Optimizing Rates of Blended Fertilizer for High Yield and Agronomic Use Efficiency of Tef (*Eragrostis tef* (Zucc.) Trotter) at Central Ethiopia

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Abstract

An experiment was conducted during two consecutive cropping seasons to optimize rates of blended fertilizer for high yield and N use efficiency of tef varieties at Chefe Donsa and Alem Tena. The treatments consisted of a factorial combination of two tef varieties (recently released for the areas) and five fertilizer rates (0, 100 kg ha^{-1} Diammonium Phosphate (DAP), 50 kg ha^{-1}, 100 and 150 kg ha^{-1} NPSB. Varieties, such as Dagim and Tesfa were used for Chefe Donsa, whereas Boset and Tsedey were used for Alem Tena. The treatments were arranged following randomized complete block design in triplicate. The result showed that phenology, growth and yield parameters were highly significantly ($P<0.01$) influenced by the main effect of blended fertilizer rates. Higher grain yield was obtained from application of 150 kg NPSB ha^{-1} fertilizer rate at both locations, but was not significantly different from the application of NPSB at rates of 100 kg ha^{-1} at Chefe Donsa, and from 100 kg ha^{-1} NPSB and 100 kg ha^{-1} DAP at Alem Tena. Economic analysis showed that application of 100 kg ha^{-1} NPSB gave the highest net benefit and acceptable marginal rate of return (MRR). Therefore, application of 100 kg NPSB ha^{-1} fertilizer could be recommended for production of tef in the study areas and other areas with similar agro-ecological and soil conditions.

Keywords: Fertilizer, net benefit, tef, variety, yield

Introduction

Tef is one of the most significant and dominant staple grain crops in Ethiopia (Eragrostis tef (Zucc.) Trotter). Tef is gaining popularity around the world as a lifestyle crop since it has great nutritional benefits and is gluten-free (Spaenij-Dekking et al. 2005). Subsistence farmers exclusively grow the crop under rain fed condition. Tef ranks first in terms of both production and consumption and second in terms of cultivated area next to maize with 17.22% of the production of cereal crops (CSA, 2021).

Tef production is growing year after year and the crop is important to the country's food, agriculture, and trade sectors. However, productivity is low compared to other cereals with a national average grain yield of 1.9 t ha^{-}

[1] (CSA, 2022). Poor agronomic practices and low soil fertility are the most significant yield-limiting factors (Mihretie et al., 2021).. The main reason of the low soil fertility status in different parts of the country is the recurrent cultivation of the same crop on a particular targeted area of land and imbalance application of fertilizers. Nitrogen (N) and phosphorus (P) fertilizers are the common fertilizers applied by smallholder farmers growing tef in Central Ethiopia. Nevertheless, continuous application of N and P fertilizers without adequate consideration of other nutrients may have resulted in deficits of other macro and micronutrients and induced and soil deterioration (Stoorvogel et al. 1993; Bindraban et al. 2012). Studies showed that not only N and P fertilizers, but also sulfur (S) boron (B) and zinc (Zn) deficiencies are widespread in Ethiopian soils (EthioSIS, 2013) and also limiting nutrients for tef production (Habtegebrial and Singh, 2006; Bereket et al., 2011).

One way to alleviate such production constraints is to use blended fertilizers that contain both macro- and micronutrients. Even though tef farmers in Ethiopia, particularly in the study areas, have limited knowledge about the effects of blended fertilizers and their rates aside from just urea and di-ammonium phosphate (DAP), blended nutrient content of the fertilizer (NPSB) can supply the nutrients that the crop required, consequently improve the productivity of the crops. In addition, there is limited information regarding the performance of different tef varieties at different rates of blended fertilizer (NPSB) in the study area as described in EthioSIS (2013). Thus, it is necessary to identify the source of nutrient and optimize blended fertilizer (NPSB) rates in order to boost tef production and productivity. The application of essential plant nutrients in optimum quantity and right proportion, through correct method and time of application, is the key to increased and sustained crop production. Therefore, the study was aimed at optimizing rates of blended fertilizer (NPSB) for high yield and agronomic use efficiency of tef varieties.

Materials and Methods

Site description

The field experiments were conducted during 2018 and 2019 cropping season at Alem Tena and Chefe Donsa, East Shewa Zone of the Oromia Region. Tef is the dominant crop in both locations. Alem Tena is located at a latitude of 8.30°N and longitude of 38.95°E with an elevation of 1,611 meters. The weather data regarding average min and max temperature (◦C) and rainfall (mm) during 2018 and 2019 cropping season is presented in Figure 1. While, Chefe Donsa is located at a latitude of 08.85^{o} N and longitude of 39.12^{o} E and at 2040 meter a.s.l. The weather data regarding average min and max temperature (◦C) and rainfall (mm) during 2018 and 2019 cropping season is presented in Figure 2. The soil type is Andisol in Alem Tena, whereas, it is Vertisol in Chefe Donsa.

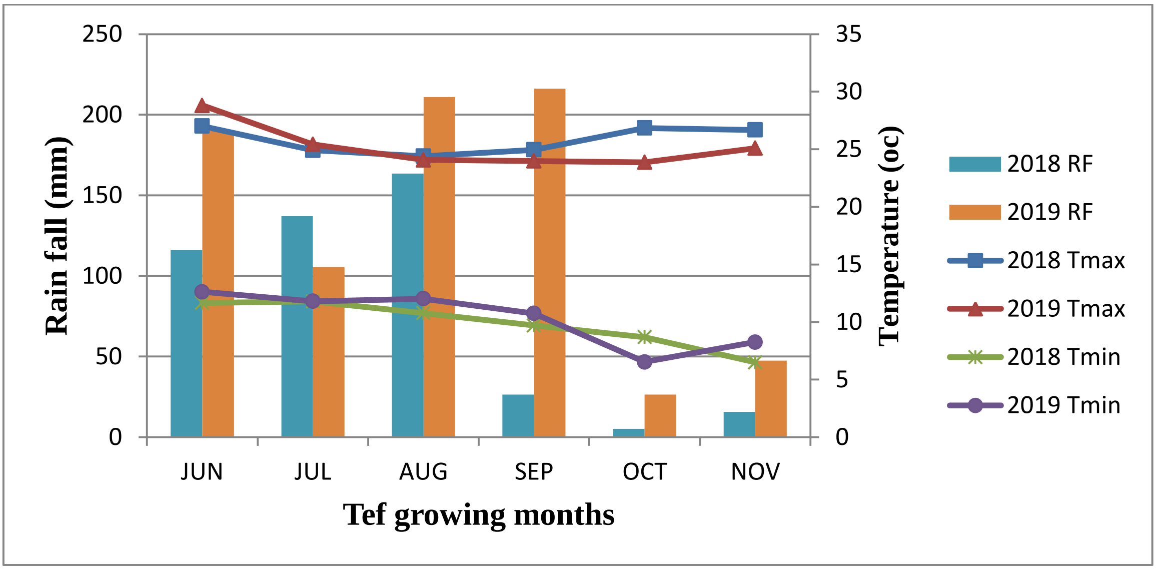

Fig. 2. Average min and max temperature (◦C) and total rainfall (mm) of Alem Tena during the cropping season of tef from June to November in 2018 and 2019

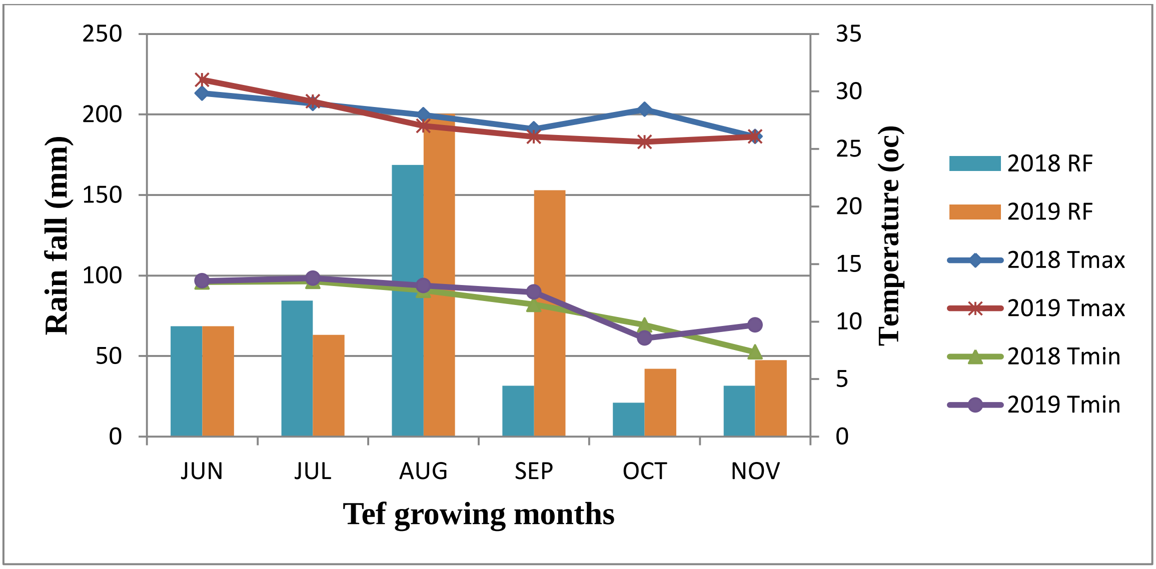

Fig. 2. Average min and max temperature (◦C) and total rainfall (mm) of Chefe Donsa during the cropping season of tef from June to November in 2018 and 2019

The soil samples from 0–30 cm depth from ten spots across the experimental field were collected, composited and analysed for determining selected soil physicochemical properties at Alem Tena and Chefe Donsa following standard procedure. Values for the selected physicochemical properties of both locations are presented in Table 1.

Table 1: Soil physio-chemical properties analysis (0-30 cm depth) of the experimental site

Soil physio-chemical properties	Alem Tena		Chefe Donsa	
	2018	**2019**	**2018**	**2019**
pH	7.3	6.99	8.02	7.4
Total N (%)	0.1	0.07	0.08	0.05
Avelable P (cmol	8.09	12.57	13.57	14.0
Avelable K	0.89	0.87	0.88	0.89
CEC [Cmol(+) kg-1 soil]	19.92	19.54	50.88	49.0
OM%	1.34	1.65	0.94	1.08
Texture	Loam	Loam	Clay	Clay

Experimental design, treatments and crop management

The treatments consisted of a factorial combination of two tef varieties (recently released for the areas) and five fertilizer rates (0, 100 kg/ha Diammonium Phosphate (DAP) (18 % N and 46 % P_2O_5), 50 kg/ha, 100 and 150 kg ha-1 NPSB (18.9% N+37.7% P_2O_5 + 6.95% S+0.1% B) (ATA, 2016)). Varieties, such as Dagim and Tesfa were used for Chefe Donsa, whereas Boset and Tsedey used for Alem Tena. The treatments were arranged following randomized complete block design (RCBD) in triplicate. Except for the control treatment, 50 kg/ha N in the form of Urea were applied to all treatments. Plot size of 4 m x 4 m was used. The spacing between replication and plots were 1 m and 0.5 m, respectively.

Tef grain was drilled into the row at the recommended rate of 15 kg per hectare. Full doses of DAP and NPSB were applied at planting, while urea was applied at tillering via side dressing. No insect outbreaks or disease incidences occurred in this study. Other agronomic practices were maintained consistently across all treatments. At physiological maturity, when the vegetative parts became yellow, the crop was manually harvested.

Data Collection and measurements

When the plant reached maturity, the height was measured from the ground's surface to the tip of the panicle. The length of the panicle was measured from the node, where the first panicle branch began, to the tip. By counting the number of new plants growing from the main stem, the number of tillers per plant was determined. Ten randomly selected plants provided the samples for the aforementioned parameters. By weighing the entire crop, including the grains, from each net plot area, above-ground biomass was calculated. By deducting the grain yield per net plot from the total above-ground biomass, straw yield was calculated. Grain yield (kg ha^{-1}) was measured after threshing and separating grains from straw from each net plot. Harvest index was calculated using the ratio of grain yield to above ground biomass.

Agronomic efficiency

Agronomic efficiency was calculated according to Ladha et al. (2005).

Agronomic efficiency of N (AE) = $(Y_F - Y_0)/F_N$

Where Y_F and Y_0 are the grain yields (kilograms dry matter per hectare) in the fertilized and unfertilized treatments, respectively, and F_N is the fertilizer N application rate (kilograms N per hectare).

Economic analysis

Partial budget analysis and marginal rate of return were used in accordance with CIMMYT (1988) guidelines to examine the economic viability of various fertilizer sources and rates. To account for the difference between the experimental output and the anticipated production of farmers from the same treatment, the average yield of grains and straw was reduced by 10%. Straw cost (8 Birr/kg) and the mean market price of tef grain (50 Birr/kg) were used. The costs of fertilizer (1786 ETB/qt) NPSZnB and DAP also were included to determine the variable costs.

Statistical Analysis

The data were subjected to combined analysis of variance (ANOVA) over years after confirmation of homogeneity of error variance using SAS software program Ver. 9.4. Separate analyses were conducted for each location because of heterogeneity of error variance. The means were compared using least significant difference (LSD) at 0.05 probability level.

Result and Discussion

Phenological Parameters

The results revealed that days of heading and days of maturity were significantly affected by source and rate of applied fertilizers at both locations. Similarly, varieties at Chefe Donsa and year at Alem Tena had a significant effect on days of heading and days of maturity. The interaction between variety and fertilizer application rate had no significant effect on the above parameters. The delayed days to heading and maturity of tef were observed in 2019 cropping season as compared to 2018. This might be due to the highest and better distribution of rain fall during 2019 as compared to 2018 cropping season (Fig 1.). When the distribution of rainfall tends to be poor, they may also be forced to head early before the needed time for vegetative growth.

Regarding varieties, the delayed days to heading and maturity of tef were recorded on variety Dagim whereas;

the earliest days to heading and maturity were recorded from variety Tesfa. This might be the result of genetic diversity among varieties, which eventually led to differences to mature.

The longest days to heading (70.83) and (133.83) days to maturity were obtained at the rate of 0 kg ha^{-1} while the shortest days to heading (64.94) and physiological maturity (127.93) were verified at the rate of 100 kg ha^{-1} NPSB at Chefe Donsa. Similarly, at Alem Tena, the longest days to heading (47.50) and (92.50) days to maturity were obtained at the rate of 0 kg ha^{-1} while the shortest days to heading (46.16) and physiological maturity (91.16) were verified at the rate of 150 kg ha^{-1} NPSB. Application of blended fertilize (NPSB) hastened the time to reach heading and maturity as compared to DAP fertilizer (NP). This might be due to the fact that application of blended fertilizers with varying rates of N, P, S, and B may have aided in the early establishment, rapid growth, and development of crops, as a result shortening the time until heading, and maturity. This might be due to favorable conditions of soils for the crop nutrient requirement by application of deficient soil nutrients found in the blended fertilizer and the presence of Boron, which is necessary for stimulation of roots and shoots development and tassel and silk formation for maize. The result is in line with Diriba et al. (2019) who reported the difference in heading and maturity date of wheat in respect to application of different rats of blended fertilizer.

Table 2. Effect of variety and fertilizer on Phenology of tef at Chefe Donsa and Alem Tena during 2018 and 2019

Chefe Donsa			**Alem Tena**		
Year	**Days of heading**	**Days of maturity**	**Year**	**Days of heading**	**Days of maturity**
2018	67.70a	130.7a	2018	45.67b	90.67b
2019	67.70a	130.7a	2019	47.67a	92.67a
Variety			**Variety**		
Dagem	68.47a	131.47a	Boset	46.93a	91.93a
Tesfa	66.94b	129.94b	Tseday	46.40a	91.40a
Fertilizer sources and rate (kg/ha)			**Fertilizer sources and rate (kg/ha)**		
0	70.83a	133.83a	**0**	47.50a	92.50a
100 DAP	68.67b	131.67b	**100 DAP**	46.88ab	91.83ab
50 NPSB	67.33bc	130.33bc	**50 NPSB**	46.50b	91.50b
100 NPSB	64.93d	127.93d	**100 NPSB**	46.50ab	91.33ab
150 NPSB	66.75cd	129.75cd	**150 NPSB**	46.16ab	91.17ab
V x F	ns	ns	ns	**V x F**	Ns

Growth parameters

Plant height, panicle length and number of productive tillers were significantly ($P<0.05$) affected by the main effect of year, and fertilizer application at both locations, but not by variety. The interaction effect of variety and fertilizer application was not significant (Table 3). The maximum plant height, panicle length and number of productive tillers were observed in 2019 cropping season as compared to 2018 cropping season at both locations. The variations in plant growth of tef were attributed to the variations in distribution and amount of rainfall registered during the cropping periods. Crops need water throughout the growing phase, so the availability of adequate water in the soil is essential to enable plants (crops) to grow rapidly.

The highest plant height (73.79 cm and 73.08 cm), panicle length (27.45cm and 27.07 cm) and numbers of productive tillers (2.72 and 2.55) were recorded from the application of NPSB at the rate of 100 kg ha^{-1} and 150 kg ha^{-1}, respectively. However, there was no significant difference with the application of DAP at the rate of 100 kg/ha DAP at Chefe Donsa. Similarly, at Alem Tena, the highest plant height (94.0 cm) was recorded on the application of NPSB at a rate of 150 kg ha^{-1}, but was not significantly different from other rates of NPSB and 100 kg ha^{-1} DAP. Regarding panicle length (36.61 cm) and numbers of productive tillers (2.26) were recorded from the application of NPSB at rate of 150 kg ha^{-1}, respectively, but were not significantly different from the applications of NPSB at the rate of 100 kg ha^{-1} and DAP at the rate of 100 kg ha^{-1}. In contrast, the lowest panicle length and number of productive tillers were observed from the control. The increase in plant height with increasing NPSB and DAP fertilizer could be attributed due to sufficient supply of nutrient which in turn facilitates plants growth since nitrogen plays a crucial role in the structure of chlorophyll and P involved in the energy transfer for cellular metabolism. Moreover, the presence of Boron is necessary for stimulation of roots and shoots development and panicle formation for tef as a result increase growth of the crop. The result is in agreement with Tesfahun et al. (2018), who reported significantly higher number of total tillers in response to the application of 90 and 120 kgha^{-1} NPS. Similarly, Feyera et al., (2014) reported that the blended fertilization application and efficient utilization of nutrient leads to high photosynthetic productivity and accretion of dry matter, eventually increases plant height and panicle length.

The possible reason for increment in number of tiller or growth as a whole might be due to the availability of more N in 150 kg/ha NPSB which played a positive role in cytokinin synthesis and cell division, which is an important hormone for cell division and shoot growth.. Similarly Okubay et al. (2014) reported a significant increase in number of total tillers with increase in levels of N from 0 to 69 kg ha^{-1} in tef. Botella et al. (1993) also reported stimulation of tillers with optimal application of N. In contrary to this finding, Teshome and Sofya (2021) reported that number of tillers of tef was not significantly affected by the rate and type of different blended fertilizers. In contrast, the lowest plant height, panicle length and number of tillers were observed from control at both locations, which might be due to the low level of those essential nutrients in the soil for crop requirements.

Table 3. Effect of variety and fertilizer on growth of tef at Chefe Donsa and Alem Tena during 2018 and 2019

Chefe Donsa				Alem Tena			
Year	**Plant Height (cm)**	**Panicle Length (cm)**	**Productive tillers**	**Year**	**Plant Height (cm)**	**Panicle Length (cm)**	**Productive tillers**
2018	65.38b	27.37a	2.36a	2018	74.43b	29.92b	1.87b
2019	70.48a	25.10b	2.52a	2019	106.59a	40.12a	2.18a
Variety				**Variety**			
Dagem	68.98a	26.72a	2.33a	Boset	88.99a	34.27a	1.99a
Tesfa	66.877a	25.76a	2.55a	Tseday	92.03a	35.77a	2.06a
Fertilizer sources and rate (kg/ha)				**Fertilizer sources and rate (kg/ha)**			
0	54.07b	23.51b	2.16c	**0**	87.17b	33.13c	1.83c
100 DAP	70.43a	26.67a	2.49abc	**100 DAP**	92.47ab	36.31ab	2.08ab
50 NPSB	58.27ab	24.48ab	2.28bc	**50 NPSB**	88.97ab	33.71bc	1.99bc
100 NPSB	73.79a	27.45a	2.72a	**100 NPSB**	89.94ab	35.36abc	2.16a
150 NPSB	73.08a	27.07a	2.55ab	**150 NPSB**	94.00a	36.61a	2.26a
V x F	ns	ns	ns	**V x F**	ns	ns	Ns

Yield and Yield components

Grain yield, biomass yield and harvest index of tef were significantly ($P<0.05$) affected by the main effect of fertilizer application at both locations. However, the main effect of variety and interaction effect of variety with fertilizer application at both locations were not significant ($P>0.05$) for all aforementioned yield components, except a significant effect of variety on biomass yield of tef at Alem Tena (Table 4). Thus, Tseday variety gave a higher biomass yield of tef as compared to Boset variety. The difference in biological yield between the two tef varieties might be due to genetic variation and adaptability to soil and climatic conditions.

Table 4. Effect of variety and fertilizer on yield and yield component of tef at Chefe Donsa and Alem Tena during 2018 and 2019

Chefe Donsa				Alem Tena			
Year	**Biological Yield (kg/ha)**	**Grain Yield (kg/ha)**	**Harvest Index**	**Year**	**Biological Yield (kg/ha)**	**Grain Yield (kg/ha)**	**Harvest Index**
2018	7740.15a	1877.6a	0.24b	2018	6675.0b	1511.7b	0.25a
2019	5798.4b	1439.2b	0.25a	2019	7468.5a	1644.0a	0.20b
Variety (V)				**Variety**	0	0	
Dagem	7025.0a	1697.7a	0.24a	Boset	6814.5b	1582.8a	0.23a
Tesfa	6513.6a	1619.1a	0.25a	Tseday	7329.9a	1573.05a	0.21a
Fertilizer sources and rate (kg/ha) (F)				**Fertilizer sources and rate (kg/ha) (F)**			
0	3499.95c	1062.6d	0.27a	**0**	5629.2c	1322.7b	0.23a
100 DAP	7083.3ab	1688.85bc	0.26a	**100 DAP**	7462.8ab	1639.8a	0.21a
50 NPSB	6666.6b	1528.5c	0.23a	**50 NPSB**	6783.6b	1565.25a	0.23a
100 NPSB	8443.1a	1962.8ab	0.23a	**100 NPSB**	7847.85a	1668.15a	0.22a
150 NPSB	8153.6a	2049.3a	0.25a	**150 NPSB**	7637.55a	1693.5a	0.22a
V x F	ns	ns	ns	**V x F**	ns	ns	Ns

At Chefe Donsa, the highest grain yield and biomass yield of tef in 2018 cropping season as compared to 2019 cropping season, whereas, at Alem Tena, the highest grain and biomass yield of tef were obtained during 2019. A higher harvest index of tef was obtained during 2018 at Chefe Donsa and 2019 cropping season at Alem Tena. Variations in distribution and amount of rainfall record during the cropping periods (Fig. 1 and Fig. 2) prompted variations in yield and yield components of tef at both locations.

The highest biomass yield (8443.10 and 8153.60 kg ha^{-1}) at Chefe Donsa and (7637.55 and 7847.85 kg ha^{-1}) at Alem Tena were recorded from the application of NPSB at rate of 150 kg ha^{-1} and 100 kg ha^{-1}, respectively, but were not significantly different from the application of DAP at the rate of 100 kg ha^{-1} DAP. At Chefe Donsa, the highest grain yield (2049.30 kg ha^{-1}) was recorded on the application of NPSB at the rate of 150 kg ha^{-1}, but was not significantly different from the application of NPSB at the rate of 100 kg ha^{-1}. On the other hand, the applications of NPSB at the rate of 100 kg ha^{-1} gave statistically similar yield as of application of 100 kg ha^{-1} DAP. At Alem Tena, the highest grain yield (1693.50 kg ha^{-1}) was recorded on the application of NPSB at the rate of 150 kg ha^{-1}, but was not significantly different from other rates of NPSB and 100 kg ha^{-1} DAP. This may be because blended fertilizer application boosts the effectiveness of fertilizer use and increase crop yields by enhancing the physical, chemical, and biological conditions of the soil (Mahajan and Gupta, 2009). This could be attributed to the beneficial effect of yield contributing characters and positive interaction of nutrients in the blended fertilizer. In addition, phosphorus found in NPSB responsible for improved root development at early growth stage and which in turn promotes N uptake and N assimilation by growth points triggering tillers which subsequently resulted to overall plant growth and yield, (Barker and Pilbeam, 2007), and sulfur facilitates the uptake of other nutrients by the crop (Samuel et al., 1993). Similarly, ample supply of boron facilitates photosynthetic activities and leaf expansion that leads into improved grain yield (Tahir et al., 2009). This result is in agreement with Brhan (2012), who reported that treatments using blended fertilizers for tef row planting produced 4155 kg ha^{-1} and increased 30% and 378% above treatments using urea and DAP for row planting and control plots, respectively. Wakjira (2018) also reported the highest grain yield of tef at a rate of 120 kg ha^{-1} NPS fertilizer.

The biomass and grain yield increment with the application of blended fertilizers which contained S and B as compared to DAP at Chefe Donsa indicated that there is a need to supplement these elements or the necessity of NPSB fertilizer for tef production for the area. However, at Alem Tena there is not a significant yield increment with regard to application of NPSB blended fertilizers as compared to DAP (NP) fertilize. This finding is inconsistent with Mulugeta and Shiferaw (2017), who reported that the recommended rate of NP fertilizer (100 kg ha^{-1} DAP) for tef grain yield was not statistically different from the application of other types of blended fertilizer.

Agronomic fertilizer use efficiency of Tef

Agronomic Efficiency indicated the grain yield production potential of variety in response to the applied nutrients. The source and rate of fertilizer had a significant effect on agronomic use efficiency of tef. The highest agronomic nutrient use efficiency was recorded at 50 kg ha-1 NPSB blended fertilizers, followed by 100 kgha-1 NPSB at both locations (Fig 3). Agronomic Efficiency can be increased by increasing the amount, uptake and utilization of available nutrients, and by increasing the efficiency with which applied nutrients are taken up by the crop and utilized to produce grain (Cassman et al., 1996). This outcome was in line with those who found that different blended fertilizers and their rates had an impact on the yield and yield-related variables of barley, as well as impacts of blended fertilizers on nutrient use efficiency (Tesfahun, 2018).

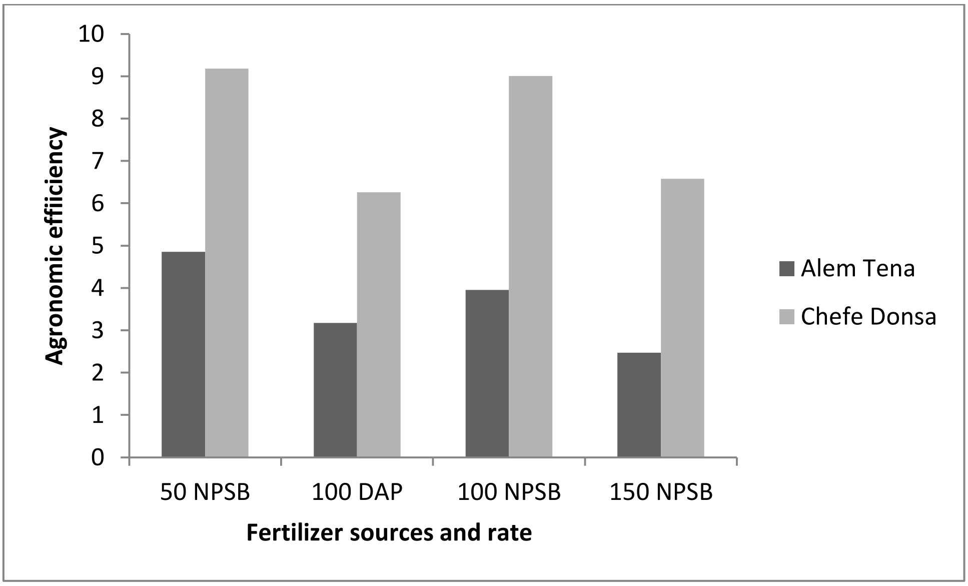

Fig.3 Agronomic use efficiency of tef at Chefe Donsa and Alem Tena

Partial Budget Analysis

The partial budget analysis showed that the application of 100 kg ha^{-1}NPSB gave the highest net benefit of 74174.36 birr ha^{-1} with marginal rate of return of 100 % at Chefe Donsa (Table 5) and the highest net benefit of 62771.41 birr ha^{-1} with marginal rate of return of 100 % at Alem Tena (Table 6). While the lowest net benefit of 41122.62 birr ha^{-1} and 51188.49 birr ha^{-1} were obtained from no fertilizer application at Chefe Donsa and Alem Tena, respectively (Table 8). The highest economic benefit for 100 kg ha^{-1} NPSB might be due to the highest grain yields produced. This implies that compared to growing tef without fertilizer application, the expected net benefit for blended fertilizer is interesting. Similarly, Yared et al. (2020) reported that combined application of 150 kg NPS and 46 kg N had given the highest economic benefit of 61315.41 Birr ha^{-1} with the marginal rate of return of 852.50%. Mathewos et al. (2022) also found the highest net benefit and MRR of wheat on application of blended fertilizer. Application of a unit fertilizer is economical, if the value of the increase in the crop yield due to the quantity of fertilizer added is greater than the cost of fertilizer used. If a unit of fertilizer does not increase the yield enough to pay for its cost, its application will not be economical and will not return profit even after a constant increase in the yield (Singh, 2004).

Table 5: Partial budget and marginal analysis for fertilizer sources and rate at Chefe Donsa

Fertilizer sources and rate (kg/ha) (F)	Grain Yield (kg/ha)	Adj. Grain Yield (kg/ha)	Total Cost Vary	Gross Benefit	Net Benefit	MRR (100%)
0	1062.6	956.34	0	41122.62	41122.62	
50 NPSB	1528.5	1375.65	893	59152.95	58259.95	95.05
100 DAP	1688.85	1519.965	1786	65358.5	63572.5	85.61
100 NPSB	1962.8	1766.52	1786	75960.36	74174.36	100.00
150 NPSB	2049.3	1844.37	2679	79307.91	76628.91	73.32

Table 6. Partial budget and marginal analysis for fertilizer sources and rate at Alem tena

Fertilizer sources and rate (kg/ha) (F)	Grain Yield (kg/ha)	Adj. Grain Yield (kg/ha)	Total Cost Vary	Gross Benefit	Net Benefit	MRR (100%)
0	1322.7	1190.43	0	51188.49	51188.49	
50 NPSB	1565.25	1408.725	893	60575.18	59682.18	90.49
100 DAP	1639.8	1475.82	1786	63460.26	61674.26	69.05
100 NPSB	1668.15	1501.335	1786	64557.41	62771.41	100.00
150 NPSB	1693.5	1524.15	2679	65538.45	62859.45	89.7

Conclusion

The study revealed that the fertilizer applications had a significant effect on grain yield and yield components of tef. However, varieties had not a significant effect on yield and yield components of tef at both locations. Higher grain yield was obtained from application of 150 kg ha^{-1} NPSB at both locations, but was not significantly different from the application of 100 kg ha^{-1} NPSB at Chefe Donsa, and from 100 kg ha^{-1} NPSB and 100 kg ha^{-1} DAP at Alem Tena. Economic analysis showed that application of 100 kg ha^{-1} NPSB gave the highest net benefit and acceptable marginal rate of return (MRR). Therefore, application of 100 kg ha^{-1} NPSB fertilizer could be recommended for production of tef in the study areas and other areas with similar agro-ecological and soil conditions.

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