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Response of Tef (Eragrostis tef (Zucc.) Trotter) to Blended Fertilizers in Tembaro, Southern Ethiopia

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Abstract
These days there is an increasing concern that other soil nutrients in addition to nitrogen and phosphorus are becoming limiting to crop production and productivity in Ethiopia. This argument is being substantiated by increasing research evidences indicating presence of responses of some crops to potassium (K), sulphur (S) and some micronutrients such as boron (B) and zinc (Zn). The present study was conducted to investigate the effect of different blended fertilizers containing some macro and micronutrients on the yield and yield components of tef in three locations on farmers' fields at Mudula, Kembata Zone. Treatments were control, recommended NP fertilizers, NPS, NPSB, NPKSB, NPSZnB-1, NPSZnB-2 and NPKSZnB. The experiment was laid out in RCB design with three replications. Tef variety, Kuncho was planted in 3 x 4 m plot size with row spacing of 0.5cm apart. All the necessary agronomic practices were applied. Data on the yield and yield components of tef were collected and subjected to ANOVA using SAS software. The results revealed that blended fertilizers containing three or more nutrients produced significantly higher yield and yield components of tef compared to that produced in the control and NP fertilizer treatments suggesting that soil S, K, B and Zn levels are low for optimum production of tef in the area. The highest yield was produced by NPSZnB-1, NPSB, NPSZnB-2 and NPKSB in that order. These treatments increased the grain yield by 91, 80, 77 and 67 % over that produced by the recommended NP fertilizers respectively. This suggests that blended fertilizers containing S, B and Zn in addition to NP is more beneficial for improving yield of tef compared to the remaining other blended fertilizers tested in this experiment. But, boron seems most deficient in the soils of the study area. Location by fertilizer interactions were significant for most parameters considered. The blended fertilizers were also found to be economically feasible to be used for tef production area. Further verification and demonstrations of blended fertilizers involving more famers in the area is recommended.
Keywords: Soil fertility decline, Potassium, Sulphur, Micronutrients

INTRODUCTION

Declining soil fertility is one of the major challenges to crop production and productivity in Ethiopia (Amsal and Tanner, 2001). Soil erosion, deforestation, continuous cultivation of the same land, inadequate applications of organic and inorganic fertilizers and decreasing or abandoning of useful traditional soil restoration practices are some of the causes of declining soil fertility. However, the unprecedented rise in population is the root cause of the soil fertility decline problem.

Aimed at investigating soil fertility status of Ethiopian soils, extensive studies have been started more than in 60s by various organizations. The results of these studies revealed that only N and P nutrients were the only limiting nutrients in most Ethiopian soils. The results of subsequently, crop response experiments to fertilizers conducted both on on-station and on-farmers' fields at about the same time revealed that applications of these inputs have appreciable improved the yields of crops and thus the use of N and P fertilizers by farmers have been recommended (NFSAP, 2007). Consequently, importation of urea and DAP fertilizers were began to be imported and used by farmers as inputs for improving crop productivity in the late 60s or early 70s. There were several occasions where by the yields of crops have been increased by over 100 % (Kelsa*et al*.,992). The adoption of fertilizer technology has been very high due to dramatic improvements in the yields of several crops by using this technology. As a result there was a steady increase in the fertilizer importation and consumption in Ethiopia (Mesfin, 2009).

However, with time yield gains from using N and P fertilizers began to decrease. According to IFPRI (2010) yield gains due to these fertilizers in the 80s were only 10% and they attribute this to decline in soil organic matter content. Depletion soil nutrients other than N and P could be addition reason for the observed decreases in yield gains. Emerging research findings are proving that K is indeed becoming a limiting nutrient in some Ethiopian soils (Wassie and Tekalign; Abiye*et al*., 2013). For example, Wassie and shifreaw (2011) reported tuber yield increase of potato from 18 t ha^{-1} in the standard control (NP fertilizers) to 53 t ha^{-1} due to application of K at 150 kg ha^{-1} in Chencha, Southern Ethiopia. Significant increases in grain and straw yield of wheat and increased N uptake has been obtained in vertisols of central Ethiopia due to application potassium in the form of potassium sulphate (Abiye*et al*., 2004). Abegaze (2008) reported significant increase in the yield of barley due to K fertilization of luvisol in Atsibi-Wonberama district in Tigray. Similarly, nutrients such as suphur, zinc and boron are also found to be limiting nutrient in many soils of Ethiopia. For instance, Asgelil*etal*. (1996) have studied the DPTA extractable contents of micronutrients (Fe, Mn, Zn and Cu) 1083 soils samples

collected from four soil types and 24 zones of Ethiopia and found that Zn and Cu, were in deficient range in 65 and 88.9 % of the samples respectively. They further reported that Zn and Cu deficiency was observed in 40 and 85 % of maize crop samples respectively. Moreover, Ethiopian soil information (ETHIOSIS) project is currently engaged in assessing the soil fertility status of Ethiopian soils and developing soil fertility map of Ethiopia soils. ETHIOPIS has reported wide spread occurrence of several nutrient deficiencies in addition to N and P. Based on such results, recently, production and uses of blended fertilizers containing three or more nutrients have already been started in Ethiopia.

However, there is a need to test and validate the ranges of blended fertilizers products in different locations for a particular crop. This is because naturally all different types of blended fertilizer products cannot be equally effective in different soils and for different crops. Thus experiment was conducted to evaluate the effects of five different blended fertilizers containing nutrients 3-6 nutrients were on the yield and yield components of tef as well as to determine the economic feasibility of using blended fertilizers to enhance production and productivity of tef in Tembaro district, Kebata Zone, Southern Ethiopia

Materials and Methods

Brief description of experimental site

The experiment was conducted at Tembaro district, Kembata Tembaro zone, Southern Ethiopia. It is located at 410 km away from Addis Ababa. It has an altitude of 1720masl and receives a mean annual rain fall 1250 mm. The area is characterized by crop-livestock farming system. Cereals are major crops cultivated in the woreda include maize, tef, wheat and barley in the decreasing order of area coverage.

Treatments, experimental design and procedures

A factorial experiment consisting of eight fertilizer types (Control, NP, NPS, NPSB, NPKSB, NPSZnB-1, NPSZnB-2 and NPKSZnB) and three locations (S/Ambukuna, Bachira, and Gaecha) were laid out in RCB design with three replications. The blended fertilizer treatments, their compositions, grades and rates applied per hectare are presented in Table 1.

Table 1: Blended fertilizer types, grades and rates applied in the experiment.

No.	Code	Treatment	Fertilizer grades	Fertilizer rate (kg ha^{-1})	Remark
1	C	Control	0:0:0	0	Local control
2	RNP*	NP	64:20	100 Urea + 100 DAP	Standard control
3	Blend-1	NPS	64:20:8.4	121 NPS + 90 Urea	
4	Blend-2	NPSB	64:20:8.54:0.9	127 NPSB + 90 Urea	
5	Blend-3	NPKSB	64:20:24.17:8.56:0.9	168. NPKSB + 90 Urea	
6	Blend-4	NPSZnB-1	64:20:9.93:3.03:0.91	136 NPSZnB + 90 Urea	
7	Blend-5	NPSZnB-2	64:20:10.01:2.93:0.32	132 NPSZnB+ 90 kg Urea	
8	Blend-6	NPKSZnB	64:20:26.08:9.86:3.03:0.44	176 NPKSZnB + 90 Urea	

*Source: Feyra Asefa *et al*., 2014

An improved tef variety 'Kuncho' (DZ-01-387) will be used as a test crop.The experimental field will be prepared by using local plough (Maresha) according to farmers' Conventional farming practices. The plot size was 3 x 4 m with 0.5 m spacing between plots and 1 m spacing between blocks.

The whole doses of blended fertilizers were broadcast applied just prior to planting tef. The Urea N was applied after 45 after planting of the experiment. N fertilizer in the form of urea was applied in those treatments with low proportion of N (Table 2) in order to meet the recommended dose of N fertilizer.

Agronomic managements of the experiment such as weeding, cultivation, pest control etc. were done as per the recommendation for tef production in Ethiopia. Data on plant height (PLHT), panicle length (PL), number of tillers per meter square (NT), thousand seed weight (TSW), harvest index (HI), grain and straw yields were collected in the course of the experiment.

Statistical analyses

Data on yield components, grain and straw yields were subjected to ANOVA using SAS software version 2000 (SAS, 2000). Parameters whose ANOVA tested significant with respect to treatments, further means separation was done using least significant difference method (LSD) at 0.05 probability level using the same software.

Economic analysis of treatment effects

Partial budget analysis of selected treatments was done according to CIMMYT (1998). The mean grain yield data of tef produced in response to different fertilizer treatments were used in the partial budget analysis. The mean grain yield data of tef in Table 2 were adjusted down by 10 % to minimize plot management variation by farmers.

The current average prices of relevant data which were needed to do the partial budget analysis were collected from different sources. Thus, the current field price of 1kg of tef was taken to be 17.5 Ethiopian Birr (ETBkg^{-1}). The prices of Urea and TSP were 16 and 20.0 ETB kg^{-1} respectively. The prices of all types of blended fertilizers are 1.6 ETB kg^{-1} based on the cost at the time of purchase.

Gross benefit (GBT) was calculated as average adjusted grain yield (kgha^{-1}) X field price the crop (17.5 ETB kg^{-1}). Total variable cost (TVC) was calculated as the sum of all costswhich was variable or specific to specific treatment against the control. Net benefit (NBT) was calculated by subtracting total variable cost from the gross benefit. Marginal rate of return (MRR) was calculated as the ratio of differences between net benefits of successive treatments to the difference between total variable costs of successive treatments.

Results and Discussion

Main effects on yield components of tef

The main effects of blended fertilizers and locations on the yield components of tef in Tembaro district are shown in Table 2. Apparently, treatments have significantly affected PLH, PL, TN and TSW. The PLHT of produced by Blend-4 fertilizer, followed by Blend-3 treatment and the least height was produced by the local control. Blended fertilizer treatments containing three or more nutrients produced significantly greater height than that produced by treatments that received standard (NP) or recommended fertilizers. Similarly, blended fertilizers produced significantly high PL, TN and TSW in tef than that produced by local control and standard control treatments. This implies that nutrients in addition to the usual N and P are deficient for tef production in the study area. Among blended fertilizers, those fertilizers containing four and five nutrients higher yield components in tef than those with three and six nutrients.

However, the highest PL, TN and TSW were produced by Blend-4 fertilizer. This treatment increased the values of these parameters by 22.8, 215 and 222 % over that produced by standard control treatment respectively. This fertilizer contains N, P, S, Zn and B. This suggests that in addition to N, P, S and, the soil of the study is starved of Zn.

Table2: Effects of different blended fertilizers on the yield components of tef grown on nitisols of Tembaro district.

Treatment	*PLHT (cm)	PL (cm)	TN	TSW (g)
Fertilizers				
C	112.6e	43.5f	4.7e	0.24g
NP	129.4d	49.1e	19.1d	0.27f
Blend-1	148.2c	52.6d	22.1c	0.31d
Blend-2	154.0b	56.7bc	22.3ab	0.35b
Blend-3	155.4ab	57.5b	24.6c	0.33c
Blend-4	156.8a	60.3a	26.1a	0.35a
Blend-5	155.7ab	55.4bc	25.3ab	0.33c
Blend-6	153.6b	55.4c	23.2c	0.29e
$LSD_{0.05}$	2.2	1.75	1.21	0.004
Location				
S/Ambukuna	143.5c	51.5c	20.2c	0.31a
Bachira	145.8b	55.7a	22.7a	0.32a
Gaecha	147.8a	55.6a	21.0b	0.31c
$LSD_{0.05}$	1.36	1.07	0.74	0.003
Fertilizers X L	**	ns	**	**
CV(%)	1.6	3.4	6	1.4

**PLHT= Plant height, PL = Panicle length, TN= Tiller number, HI = Harvest index, TSWT = Thousand seed weight*

Similarly, locations have significantly affected PLHT, PL, TN and TSW of tef in the study area. The highest values of these parameters were produced in L2 followed by L3 and the least by L3 in that order. It is natural or expected that locations have profound effect on the yield and yield components of crops. Thus, the observed significant variations among location on the yield components of tef could probably be due to difference in soil condition, variations in weather variables and management practices employed during executing the trial. Accordingly, L2 had more conducive for treatments express their ability in improving the productivity of tef than the rest of the soil.Treatments by locations interactions were also significant for PLH, TN and TSW (Table 2).

Main effects of Blended Fertilizers on grain and straw yields of tef

Blended fertilizers have significantly increased both the grain and straw yield of tef in the study area (Table 3). The highest grain yield was produced by Blend-4 fertilizer followed by Blend-2 and the least grain yield was produced by standard and local control treatments. Blended-1, 2, 3, 4 and 5 increased the grain yield by 53, 80, 67, 91 and 52 % over the standard control (NP) treatment respectively. This implies that definitely nutrients in addition to N and P such as S, Zn, B and K are deficient in the soils of the study area for optimum production of tef. Similar to what was observed with yield components, significantly the highest, grain and straw yield was produced by Blend-4 treatments containing both micronutrients, B and Zn in addition to NPS. However, with

Blend-5 contained K in addition to those nutrients in Blend-4, the yield obtained with it was much lower than in rest of the blends except compared to Blend-1. This shows some kind of negative interactions among or between elements contained in Blend-5.

Harvest index (HI) of teff was also significantly and positively affected by blended fertilizers (Table 3).The highest HI was obtained with Blend-4 treatment and the least HI was recorded in standard and local treatments. Interestingly, all fertilizer treatments containing one or more of micronutrient in addition to major nutrients produced significantly HI than those treatment that received macronutrients. This indicates that B and Zn favored the greater proportion of partitioning of photosynthate to grain than to the straw of tef.

Table3:Main effects of blended fertilizers on the yield and harvest index (HI) of tef at Tembaro.

Treatment	Grain yield	Straw Yield	HI
	tha^{-1}		
Fertilizers			
Control	0.81g	1.9f	0.29f
RNP	1.6f	3.6e	0.31e
Blend-1	2.5e	4.8bc	0.34d
Blend-2	2.9b	4.9b	0.37b
Blend-3	2.7d	4.8dc	0.36c
Blend-4	3.1a	5.2a	0.39a
Blend-5	2.8c	4.8bc	0.37b
Blend-6	2.5e	4.6d	0.37b
$LSD_{0.05}$	0.27	0.66	0.004
Location			
S/Ambukuna	2.1c	35.7c	0.33c
Bachira	2.7a	50.0a	0.36a
Gaecha	2.3b	45.5b	0.35b
LSD	0.16	0.4	0.006
Fertilizer X Location	**	**	**
CV	7.8	8.0	1.7

Both grain and straw yields of tef were also significantly affected by location (Table 3). The highest yield was produced in Bachira followed by in Gaecha and the lowest in S/Ambukuna.

The mean grain yield of tef in Gaecha was higher by 28 and 11 % over that produced in S/Ambukuna and Bachira respectively.

Interaction effects of blended fertilizers and location on the tef

There was a significant interaction between blended fertilizers and locations on grain yield of teff in the study area (Fig. 1). In location two(L2) for example, the highest grain yield of tef was achieved with Blend-3 and Blend-4 fertilizers whereas the highest yield of tef in L1 and L3 was obtained with Blend-2produced significantly the higher grain yield of tef in that order than that produced with the same fertilizers in L1 and L3. On the other hand, in L3, the highest grain yield of tef was produced by Blend-2 and Blend-4 respectively.

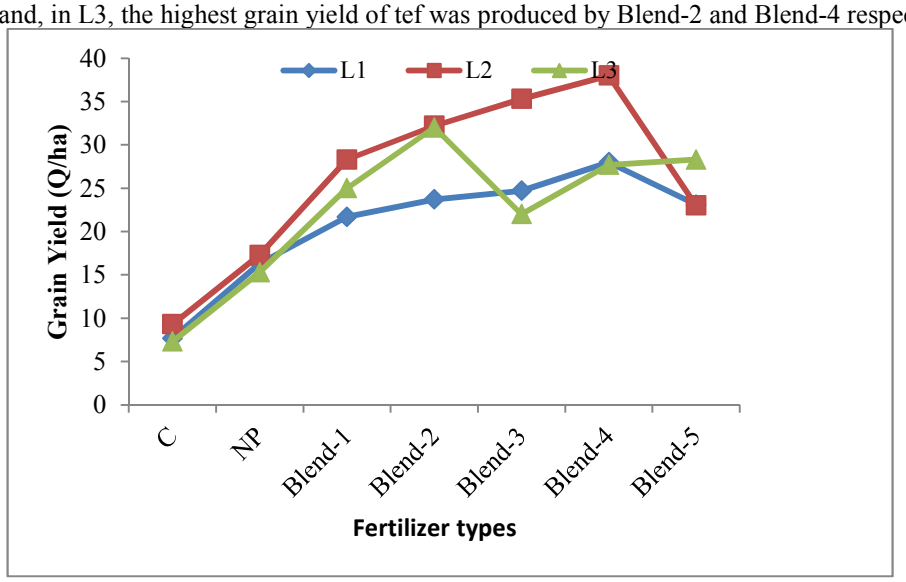

Figure1: Interaction effects of fertilizers and location on the grain yield of tef at Tembaro district.

The occurrences of location by fertilizers interaction have been reported by several authors (Jevdovic*et al.*,

2013; Wassie *et al*., 2008). Jevdovic *et al*. (2013) studied the effect of KAN fertilizer containing 27 % N and NPK fertilizers on Pot Marigold in four locations Serbia. They found significant interaction between fertilizer and seed yield for yield components of the crop.

Economic feasibility of blended fertilizer for tef production

The results of partial budget analysis data revealed that application of blended fertilizers were feasible for tef production in Tembaro district (Table 4). The highest net benefit and marginal rate of return was obtained from Blend-4 treatment followed by Blend-2 and Blend-3 in that order.

Table 4: Partial budget analysis data of treatment effect on tef at Tembaro district.

	Treatments						
Variables	C	NP	NPKSZnB	NPS	NPKSB	NPSB	NPSZnB
Average yield (kgha^{-1})	811	1632.2	2493.3	2500	2733.3	2933.3	3122.2
Adjusted yield (kgha^{-1})	729.9	1469.0	2244.0	2250.0	2460.0	2640.0	2810.0
Gross benefit (ETB)	12773.3	25707.2	39269.5	39375.0	43049.5	46199.5	49174.7
Cost of Urea-N	0	1600	0	0	0	0	0
Cost of TSP-P	0	4000	0	0	0	0	0
Cost of Blended fertilizers	0	0	2816	2936	3488	3820	4100
Total Variable Cost	0	5600	2816	2936	3488	3820	4100
Net Benefit (Birr)	12773.3	20107.2	36453.5	36439.0	39561.5	42379.5	45074.7
MRR (%)	-	1.31	-	D	5.6	8.5	9.6

Application of the usual NP fertilizer for tef production is also feasible when compared to the production of tef without the application fertilizer in the area.

Conclusion

It is concluded that application of blended fertilizers produced significantly higher yield components and yield of tef in Tembaro district than that produced with application of conventional or stranded N and P fertilizers. This implies that the soils of the study area are low in one or more of nutrients in addition to N and P. This is because blended fertilizers tested in this experiment contained 3-6 nutrients contained nutrients. Yield gain from blended fertilizer containing K in addition to N, P, S, B and Zn was relatively lower than that gained from the other blend types. This shows the presence of antagonism among nutrient elements when K is present in the blend. This needs further research in the future to exactly pinpoint out the cause.

The results of economic analysis data revealed that the highest net benefit and marginal rate of return was obtained from treatments was in the order of NPSZnB> NPSB > NPKSB. This suggests that application of blended fertilizer for production of tef in Tembaro district is economically feasible.

Further, verifications and demonstrations of best performing blended fertilizers such as NPSZnB and NPSB identified in this study involving more famers and sites are recommended.

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