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(Research Article)

Evaluation of different blended fertilizer types and rate for better production of Tef in Abashgie District, Guragie Zone, Ethiopia

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Abstract

Tef is one of the major crops grown at Abashgie District, Southern Regional State; however, its productivity is low due to lack of balanced nutrient. An experiment was conducted in Guragie Zone, Abashgie District on farmers' field in 2018/-2019 G.C cropping seasons, to evaluate different blended fertilizer types and rates on yield and yield components of Tef. The Tef variety "Boset" was tested at three types of different blended fertilizers that have three rates per each blend, that is NPSB (150,200 and 250) kg ha^{-1}, NPSZnB (160, 213 & 267) kg ha^{-1} and NPSZnBFe (160,213 & 267) kg ha^{-1} adjusted with different rate of urea. The experiment consisted of ten treatments including control and arranged in RCBD with three replications. Results showed a significant response to all tested growth and yield parameters. The highest grain yield (2660 kgha^{-1}) was obtained from application of Treatment 10 (267 kg NPSZnB+ 152 kg urea ha^{-1} +Fe) which is not statistically different from Treatment 9 (213 kg NPSZnB + 122 kg urea ha^{-1}) + Fe) and Treatment 7 (213 kg NPSZnB + 122 kg urea ha^{-1}) which gave (2470 kgha^{-1}) and (2500 kgha^{-1}) respectively. The lowest grain yield (480 kg ha^{-1}) was obtained from control. According to economic analysis results, seven treatments were selected as dominant over others and treatment 9 (213 kg NPSZnB + 122 kg urea ha^{-1} + Fe) showed low cost, good net benefit and acceptable MRR which is better compared to others. Therefore, based on the results, application of treatment 9 (213 kg NPSZnB + 122 kg urea ha^{-1} + Fe) was recommended for better production of tef at Abashgie District.

Keywords: Blended Fertilizers; Fertilizer rate; Fertilizer type; Economic analysis; Yield

1. Introduction

Tef [Eragrostis tef (Zuccagni) Trotter] is one of the most important food cereal crops in Ethiopia, occupying about 22.6% of the cultivated land from the total area of cereals (86.06%) with accounting 16% of the grain production and national average yield of 1.66 t ha^{-1} (CSA, 2017). It is a self-pollinated annual cereal (Seyfu, 1993) and is indigenous to Ethiopia (Vavilov, 1951) that grown under diverse agro-climatic zones. It grows at altitudes ranging from sea level to 2800 masl with varying annual rainfall of 750-850 mm and temperatures between 10 and 27^{o}C (Seyfu, 1993). In addition, it can thrive well in both waterlogged and drought conditions. Since it is valuable to the Ethiopian economy in terms of supplying grain for human consumption and fodder for livestock, it is crucial to address the fertility constraints so as to boost its production. The Central Statistical Authority (CSA, 2014, CSA, 2010) stated that despite its versatility in adapting to extreme environmental conditions, the productivity of Tef in the country is very low ranging 1.28 up to 1.5 t ha^{-1} under traditional practices.

Since late 1960s N and P fertilizers were applied throughout the country to improve the productivity of the soil (Wassie and Tekalign, 2013). Subsequently, crop response experiments to fertilizers conducted on-stations and on-farmers' fields revealed that applications of these inputs have appreciably improved the yields of crops and thus the use of N (100 kg urea (46-0-0) and P (100 kg DAP (18-46-0) fertilizers by farmers have been recommended (NFSAP, 2007). However, the nutrients in the blanket recommendation are not well balanced for agronomic improvement and its

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continued use gradually exhausted soil organic matter (IFPRI, 2010). Plant growth and crop production require an adequate supply and balanced amounts of all nutrients (Mengel and Kirkby, 1987) in order to maximize productivity by optimizing the plant nutrient uptake.

The current productivity obtained from the Tef through using the recommended blanket fertilizers is very low compared to the potential yield of the crop, in all parts of the country. Consequently, soil productivity and chemical fertilizers that have been practiced in the area, requiring improvements to solve low productivity of the crop. The soil fertility mapping project in Ethiopia reported that deficiency of K, S, Zn, B and Cu in addition to N and P in major Ethiopian soils were common (Ethio-SIS, 2014). As a result, six soil nutrients (N, P, K, S, Zn and B) were found to be deficient in the soils of Abashgie (Ethio SIS, 2014). By considering the extent of deficiency of the 6 soil nutrients; it was found that Abashgie soils require more fertilizer types. The major recommended blended fertilizers for the area are NPS, NPSB, NPSZn, NPSZnB and NPSZnBFe (EthioSIS, 2016). Out of this based on the selected kebele, three types of the blend (NPSB, NPSBZn and NPSBZn) were selected for evaluation. Apart from the blanket recommendation of nitrogen and phosphorus, the effect of other fertilizers on yield, yield components, and overall performance of Tef were unknown, even though new blended fertilizers such as NPSB (18.7N + 37.4 P2O5 + 6.9 S + 0.71 B) (Ethio-SIS, 2016) are currently being used by the farmers in the study area. Mainly, best performing fertilizer type and rate determination is yet not identified. Therefore, this study was conducted to identify the best fertilizers type and rate for better production of Tef in Abashgie district.

2. Materials and Methods

2.1. Description of the study area

The study was conducted in Gurage Zone of Southern Region, at Abashgie district, Lache Kebele, on farmers' fields during 2018 and 2019 main cropping seasons. Lache Kebele is located at 8° 18' 26.22'' N and 37° 42' 07.64'' E with elevation of 1728 masl. Soils of Lache kebele is dominantly black Soil/Vertisols. Also, the soil is low for N and organic matter; while very low for P and S (EthioSIS, 2014). Major crops grown in the district are tef, maize, faba bean and chickpea. The experimental site was under maize cultivation during the previous growing seasons. The area is characterized by mixed farming crop-livestock production system; thus, because of fragmented plots of land, they continually cultivate the land. So poor soil fertility is a common problem in the area.

2.2. The experimental design, treatments and experimental procedure

The experiment consisted of 10 treatments; three types of blended fertilizers at three rates per each type and control. The treatments were arranged in randomized complete block design (RCBD) with three replications on farmers' field. The whole doses of blended fertilizers were applied at planting time while Urea was top dressed at tillering stage and Iron in the form of (Fe^{2+}) from $FeSO_4$ was foliar applied.

Table 1 Treatment set up

Treatments (kg ha^{-1})	Nutrient rates per hectare					
	N	P_2O_5	S	B	Zn	Fe
Control	0	0	0	0	0	0
150 kg NPSB (F2)+ 41 kg urea TD	46	54	10	1.07	0	0
200 kg NPSB (F2) + 72 kg urea TD	69	72	13	1.4	0	0
250 kg NPSB (F2) + 102 kg urea TD	92	90	17	1.7	0	0
160 kg NPSZnB (F4) + 91 kg urea TD	69	54	12	1.07	3.57	0
213 kg NPSZnB (F4) + 122 kg urea TD	92	72	16	1.4	4.75	0
267 kg NPSZnB (F4) + 152 kg urea TD	115	90	19	1.7	5.96	0
160 kg NPSZnB (F4) +91 kg urea TD + Fe (FA)	69	54	12	1.07	3.57	1
213 kg NPSZnB (F4) + 122 kg urea TD + Fe (FA)	92	72	16	1.4	4.75	1
267 kg NPSZnB (F4) + 152 kg urea TD + Fe (FA)	115	90	19	1.7	5.96	1

TD= top dressing; FA= foliar application

The experimental site was prepared according to farmers practices and was plowed using Oxen three times before planting. A plot size was 3m*3m (9 m^2) with spacing of 15 cm between row and 1 m between plots. Improved Tef variety "*Boset*" was used and planted by drilling along the rows at a seed rate of 10 kg ha^{-1}. The outermost two rows from each side of the plot were considered as border and avoided during data recording. Therefore, the net harvestable area was 2.85*2.85 (8.12m^2). The harvested total biomass yield was sun dried for three days until constant weight. The total dry matter was weighed by using field balance. Threshing and winnowing were done manually on a mat. After threshing, the grain yield was weighed using sensitive digital balance. All recommended cultural practices for the test crop were done as per the recommendation of the area.

2.3. Soil sampling and analysis

Soil samples were collected before planting and after harvesting for analysis of different physico-chemical properties of soil from the experimental field. Before planting soil samples were collected by zigzag manner and composited to one sample and after harvesting soil samples were collected from each plot (at five spots) and composited to treatment level. The collected soil sample was prepared following standard procedures under the shade, grounded using mortar and pestle, sieved through a 2 mm sieve. Sieved soil was stored in a clean plastic container for subsequent physical and chemical analysis. The soil analysis was done for soil textural class, soil pH, organic carbon, total N, available P, available S and CEC at Areka Agricultural Research Center Soil Laboratory. Soil textural class was determined by Bouyoucos level by Hydrometer Method (Bouyoucos,1954). Soil pH was determined in 1:2.5 soils to water ratio using a glass electrode digital pH meter (Carter and Gregorich 2007). Organic carbon was determined by wet digestion method (Bray and Kurtz, 1945) then the organic matter (%) was calculated by multiplying the OC% by factor 1.724. Total N (%) was determined using the Kjeldhal method (Ranist et al., 1999). Available P (mg/kg (ppm) was determined by Bray and Kurtz method (Bray and Kurtz, 1945). Available S (mg/kg (ppm) and exchangeable bases (potassium, magnesium, sodium and calcium) were determined by Melich-3 methods (Mehlich, 1984). For Cation Exchange Capacity of the soil (Meq/100 g soil), the sample was first leached using 1M ammonium acetate, washed with ethanol and the adsorbed ammonium replaced by sodium (Na). Then, the CEC was determined titrimetrically by distillation of ammonia displaced by Na

2.4. Data collection and measurement

Plant height was measured at physiological maturity from the ground level to the tip of panicle from ten randomly selected plants in each plot. The numbers of total tillers were determined by counting the tillers from an area of 0.25 m x 0.25 m plants by throwing a quadrat into the middle portion of each plot. Biomass yield was measured by weighing the sun- dried total above ground plant biomass of the net plot at physiological maturity. Grain yield data for each plot was recorded by weighing the grain harvested from each net plot after trashing/separating the seed from its straw and after the seeds were thought to be completely dried and finally the result was converted to quintals per hectare. Straw yield was calculated by subtracting grain yield from the total above ground biomass (biomass yield) from each net plot. After that it was converted to quintals per hectare. Harvest index was calculated on a plot basis as the ratio of grain yield to the aboveground biomass yield and expressed as a percentage.

2.5. Economic analysis

The economic analysis was performed to examine the economic feasibility of the treatments. Marginal rate of return (MRR) was calculated as the change in net revenue (NR) divided by the change in total variable cost (TVC) of the successive treatments (CIMMYT, 1988). The average yield was adjusted by 10%, assuming that farmers would get 10% less yield than is achieved on an experimental site. The average open market price (Birr kg^{-1}) for tef and the official prices of blended fertilizers were used for analysis. The average market price for tef (24 ETB kg^{-1}), for N (urea: 11.5 ETB kg^{-1}), NPSB (16.50 ETB kg^{-1}), Fe ($FeSO_4$: 900 ETB kg^{-1}), NPSZnB (17.50 ETB kg^{-1}).

2.6. Data analysis

Data was subjected to analysis of variance (ANOVA) using General Linear Model (GLM) procedures of SAS 9.1.3 (SAS, 2009). Differences among treatment means were compared using Least Significant Difference test at 5% level of significance.

3. Result and Discussion

Two years experiment result showed significant difference among the different nutrient combinations considered in this trial. Based on analysis of variance, there was significant difference among the effect of the treatments ($P \leq 0.05$) on all measured parameters. The highest plant height (117 cm) was obtained from application of treatment 7 (267 kg NPSZnB ha^{-1} + 152 urea ha^{-1}) while the shortest plant height (82.7 cm) was in response to the control treatment (Table

2). The highest plant height obtained at the higher blended fertilizer levels might be due to the vital role of N applied for elongation and vegetative growth. Therefore, application of blended fertilizer under balanced N increases plant height of wheat. This result was in agreement with the research findings of Tewolde et al. (2020) where the maximum tef plant height (120.67 cm) was obtained from the application of the highest rate (250 kg NPSB ha^{-1}) whereas the lowest plant height was obtained from the control plot. In contrast to this finding, Esayas (2015) reported that plant height of tef was not significantly affected by the rate and type of different blended fertilizers. The highest number of tiller (5.5) was recorded from application of treatment 10 (267 kg NPSZnB + 152 kg urea ha^{-1} + Fe) while the lowest result (1.98) was from control. Total tiller increased across the increasing rate of the nutrients in the treatments. The possible reason for increment in number of tillers might be due to the effect of balanced fertilization in which readily soluble minerals help to the vegetative growth of the crop. The more availability of N playes a positive role in cytokinin synthesis and cell division (Teshome *et al.,* 2019). In line with the current result, (Fayera *et al.* 2014; Wakjira, 2018) reported that blended fertilizer produced high number of tillers and effective tillers.

Application of different types of blended fertilizer significantly ($p < 0.05$) increased biomass and grain yield of tef (Table 2). The highest grain yield of 2.66 t ha^{-1} and biomass of 12.02 t ha^{-1} was recorded from application of Treatment 10 (267 kg/ha NPSZnB + 152 kg urea ha^{-1} + Fe) which was not significantly different from Treatment 9 (213 kg/ha NPSZnB + 122 urea ha^{-1} + Fe) for yield which gave 2.5 t ha^{-1}. The second-best result of biomass (11.67 t ha^{-1}) and grain yield (2.47 t ha^{-1}) was recorded by treatment 7 (267 kg NPSZnB + 152 kg urea ha^{-1}). From these two results it is possible to conclude that how tef biomass and grain yields were increased by providing appropriate micronutrients on a location-specific basis. The maximum grain yield has 81.95 % and 39.47 % yield increment over control and treatment 2 (150 kg NPSB + 41 kg urea ha^{-1}), respectively. The highest grain yield (2.66 t ha^{-1}) overwhelmed the national average yield (1.66 t ha^{-1}) (CSA, 2017).

This could be due to the combined effect of nutrients in the blend and the highest rate of the nutrients especially N and P which might have enhanced growth and development of crop compared to the rest of the treatments. Even though in the soil fertility map of the district clearly indicated that N, P, K, S, Zn and B are deficient in the soils of the area, the amount of NP in the nutrient combination is critical. The result clearly showed that application of NP below recommended rate with other macro and micro nutrients presence still ended with significantly lower yield result. When NP increased in the presence of Fe from 69 to 115 and 54 to 90, yield showed 30.45 % increment.

Table 2 Growth and yield components of teff influenced by different fertilizer types

Treatments	**Plant height (cm)**	**No of tiller**	**Biomass (t ha^{-1})**	**Grain yield (t ha^{-1})**
1.Control	82.7e	1.98e	3.56e	0.48g
2. 150 kg NPSB (F2)+ 41 kg urea TD	104.5cd	3.08d	6.53d	1.61f
3. 200 kg NPSB (F2) + 72 kg urea TD	108.26bc	3.86cd	8.50c	2.14d
4. 250 kg NPSB (F2) + 102 kg urea TD	108.86bc	4.05c	10.48b	2.27cd
5. 160 kg NPSZnB (F4) + 91 kg urea TD	105cd	3.8cd	8.56c	1.79ef
6. 213 kg NPSZnB (F4) + 122 kg urea TD	106.83cd	4.36cb	9.66b	2.29bcd
7. 267 kg NPSZnB (F4) + 152 kg urea TD	117a	5.05ab	11.67a	2.47abc
8. 160 kg NPSZnB (F4) +91 kg urea TD + Fe (FA)	103.66d	3.95cd	8.38c	1.85e
9. 213 kg NPSZnB (F4) + 122 kg urea TD + Fe (FA)	108.5bc	4.53cb	10.58b	2.50ab
10. 267 kg NPSZnB (F4) + 152 kg urea TD + Fe (FA)	111.8b	5.50a	12.02a	2.66a
LSD (0.05)	3.62	0.94	1	0.22
CV (%)	4.48	20.13	9.59	9.37

TD= top dressing; FA= foliar application; variable means followed by the same letters are not significantly different ($p \leq 0.05$) according to LSD tests.

In line with this study, many findings were reported that application of blended fertilizers at highest rate significantly increased yield of tef over the control and lower rate treatments (Mulugeta and Shiferaw, 2017; Tewolde et al., 2020; Fekadu and Geremew, 2019 and Wakijira, 2018). In contrast to the current study, NP application which gave statistically similar result with blended fertilizer was reported by Molla (2016). On top of that, high response of NP is understandable because, the availability of N and P in Vertisol is generally low because the phosphorus is bound by Ca, low N due to denitrification resulting from poor drainage (Munir 1996).

3.1. Economic analysis

Partial budget analysis was done considering all variable costs and benefits. To identify treatments with the optimum return to the farmer investment, marginal analysis was performed over the control treatment. For a treatment to be acceptable option to farmers, the marginal rate of return has to be above 100% (CIMMYT, 1988). As a result, seven treatments were with the acceptable marginal rate of return (MRR) while three treatments were dominated (Table 3). Economic analysis results also supported the biological yield. Thus, the highest net benefit of 50585.5 Birr ha^{-1} was obtained from application of treatment 10 (267 kg NPSZnB + 152 kg urea ha^{-1} + Fe) while the lowest net benefit of 10368 Birr ha^{-1} was obtained from control treatment (Table 3). However, treatment 9 was economically more profitable than treatment 10. It is also the second treatment resulted with higher biological yield.

Table 3 Partial budget analysis of blended fertilizer rates for grain yield of tef

Treatments	Av. Yield	Adj. yield	GB (EB ha^{-1})	TCV (EB ha^{-1})	NB (EB ha^{-1})	MRR (%)
1.Control	480	432	10368	-	10368	-
2. 150 kg NPSB (F2)+ 41 UTD	1610	1449	34776	2946.5	31829.5	332
5. 160 kg NPSZnB (F4) + 91 UTD	1790	1611	38664	3846.5	34817.5	2585.61
3. 200 kg NPSB (F2) + 72 UTD	2140	1926	46224	4128	42096	223.19
8. 160 kg NPSZnB (F4) +91 UTD + Fe (FA)	1850	1665	39960	4296.5	35663.5	D
6. 213 kg NPSZnB (F4) + 122 UTD	2290	2061	49464	5130.5	44333.5	908
4. 250 kg NPSB (F2) + 102 UTD	2270	2043	49032	5298	43734	D
9. 213 kg NPSZnB (F4) + 122 UTD + Fe (FA)	2500	2250	54000	5580.5	48419.5	167.91
7. 267 kg NPSZnB (F4) + 152 UTD	2470	2223	53352	6420.5	46931.5	D
10. 267 kg NPSZnB (F4) + 152 UTD + Fe (FA)	2660	2394	57456	6870.5	50585.5	736.27

MRR=marginal rate of return; GB=gross benefit; NB=net benefit; TCV=total cost that Vary; UTD=urea top dress; FA=foliar application

4. Conclusion and Recommendation

Appropriate fertilizer management is a practical step in establishing fertilizer-use efficiency of any crop production program. One of the strategies to establish fertilizer-use efficiency of any crop is to evaluate location wise effectiveness of blended fertilizers based on ethiosis map. Hence, an experiment was conducted during the (2018-2019 GC) cropping seasons at Guragie Zone Abashgie district to evaluate different blended fertilizer types and rates for better production of Tef. The highest grain yield 2.66 t ha^{-1} was obtained from application of 267 kg NPSZnB + 152 kg urea ha^{-1} + Fe with nutrient rate of 115, 90, 19, 5.96, 1.79. According to economic analysis results, seven treatments were selected as dominant over others and treatment 9 (213 kg NPSZnB + 122 kg urea ha^{-1} + Fe showed low cost, good net benefit and acceptable MRR which is better compared to others. Treatment 10 (267 kg NPSZnB +152 kg urea ha^{-1} + Fe) has high net benefit but MRR is exaggerated. Therefore, based on the results, application of treatment 9 (213 kg NPSZnB + 122 kg urea ha-1 + Fe) was recommended for better production of tef at Abashgie district.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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