wheat Workshop for Eastern, Central and Southern Africa. CIMMYT, Addis Ababa, Ethiopia

Beegle D. 1985. Comparing Fertilizer Materials. Penn state extension, Agronomy Facts 6

Hailu Beyene, Mwangi, W. and Workneh Negatu. 1991. Wheat production constraints in Ethiopia. pp. 17-32. In: Hailu Gebre Mariam, D. G.Tanner and Mengistu Hulluka (eds.). Wheat Research in Ethiopia: A historical perspective. IAR/CIMMYT, Addis Ababa, Ethiopia.

Leonard J. E. 1996. Technology of Fertilizer Blending- Proc. Fert Soc., No.388 Dec 1996.

Rieetra, R.P., Hienen, M. Dimkpa, C. and BIndraban P.S. 2015. Effect of nutrient antagonism and synergisim on fertilizer use efficiency. VFRC report 2015/5, virtual fertilizer research center, Washington DC 42 pp.

Scoones I. and C. Toulmin. 1999. Policies for Soil Fertility Management in Africa: A Report Prepared for the Department for International Development. International Institute for Environment and Development, Russell Press, Nottingham, England, 128 pp.

Young T. M. 1987. Blending in Ireland; Proc. Fert Soc., No. 255 Apr 1987.

Miserquea, O. and E. Pirardb. 2004. Segregation of the bulk blends fertilizers. Chemo metrics and Intelligent Laboratory Systems 74 (2004) 215 – 224.