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Effect of Blended Fertilizers on Yield, Yield components and nutrient concentration of tef *[(Eragrostis tef (zucc.) trotter]* on Vertisols in Ada'a district, Central highlands of Ethiopia

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Agriculture involves major nutrient withdrawals from the soil, which must be returned in the form of mineral or organic fertilizers, as maintaining a balance between inputs and outputs is a key to sustainable production. Therefore, a field experiment was carried out at Debrezeit agricultural research in Ada'a district during the 2017 main cropping season with the objective of assessing the effect of blended (NPSZnB) fertilizers on yield, yield components and nutrient content of tef. The experiment was conducted in a randomized complete block design (RCBD) with five treatments replicated three times. The treatments included control, 100 kg NPSZnB ha^{-1} with nutrient content of (17.8N, 35.7P2O5, 7.7S, 2.2Zn, 0.1B) kg ha^{-1}, 150 kg NPSZnB ha^{-1}, 200 kg NPSZnB ha^{-1} and 250 kg NPSZnB ha^{-1}. Results showed that responded to blended fertilizer rates were significant ($p<0.05$) for number of days to panicle emergence, Plant height, grain yield, biomass yield and harvest index. However, no significant response was observed for number days to 90 % physiological maturity, panicle length, total and effective number of tillers per plant and lodging index. The highest plant height and grain yield were obtained from application of 200 NPSZnB (35.6N, 71.4 P_2O_5, 15.4 S, 4.4Zn, 0.2B) kg ha^{-1}. On the other hand, the maximum above-ground dry biomass and straw yields were recorded from 250 NPSZnB (49.84N, 89.25 P2O5, 19.25 S, 5.5Zn, 0.25B) kg ha^{-1}. While, the lowest value was from the control plot. Similarly, the concentrations of nitrogen, sulfur and Boron in straw were significantly influenced by application of blended fertilizer. Therefore, taking the findings of the present study consideration it may be concluding that farmers can use 200kg ha^{-1} of 35.6N71.4 P2O5 15.4 S, 4.4Zn and 0.2B kg ha^{-1} to improve soil fertility and productivity of tef in the study area. However, further research may be required at various locations and in different season to come up with a comprehensive recommendation.

Keywords: Blended fertilizer, Nutrient concentration, Yield.

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INTRODUCTION

Teff (*Eragrostis tef* (Zuccagni) Trotter) is a panicle bearing C_4 cereal crop originating in Ethiopia (Kebede *et al*.,1989). It is considered as one of the most important cereal crops in the country. It accounting for about a quarter of the total cereal production of the country (Eleni, 2001). During the 2012 cropping season tef occupied the largest area (22.6%) of the total cultivated land for cereals (86.06%). In spite of the significant growth in terms of area cultivated under tef production, its yield is still very low (Alemayehu *et al*., 2011).

Severe depletion of nutrients in Ethiopia is one of the major factors for the slower growth of food production. The annual net loss of nutrients is estimated to be more than 40, 6.6 and 33.2 kg ha^{-1} for N, P and K, respectively (Scoones and Toulmin, 1999). Problems of declining soil fertility are widespread in Ethiopia causing large yield loss in different areas of the country (Zingore, 2011). Continuous cropping, high proportion of cereals in the cropping system, and application of suboptimal levels of mineral fertilizers and organic nutrient sources aggravate the decline in soil fertility (Workneh and Mwangi, 1992), which results in lower crop yields and biomass production (Selamyihun *et al*., 2005, Nigussie *et al,* 2007).

Previously, nitrogen (N) and phosphorus (P) were considered to be the only limiting nutrients in Vertisols of Ethiopia (Tekalign *et al.,* 2001). However, the results of national soil fertility mapping initiative indicated that other nutrients including S, Zn and B are also found to be deficient in these soils (ATA, 2014). Recently, some studies showed that sulfur (S) and zinc (Zn) are also limiting nutrients for tef production (Bereket *et al*., 2011).

Balanced fertilizers containing N, P, K, S, B and Zn in blend form are recommended for ameliorating site specific-nutrient deficiencies and thereby increasing productivity for crops (ATA, 2014). The need for site-specific fertilizer prescriptions is increasingly apparent, though; fertilizer trials involving multi-nutrient blends that include micronutrients are rare in the Ethiopian context. Although there is a general perception that the new fertilizer blends are better than the traditional fertilizer recommendation (urea and DAP), their comparative advantage is not explicitly examined and understood under various production environments.

Application of balanced fertilizers could be the basis to produce more crop output from existing land under cultivation and to meet nutrient needs of crops according to their physiological requirements and expected yields (Ryan, 2008). Balanced fertilization not only guarantees optimal crop production, better food quality and benefits for the growers, but is also the best solution for minimizing the risk of nutrient losses to the environment. Based on the EthioSIS soil fertility (ATA,2014) map N, P, S, Zn and B in blend were identified as deficient nutrients in Ada'a woreda (district).

Therefore, this study was initiated with the objective of evaluating the effect of blended fertilizer consisting N,P,S Zn and B on growth, yield, yield components and nutrient uptake of tef and to determine economically optimum blended fertilizer application rate for high grain yield of the crop.

MATERIALS AND METHODS

Site description

The field experiment was conducted under rainfed condition during the main cropping season from July to December, 2017 in Ada'a district located in the central high lands of East Showa zone of Oromia Regional State, Ethiopia. The site is geographically located at 09°45.11" N latitude and 038°46.73"E longitude and at an altitude of 1900 meters above sea level. The area has mean maximum and minimum temperature of 26.68°C and 11.93°C, respectively and average long term annual rainfall of 824.6 mm. Some of the physical and chemical properties of the soil are given in Table 1. Accordingly, the section soil is classified as neutral (Murphy, 1968), in accordance with Tekalign (1991), the organic carbon and total nitrogen contents could be rated as low. According to Landon (1991) CEC value of soil was very high. Similarly, based on the nation of Olsen, *et al*. (1954), available P content of the soil was in the medium range. Based on Hariram and Dwivedi, (1994) soil classification, Sulfur values were in the very low range. Similarly, in accordance with Ethio-SIS rating (2013), the critical B value of the soil was in low range. In accordance with Jones (2003), soil fertility indices the available zinc content of the soil was low (Table 1).

Table 1. Selected soil Physico-chemical characteristics of the experimental site before planting

Parameter			
Physical properties	Values	Rating	Reference
Texture Clay (%)	64.67		
Silt (%)	25.95		
Sand (%)	9.38		
Textural class	Clay	Clay	Bouyoucos (1962)
Chemical properties			
pH	6.73	Neutral	Murphy (1968)
Total Nitrogen (%)	0.09	Very low	Tekalign (1991)
Available Phosphorus (mg kg^{-1})	12.74	Optimum	Olsen (1954)
Available potassium (mg kg^{-1})	510.15	Optimum	Ethio-SIS (2014)
Available Sulfur (mg kg^{-1})	4.19	Low	Hariram and Dwivedi, (1994)
Available Zinc (mg kg^{-1})	0.63	Low	Jones (2003)
Available Boron (mg kg^{-1})	0.9	Low	Ethio-SIS (2013)
Organic carbon (%)	1.2	Low	Tekalign (1991)
CEC [Cmol (+)/kg)]	55.22	High	Landon (1991)

Experimental Design and Treatments

A total of five treatments (0, 100, 150, 200 and 250 kg ha^{-1}) of NPSZnB blended fertilizer were used. The experiment was laid out in randomized complete block design (RCBD) with three replications. The blended fertilizer (NPSZnB) with the formula (17.8N, 35.7P_2O_5, 7.7S, 2.2Zn, 0.1B) kg ha^{-1} used in this experiment was selected based on the soil fertility map developed by ETHioSIS. Blended fertilizer was applied at planting. The gross plot size was 3 m × 4 m (12 m^2) with a net plot size of 2×2 m (4 m^2). All other cultural practices were uniformly applied as per the recommendations.

Data Collection

Soil Physic-Chemical properties

Soil samples were taken from 10 spots of the experimental area at a depth of 0-20cm and composite sample of approximately 1kg was prepared for analysis before planting. Similarly, after crop harvesting, soil samples were taken from each treatments. The samples were analyzed for texture, PH, CEC, OC, Total Nitrogen, available phosphorus, sulfur, potassium, zinc and boron.

Particle size distribution (soil texture) was determined in the laboratory by the Bouyoucos hydrometer method (Bouyoucos, 1962) using sodium hexametaphasphate as dispersing agent. Soil textural class was determined based on the relative contents of the percent sand, silt, and clay separates using the soil textural triangle of the USDA.

Total nitrogen content was determined following the Kjeldahal method as described by Jackson (1958). Soil samples weighing 0.5-1 gm (according to the organic matter content) that passes through a 0.5 mm sieve were used. The samples were digested by 7 mL of concentrated H2SO4 for 3 hour, distilled and back titrated with 0.1 N of standard H_2SO_4 (Sahlemedhin and Taye, 2000).

Available phosphorus content of the soil was analyzed using 0.5M sodium bicarbonate extraction solution (pH 8.5) following the method of Olsen (Olsen *et al.*, 1954). Five gram of soil sample was shaken with 100 mL of 0.5M sodium bicarbonate extracting solution for 30 minutes and filtered. Three ml of the filtrate was mixed with 3 mL of mixed reagent and after the solution developed color, available P content was determined by spectrophotometer at 882 nm wavelength.

Organic carbon content of the soil was determined following the wet oxidation method of Walkley and Black (1934). The organic matter in one gram of soil ground to pass 0.5 mm was oxidized by excess potassium dichromate in sulfuric acid (96 %) solution. The excess dichromate was titrated with 0.5 N ferrous sulphate after addition of water, phosphoric acid (85 %) and diphenylamine indicator. The OC content was calculated against the blank. CEC was determined by 1M buffered ammonium acetate extraction method and distillation of the ammonium saturated soil in a kjeldahl distillation apparatus while receiving the distillate in boric acid and then titrating with sulfuric acid (Chapman, 1965). The soil pH was measured using a glass rod pH meter in a supernatant solution of 1:2.5 soils to water ratio (FAO, 2008).

Available S, B, Zn and exchangeable (K) of the soils were extracted by Mehlich-III multi-nutrient extraction method (Mehlich,1984) and were measured with their respective wave length range by Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) at Horticoop PLC Soil and Water Analysis Laboratory, Debre Zeit, Ethiopia.

Plant Tissue Analyses

Nitrogen content of tef grain and straw was determined using micro-Kjeldahl Method (Bremner and Mulvarey, 1982). Each about 0.3 g of grain and straw were taken for analysis. N uptake in the grain was determined after multiplying nitrogen content of the grain by grain yield, and straw nitrogen uptake was also determined by multiplying nitrogen content of the straw by the straw yield.

Phosphorus content of plant samples was analyzed, Using 0.3 g of finely-ground samples digested with a 2:1 mixture of nitric (HNO3) and perchloric acids (HC1O4). The concentration of phosphorus in the solution was determined colorimetrically using molybdate and metavanadate for color development (Sahlemedehen and Taye, 2000). The reading was made using spectrometer at 460nm wavelength.

Available S extraction was done with 0.15 % $CaCl_2.2H_2O$ and sulfate concentration in the extracts was measured by a turbidimeteric producer using barium chloride (FAO, 2008). Sulfur in grain and straw was determined turbidi-metrically using a spectrophotometer by di-acid (HNO_3–$HClO_4$) digestion as stated in FAO guide to laboratory establishment for plant nutrient analysis (FAO, 2008). Sulfur uptake in grain and straw was determined from the sulfur content of the respective parts after multiplying with the grain yield and straw yield, respectively.

The concentration of Zn and B in grains and straw was determined by wet digestion method. Total Zinc was determined by DTPA (dietylene triamine penta acetatic acid) method (Lindsay and Norvell, 1978). The content of boron in sample digest was analyzed by colorimetric method and subsequent measurement of B was done by colorimetry using Azomethine-H (Bingham, 1982). Boron and Zinc uptakes by grain and straw were also determined by multiplying the respective concentrations by the grain and straw yield.

Growth and Yield parameters

Number of days to 50% panicle emergence: - It was determined by counting the number of days from sowing to the time when 50% of the plants in a plot started to emerge the tip of panicles through visual observation.

Number of days to 90% physiological maturity:- Days to physiological maturity was determined as the number of days from sowing to the time when 90% of the plants in a plot reached maturity based on visual observation. It was indicated by senescence of leaves as well as by free threshing of grain from the glumes when pressed between the forefinger and thumb.

Plant height:- Plant height was measured at physiological maturity from the ground level to the tip of panicle using randomly pre-tagged mother plants in each plot.

Panicle length: - It is the length of the panicle from the node where the first panicle branches emerge to the tip of the panicle was measured using an average of ten randomly pre-tagged mother plants per plot.

Number of productive tillers: The number of effective tillers was determined by counting the tillers in an area of 0.25 m × 0.25 m by throwing a quadrat into the middle portion of each plot.

Biomass yield: At maturity, the whole plant parts, including leaves, stems and kernels in the net plot area was harvested and, after sun drying for five days the biomass weight was measured.

Grain yield: Grain yield was measured by harvesting the crop from the net plot area of 2 × 2 m excluding border effects.

Harvest index: - Harvest index was calculated by dividing grain yield by the total above ground air dry biomass yield.

Lodging index:- Lodging percentage was taken as the sum of the product of each scale of lodging (0-5 scale) and its respective percentage divided by five where 0 stands for upright stand, 1 for slightly slant, 2 for medium slant, 3 for very slant and 4 for extremely slant and 5 stands for 100% plants lodged.

Data analysis

The collected data was analyzed by general linear model (GLM) procedure for RCBD using SAS software version 9.2 (Gomez and Gomez 1984). Treatment means were separated using the Least Significant Difference (LSD) test at 5% level probability.

RESULTS AND DISCUSSIONS

Days to 50% panicle emergence

The analysis of variance showed that number of days to panicle emergence was significantly ($P<0.05$) influenced by application of blended fertilizer.

The maximum number of days (63.7) to panicle emergence was observed for the control plot. While, application of 250 kg ha^{-1} blended fertilizer hastened the duration. days of panicle emergence (Table 2). Application of blended fertilizer resulted in shortest period to Panicle emergence because the tef plants were able to take up sufficient nutrients from the soil which encouraged early establishment, rapid growth and development of crop. Similar result was reported by Seifu (2018), indicated that the highest number of days to 50% panicle emergence was obtained from the control plot, while the lowest was recorded from the application of 200 kg ha^{-1} blended fertilizers (NPSB).

Days to 90% physiological maturity

Number of days to attain physiological maturity did not significantly differ due to application of blended fertilizers. However, the period required to attain maturity was relatively shortest with application of fertilizers (Table 2).
Lack of significant difference between the treatments may be due to inadequate amount of nitrogen fertilizer contents of the blended fertilizer.

Table 2. Number of days to Panicle emergence and days to Physiological maturity as affected by blended (NPSZnB) fertilizer rates

Treatment	Days to Panicle emergence	Days to physiological maturity
Control	63.7a	108.7
100 kg NPSZnB ha^{-1}	50.0b	107.0
150 NPSZnB ha^{-1}	51.7bc	102.3
200 NPSZnB ha^{-1}	54.7bc	99.3
250 NPSZnB ha^{-1}	56.0c	95.3
LSD (<0.05)	4.69	ns
C.V (%)	4.51	6.96

Where, LSD= Least Significant Difference at 5% P level; CV= Coefficient of Variation. NS= non-significant, Means followed by the same letters within a column, are not significantly different at 5% P level.

Plant height

The analysis of variance showed that application of blended fertilizer had a significant effect on plant height. The tallest (107 cm) and shortest (76.9 cm) plant height were recorded from 200 kg blended fertilizer ha^{-1} and the control plot, respectively (Table 3). However, application of different rate of blended fertilizer was statistically at par. In contrast, Sate (2012) has reported that plant height of tef was significantly affected by application of P and N with blended fertilizer. The lack of significant variation among the blended fertilizer treatments for plant height might be due to small difference in the amount of nitrogen, though increases in nitrogen slightly increased plant height. In agreement with this finding, Adera (2016) and Esayas (2015) have reported that plant height of tef was not significantly affected by the rate and type of different blended fertilizers.

Panicle Length

The analysis of variance showed that Panicle length was not significantly (P>0.05) influenced by application of blended fertilizer. Like the case with plant height, this could probably be due to the non-responsive nature of the crop to small differences in nitrogen rate.

Total number of Tiller

Application of different rates of blended fertilizer had no significant effect on total number of tillers (Table 3). This may be due to lower N contents of blended fertilizer as compared to the amount required for proper production of tillers.

Number of productive tillers

Number of productive tillers was not significantly influenced by application of different rates of blended fertilizer rate. Generally, there was no difference in number of productive tiller between the levels of blended fertilizer. Though it showed an increasing trend as the of fertilizer rate increased (Table 3).

Table 3. Plant height (PH), Panicle Length (PL), Total number of Tillers (TNT) and number of effective tiller (ENT) of tef as affected by application of blended (NPSZnB) fertilizer rates

TRT	PH	PL	TNT	NPT
Control	76.9b	34.1	3.2	2.7
100 kg NPSZnB ha^{-1}	92.7ab	37.0	4.0	3.4
150 NPSZnB ha^{-1}	106.3a	39.0	4.5	3.9
200 NPSZnB ha^{-1}	107.0a	38.8	5.0	4.4
250 NPSZnB ha^{-1}	103.8a	38.7	6.0	5.2
LSD (<0.05)	16.41	Ns	Ns	ns
C.V (%)	8.95	7.53	28.73	32.33

Figures followed by the same letters with in a column are not significantly different at 5% P level

Total above ground dry biomass Yield

Total above ground dry biomass yield was highly significantly (P<0.001) affected by application of different rates of blended fertilizer.

Generally, as the fertilizer rate increased from null to 250 kg ha^{-1}, total above ground dry biomass yield also proportionally increased by 43% over the control plot.

The highest (6250 kg ha^{-1}) above ground dry biomass yield was obtained from application of 250 kg ha^{-1} NPSZnB (44.5 kg N+89.25 kg P2O5 + 19.25 kg S +5.5 kg Zn +0.25 kg B) blended fertilizer, while the lowest (2666.7 kg ha^{-1}) was from the control plot (Table 4). The result was in conformity with the findings of Adera (2016) and Bereket *et al.* (2014) which showed that above ground dry biomass yield was significantly affected by application of blended fertilizer. Others authors have also reported that application of 120 kg ha^{-1} NPS fertilizer produced the maximum biomass yield of tef (eg.Wakjira, 2018). Similarly, effect of blended NPS fertilizer and supplemental nitrogen rate had effect on both aboveground dry biomass yield of wheat (Tagesse *et al*, 2018; Melesse, 2007 and Iqtidar *et al.*2006).

Grain Yield

Grain yield of tef was highly significantly (P < 0.01) influenced by application of different rates of blended (NPSZnB) fertilizer.

The highest grain yield (1132.5 kg ha-1) was obtained due to application of 200 kg NPSZnB ha^{-1} which was statistically similar with 250 and 150 kg NPSZnB ha^{-1}, while the lowest values (333.3 kg ha^{-1}) was recorded for the control treatment (Table 4). It was observed that, increased application of blended fertilizer up to 200 kg NPSZnB ha^{-1} increased grain yield, which showed a decreasing trend with further increased blended fertilizer rate. Similarly, Abay and Mulugeta (2017) have reported that application of blended fertilizer supplemented with urea gave maximum grain yield of tef. On the other hand, the findings of Mulugeta and Shiferaw (2017) have shown that application of different types of blended fertilizer did not show statistically difference from the recommended rate of NP fertilizer for grain yield of tef, Although balanced nutrients were applied, yield was significantly lower than the recommended NP amount (Mulugeta and Shiferaw,2017). Generally, without the supplementation of N fertilizer, application of different rates of blended fertilizer couldn’t attain maximum grain yield of Tef relative to the national average production (CSA, 2017)

Straw yield

Straw yield was highly significantly (P<0.01) affected by application of blended fertilizer and consistently increased with the increasing rate of application .The highest straw yield (5144 kg ha^{-1}) was obtained from 250 kg NPSZnB ha^{-1} which was statistically at par with all fertilized plots, while the lowest values (2333 kg ha^{-1}) was from the unfertilized plot (Table 4). The result also indicated that application of blended fertilizer beyond 100 kg ha^{-1} had no significant effect on the straw yield (Table 4).

Lodging index

Lodging index was not significantly (P>0.05) influenced by application of different rates of blended fertilizer. However, as the rate of blended fertilizer increases, lodging index also increased (Table 4).

Harvest index

The analysis of variance showed that application of blended fertilizer had a significant (P<0.05) effect on harvest index. The maximum value (0.19) was obtained from application of 200 kg NPSZnB ha-1 which was statistically similar with all the fertilized plots, while the lowest value (0.11) was recorded for the control plot. Application of blended fertilizer at a rate of 100 kg ha^{-1} or beyond had no significant effects on harvest index of Tef. In contrast to this finding, Esayas (2015) has reported that application of different types of blended fertilizer showed non-significant difference among treatments for harvest index of durum wheat.

Table 4. Yield and yield components of tef as affected by rates of blended (NPSZnB) fertilizer

TRT	GY	AGB	SY	LI	HI
Control	333.3c	2666.7b	2333.3b	8.1	0.11b
100 kg NPSZnB ha^{-1}	758.3b	4833.3a	4075.0a	19.6	0.17a
150 NPSZnB ha^{-1}	975.8ab	5250.0a	4274.2a	26.4	0.18a
200 NPSZnB ha^{-1}	1132.5a	6083.3a	4950.8a	20.4	0.19a
250 NPSZnB ha^{-1}	1105.8a	6250.0a	5144.2a	26.6	0.18a
LSD (<0.05)	303.77	1491.0	1226.9	ns	0.04
C.V (%)	18.73	15.79	15.68	36.66	13.11

Where, GY=grain yield, AGB=above ground biomass, SY=straw yield, LI=lodging index, HI=harvest index.
Figures followed by the same letters with in a column are not significantly different at 5% P level

Nitrogen concentrations in Straw and Grain

Nitrogen concentration in straw was significantly (P<0.01) affected by application of (NPSZnB) fertilizer, while N concentration in grain was not significantly (P>0.05) influenced by blended fertilizer.

The highest N concentration in straw (0.84 %) was obtained from 100 kg NPSZnB ha^{-1} which was statistically at par with 150 kg NPSZnB and the control plot. This might have happened due to lower lodging index in those plots than the other fertilizer treatments. While, the lowest values (0.47%) was recorded for application of 250 kg NPSZnB ha^{-1} (Table 5).

Phosphorus concentrations in Straw and Grain

Phosphorus concentration in both grain and straw were not significantly (P>0.05) affected by different rates of blended fertilizer.

The value of P concentration in grain and straw across treatments was almost similar. This may be due to initial P value of the soil which was optimum relative to other nutrients (Table 5).

Sulfur concentrations in Straw and Grain

Sulfur concentration in straw was significantly (P<0.01) affected by application of (NPSZnB) fertilizer. While, its concentration in grain was not significantly (P>0.05) influenced by blended fertilizer.

Maximum sulfur concentration in straw (0.23%) was recorded for the highest (250 Kg ha^{-1} NPSZnB) rate, while the lowest (0.12 %) was for 150 kg ha^{-1} blended fertilizer. In line with these result, Lemlem *et al.* (2015) have found that application of blended fertilizer significantly increased concentration of N (20.05%), P (36.8%), Zn (10.8%), Mg (15.03%) and S in tef grain (15.58%) compared to the control in Vertisols (Table 5).

Table 5. Tef grain and straw nutrient content as affected by application of blended (NPSZnB) fertilizer

Treatment/ kg ha^{-1}	**N Straw (%)**	**N grain (%)**	**P straw (%)**	**P grain (%)**	**S straw (%)**	**S grain (%)**
Control	0.80a	1.61	0.23	0.42	0.15bc	0.69
100	0.84a	1.11	0.22	0.45	0.19ab	0.72
150	0.76ab	1.73	0.25	0.34	0.12c	0.59
200	0.67b	1.46	0.24	0.30	0.14bc	0.65
250	0.47c	1.46	0.22	0.30	0.23a	0.55
LSD (<0.05)	0.13	ns	Ns	ns	0.06	ns
C.V (%)	9.44	18.44	20.63	33.59	18.58	18.74

Where, N=Nitrogen, P=Phosphorus, S= sulfur, Figures followed by the same letters with in a column are not significantly different at 5% P level

Zinc concentrations in Straw and Grain

Zinc concentration both in straw and grain were significantly (P<0.01) influenced by application of blended fertilizer. The highest zinc concentration in straw of Tef (113.1 mg kg^{-1}) and grain(275.4 mg kg^{-1}) were obtained from 200 kg NPSZnB ha^{-1}, while the lowest straw (62.5 mg kg^{-1}) and grain (256.5 mg kg^{-1}) were obtained from 250 kg NPSZnB ha^{-1} and the control plot, respectively (Table 6). Different research reports have shown that zinc concentration in tef plants were varied from 8.71-417.1 mg kg^{-1} (Zerihun, 2018; Asgelil et al, 2007). Such variability have been attributed to error associated to plant part sampling, sample preparation, soil type treatment effects and genetic diversity among tef variety (Asgelil *et al,* 2007).

Boron concentrations in Straw and Grain

The analysis of variance showed that boron concentration both in straw and grain of Tef were significantly (P<0.01) influenced by application of different rates of blended fertilizer.

Application of 200 kg NPSZnB ha^{-1} resulted in maximum boron concentration (79.5 mg kg^{-1}) in straw, while the lowest value (59.3 mg kg-1) was recorded for 150 kg NPSZnB ha^{-1}. The highest mean value of boron concentration in grain (80.9 mg kg^{-1}) and the lowest (66.4 mg kg^{-1}) were obtained from 150 kg and 250 kg NPSZnB ha^{-1} , respectively. In line with this, Zerihun (2018) has reported that the mean value of boron content in tef grain was 77.67 mg kg^{-1} which was a comparable value with the result obtained from the current study. The result revealed that mean value of boron content in tef grain and straw was in the medium range (Table 6)

Table 6. Tef Grain and straw plant tissue nutrient content as affected by application of blended (NPSZnB) fertilizer

Treatment/kg ha^{-1}	Zn Straw (%)	Zn grain (%)	B Straw (%)	B Grain (%)
Control	84.27b	256.49c	71.64b	71.89b
100	69.57d	261.78bc	71.64b	66.57c
150	77.65c	264.48b	59.33c	80.93a
200	113.06a	275.37a	79.50a	71.86b
250	62.54e	274.35a	55.48d	66.44c
LSD (<0.05)	5.60	7.56	2.09	3.46
C.V (%)	3.65	1.51	1.64	2.57

Where, LSD= least significance difference, Zn=Zinc, B=Boron, Figures followed by the same letters with in a column are not significantly different at 5% P level

CONCLUSION AND RECOMMENDATION

Fertilizer in Ethiopia, since its start in the early 1970's, has focused mainly on the use and application of nitrogen and phosphorous fertilizers in the form of urea and di-ammonium phosphate (DAP) for almost all cultivated crops. Such unbalanced application of plant nutrients may aggravate the depletion of other important nutrient elements in soils such as K, Mg, Ca, S and micronutrients in the soil.

The analytical results of chemical properties of the soil at the trial before planting indicated it was neutral in reaction (pH 6.73), low in OC (1.2 %), Total N (0.09%), available S (4.19 mg kg^{-1}), available Zn 67 (0.63 mg kg^{-1}) and available B (0.9 mg kg^{-1}) , medium in available P (12.74 mg kg^{-1}) and available K (510.15 mg kg^{-1}).

Application of 200 kg NPSZnB ha^{-1} resulted in significantly higher plant height, grain yield, harvest index and concentration of grain and straw. While, most of the growth parameters were non-significant due to application of blended fertilizer. This probably happened may be due to lower N contents in the blended fertilizer.

Therefore, application of blended fertilizer without the addition of N fertilizer did not give higher grain yield though 200 kg ha^{-1} showed better results than did the other treatment, it need maximum dose of N relative to N content of blended fertilizer. Generally, application of blended fertilizer without supplementation by N fertilizer could not give higher tef yield in the study area.

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APPENDICES

Appendix 1. Mean squares of ANOVA for phenologicl and growth parameters as affected by blended (NPSZnB) fertilizer rates

Source of variation	Mean square											
	Df	DPE	DM	PH	PL	TNT	NPT	AGB	GY	SY	HI	LI
Replication	2	4.2	147.5	880.4	7	3.3	2	4054167	169622	2593955	1.3	306.3
Blended fertilizer	4	84.1	89.8	489.6	12.8	3.3	2.8	6202083	326861	3713153	3	169.7
Error	8	6.2	50.9	7	8	1.7	1.6	627083	26029	424634	4.9	54.9
CV%		4.51	7	9	7.53	28.7	32.3	15.8	18.7	15.7	13.1	36.6

Where, DF= Degree of freedom, **DH** = days to 50% panicle emergence; DM = days to maturity; PH = Plant height; PL = panicle length; TNT = Total number of tiller; NPT = Number of productive tillers. AGB=Above ground biomass, GY=Grain yield, SY=Straw yield, HI= Harvest index, LI=lodging index.

Appendix 2. Mean squares of ANOVA for phenologicl and growth parameters as affected by blended (NPSZnB) fertilizer rates

Source of variation	Mean squares										
	Df	N straw	N grain	P straw	P grain	S straw	S grain	Zn straw	Zn grain	B straw	B grain
Replication	2	0.002	0.5	1	0.2	2.4	0.02	11.15	36.6	0.3	2.5
Blended fertilizer	4	0.06	0.2	4.9	0.02	5.1	0.02	1140.5	200	292.1	104.3
Error	8	0.004	0.07	2.3	0.01	9.4	0.01	8.85	16.11	1.2	3.4
CV%		9.4	18.4	20.6	33.6	18.6	18.7	3.7	1.15	1.6	2.6

Where, N= Nitrogen= phosphorus, S= Sulfur, Zn= Zinc, B=Boron