Asian Plant Research Journal

8(1): 29-40, 2021; Article no.APRJ.72721
ISSN: 2581-9992

Effect of Blended NPSZnB Fertiliser Rates on Growth and Yield of Tef [*Eragrostis tef* (Zucc.) Trotter] Varieties in Haro Limmu District

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/APRJ/2021/v8i130167
Editor(s):
(1) Dr. Suleyman AVCI, Eskisehir Osmangazi University, Turkey.
Reviewers:
(1) Fatih Hanci, Erciyes University, Turkey.
(2) Kaouther Ardhaoui, Gabes University, Tunisia.
Complete Peer review History: https://www.sdiarticle4.com/review-history/72721

Original Research Article

Received 14 June 2021
Accepted 19 August 2021
Published 20 August 2021

ABSTRACT

Tef (*Eragrostis tef* (Zucc.) Trotter] is one of the most important cereal crops and predominant staple food in Ethiopia. However, its productivity is constrained by a number of problems, lack of site-specific fertilizer recommendation and high yielding varieties are crucial in the study area. Hence, a field experiment was conducted during 2020 main cropping season to identify most productive variety and determine most economically feasible blended NPSZnB fertilizer rate at Farmers Training Center in Ucha Kebele, Haro Limmu district. The experiment included five different NPSZnB fertilizer rates (0, 50,100, 150 and 200 kg ha^{-1}) and three Tef varieties (Negus, Tesfa and local). The treatments were factorially combined and laid out in randomized complete block design with three replications. Days to 50% heading, days to 90% physiological maturity, plant height and thousand seed weight of Tef were significantly influenced by main effect of varieties, blended NPSZnB fertilizer rates and their interactions. Panicle length, dry biomass yield, lodging index, grain yield, straw yield and harvest index of Tef were significantly ($P<0.001$) affected by main effect of blended NPSZnB fertilizer rates and the interactions of the two factors, while the panicle length, dry biomass yield, lodging index and grain yield, straw yield and harvest index of Tef were significantly ($P<0.01$; 0.05) affected by main effect of varieties respectively. Highest (118.20 cm) plant height,

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dry biomass yield (9. 64 t ha^{-1}), straw yield (7.02 t ha^{-1}), grain yield (2.62 t ha^{-1}), thousand seed weight (0.42 t ha^{-1}) and harvest index (27.1%) were recorded from Tesfa variety with 150 kg NPSZnB ha^{-1} blended fertilizer rate. Similarly, the highest (7.42 t ha^{-1}), straw yield, dry biomass yield (9.76 t ha^{-1}), grain yield (2.34 t ha^{-1}), thousand seed weight (0.4 g) and panicle length (44.20 cm) were recorded from Tesfa variety with application of 200 kg NPSZnB ha^{-1} blended fertilizer rate and the highest total number of tillers (10.1) and effective number of tillers (9.7) were recorded with 150 kg NPSZnB ha^{-1} blended fertilizer rate. Grain yield of Tef showed increment by 91.22 % with the application of 150 kg NPSZnB ha^{-1} with Tesfa variety over the control. Highest net profit of ETB 83229.4 with marginal rate of return of 1553.71% was recorded from Tesfa variety with application of 150 kg NPSZnB ha^{-1} blended fertilizer rate. Therefore, farmers of the study area should use Tesfa variety based on the grain yield and net profitability benefits achieved with 150 kg NPSZnB ha^{-1} fertilizer rate to enhance Tef production and productivity. However, this experiment was conducted only for a single season and site, further study has to be done under different seasons and agro-ecologies to make more reliable recommendations.

Keywords: Tef; varieties; NPSZnB rates; yield.

1. INTRODUCTION

Tef [*Eragrostis tef (*Zucc.) Trotter] is ranks prior to maize (*Zea mays*), sorghum (*Sorghum bicolor*) and wheat (*Triticum aestivum* L.) in area coverage, while it stands second in total production after maize in Ethiopia. It is grown annually on 2.93 million hectares of land in Ethiopia with a total production of 5.51 million tons at an average productivity of 1.88 t ha^{-1} [1]. However its productivity is still low as compared to the yield potential due to lack of adequate synthetic-fertilizer input, limited return of organic residues and manure and high biomass removal by erosion, and leaching rates and susceptibility of the crop to lodging [2].

The most important short coming in Tef production is its inherent low productivities of local cultivars and low soil fertility status [3]. Lack of appropriate blended fertilizers and lack of micronutrients in fertilizer blends are the major constraints to higher tef productivity. Therefore, this experiment was caried out to evaluate the effect of blended NPSZnB fertilizer rates, to identify the best performing Tef varieties and to determine economically optimum blended NPSZnB fertilizer rate for Tef production in Haro Limmu district.

2. MATERIALS AND METHODS

The field experiment was conducted from July to December, 2020 main cropping season under rainfed conditions at *Ucha kebele* on farmers training center (FTC) in Haro Limmu district, East Wollega zone of Oromia Regional National State. Haro Limmu is one of the 17 districts in East Wollega zone; it is located between 9° 50' 30" N - 9° 55' 0" latitude and 36' 7' 0"- 36'17' 30" E longitude and a distance of about 20 km from Haro Limmu district in the west direction and with a total land area of 1235.895 km^2.

The district town is located at 491 km from west of Addis Ababa and about 165 km from Nekemte zonal town. Geographically, the district is situated at altitude of 1000 to 2232 m above sea level and the topography of the district is estimated to be 20% mountains, 22% valley and 53% plane. The major soil type of the study area is Nitisols. The soil is clay textured with pH of 5.68, low available of P (7.7 ppm), available S (18.64 ppm) and low available Zn (<0.32 ppm). The experimental site was under wheat cultivation during the previous season.

The agro-climate zone of the district includes highland 0%, midlands 65% and lowland 35%. The total annual rainfall of the study area for 2020 was ranging between 1200-1400 mm and per year with the minimum and maximum temperature of 15 and 27^0c, respectively (HLWANR, 2020). The rainfall of the district was started from April and extended up to mid-November during crop growing period. The area is characterized by heavy and erratic rainfall distribution. The area has crop-dominated mixed crop-livestock farming system. The land is continuously exploited and is poor in fertility and particularly very low in organic matter as crop residues are not left in the fields after harvest basically for straw utilization.

The Tef varieties Negus (DZ-Cr-429 RIL 125) and Tesfa (DZ-Cr-457RIL-181) which were released from Debre Zeit Agricultural Research Center (DZARC) in 2017 and local cultivar were used for the experiment. Negus is very white seeded and high yielding variety, Tesfa is white seeded and high yielding variety resulting from a simple cross and released as an alternative variety and Guyo cultivar is locally cultivated seed. The seeds of Tef varieties were obtained from Debre Zeit Agricultural Research Center [4]. Blended NPSZnB (17.8% N, 35.7% P_2O_5, 7.7% S, 2.2 % Zn and 0.1% B) and Urea fertilizers were used as a source of nitrogen.

The treatment included control (without external fertilizer application) and blended NPSBZn fertilizer rates plus Urea (100 kg ha^{-1}). The experimental design used for this experiment was Randomized Complete Block Design (RCBD) with factorial arrangement of three varieties (Negus, Tesfa and local) and five blended fertilizer rates (0, 50, 100, 150 and 200 kg ha^{-1}) with three replications. The gross experimental area was 37 m x 8 m (296 m^2); each plot area was 2 m X 2 m (4 m^2) and net plot size of 1.4 m x 1.8 m (2.52 m^2) with 10 rows. The spacing between rows, plots and blocks were 0.20 m, 0.5 m and 1 m, respectively. By excluding the two outer rows from both sides of a plot and 0.1 m row length on both ends of each plant, row of each plot to avoid border effects resulting in to a net plot size. The blended NPSZnB fertilizer with the formula (17.8%N, 35.7%P_2O_5,7.7%S, 2.2%Zn and 0.1%B) kg ha^{-1} used in this experiment was selected based on the soil information data of ETHioSIS map [5]. Blended NPSZnB fertilizer rates are applied at sowing time for all plots except control. Supplementary nitrogen fertilizer in the form of Urea was applied in two splits times to maintain the N requirement of the crop.

The experimental field was prepared following the conventional tillage practice. Accordingly, experimental field were ploughed four times with oxen to a fine tilth and the plots was leveled manually. As per the design, a field layout was made and each treatment was assigned randomly to the experimental units within a block.

All blended NPSZnB fertilizer rates and half of the urea fertilizer (50 kg ha^{-1}) was applied in basal application at sowing time for all plots and incorporated into the soil. The remaining 50 kg ha^{-1} of urea was applied at mid tillering stage of the crop (30 days after sowing) in the soil as side-dressing (5 cm away from plants) by making a shallow along the teff row to avoid the contact and then covered with soil. All other agronomic practices were properly carried out as per the recommendation of the crop.

Tef seed was sown on August 10, 2020 manually drilled uniformly at the rate of 10 kg ha^{-1} in 2 m long rows at a depth of about 3 cm in each plot placed 20 cm apart and weeds were removed by hand weeding on September 10, 2020 at maximum tillering and booting stages of growth. Harvesting was done manually on December, 2020 using hand sickles when senescence of the leaves took place as well as the grains came out free from the glumes and when pressed between the forefinger and thumb. The harvested total biomass yields were sun dried for three to five days till constant weight. The total dry matter was weighed by using field balance. Threshing and winnowing were done manually on mat. After threshing, the grain yield was weighed using sensitive digital balance.

Each phenological, crop growth, yield and yield related parameters were measured from each net plot across the treatment level by using the following sampling and analytical procedures.

2.1 Data Collected

Days to 50% panicle emergence: It was recorded by counting the number of days from emergence to heading (when 50% of the plants started to form panicles). Visual observation was used to determine heading of the plants.

Days to 90% physiological maturity: Number of days from sowing up to the date when 90% of the plants reached physiological maturity based on visual observation, which was indicated by senescence of the leaves as well as free threshing of seeds from the glumes when pressed by thumb and the forefinger.

Plant height: It was measured at physiological maturity from the ground level to the tip of the main shoot panicle on ten pre-tagged random samples of plants in the central rows of the net plot area.

Panicle length: The length of the panicle from the node where the first panicle branches were emerged to the tip of the panicle was measured the main shoot panicle for ten pre-tagged random samples of plants in the central rows of the net plot area.

Number of total tillers: It was counted at physiological maturity by counting all the tillers in 0.5 m length from two central rows of the net plot areas.

Number of productive tillers: It were recorded by counting the tillers from an area of 0.5 m length from two rows of net plot at maturity stage.

1000-seed weight: It were recorded by carefully counting a random sample of the small grains harvested from the net plot area and weighing them using a digital balance.

Dry biomass yield: The weight (kg) of the whole above-ground plant biomass including, leaves, stems, seeds and chaff of all the crops harvested from the net plot area after sun drying was recorded at maturity and was converted as tha^{-1}.

Grain yield: It was taken as the weight (kg) of the grains harvested from the net plot area after threshing and sun-drying to about 12.5% moisture content. It was converted to grain in $t\ ha^{-1}$.

Straw yield: After threshing and measuring the grain yield; the straw yield was obtained by subtracting the grain yield from the total above-ground biomass yield.

Harvest index: It was calculated by dividing grain yield by the total above ground biomass yield and multiplying by 100.

Lodging index: The degree of lodging was assessed just before the time of harvest by visual observation based on the scales of 1-5 where 1 (0-15^o) indicates no lodging, 2 (15-30^o) indicate 25% lodging, 3 (30-45^o) 50% indicate lodging, 4 (45-60^o) indicate 75% lodging and 5(60-90^o) indicate 100% lodging (Donald, 2004). The scales were determined by the angle of inclination of the main stem from the vertical line to the base of the stem by visual observation. Each plot was evaluated based on the displacement of the aerial stem into all scales by visual observation. Each scale was multiplied by the corresponding percent given for each scale and average of the scales represents the lodging percentage of that plot.

2.2 Statistical Analysis

The collected data were analyzed using the General Linear Model (GLM) procedure (SAS version 9.0) [6]. Mean values were separated according to following the standard procedure given by Gomez and Gomez [7]. Whenever the effects of the treatments were found to be significant, the means were compared using 5% level of Least Significant Difference [8].

2.3 Economic Analysis

Economic analysis was conducted as per the partial budget analysis procedure described by CIMMYT [9]. Economic analysis of Tef production was done to identify the profitability fertilizer rates for the tested Tef varieties. This analysis was performed in order to evaluate the economic feasibility of the treatments at the minimum rate of return 50 to 100% [9]. Grain and straw yield of Tef from experimental plots was adjusted down ward by 10% for management and plot size differences to regulate the difference between the experimental yield and the yield that farmers could expect from the same treatment. Farm gate prices of Tef in Ethiopian birr were the average price of one month from the time of crop harvesting.

Partial budget analysis was done to obtain the highest net benefit and the lowest net benefit return among treatments. The dominant market values of the inputs at the time of use were taken into consideration for working out the cost of cultivation (cost of NPSBZn 19.0871 ETB kg^{-1}, Urea 16.2151 ETB kg^{-1}, Negus and Tesfa and Local Tef seed 37.50 and 29.4 ETB kg^{-1}respectively, market price of Tef grain 41 ETB kg^{-1}, sale price of Tef straw 1.50 ETB kg^{-1}) were considered and other input costs used as constant for all treatments.

3. RESULTS AND DISCUSSION

3.1 Days to 50% Panicle Emergence

The main effect of varieties, blended fertilizer rates and interactions of the two factors showed highly significant ($p<0.001$) effect on days to panicle emergence. The result showed that the maximum (68.20) days to 50% heading were recorded from local cultivar whereas a minimum (58.60) day to 50% was obtained from Negus variety (Table 1). This difference could be attributed to the genetic makeup of the varieties.

The highest (77 days) number of days to panicle emergence was observed from local cultivar, which was statistically at par with Tesfa variety under the control plots whereas the shortest (53 days) days to panicle emergence was recorded from Negus variety with application of 150 kg NPSZnB ha^{-1} blended fertilizer rate. Even though the 50% panicle emergence was extended one genotypes (local cultivar) within, the increase of blended NPSZnB fertilizer rates the growth periods of Negus variety in each application of blended NPSZnB fertilizer rate was lower than local cultivars in the same level of blended fertilizer application.

The observed variation might be due to genetic factor; moreover, as the blended fertilizer application rates increased from 0 to 150 kg ha^{-1}, the days to 50% panicle emergence decreased due to application of blended fertilizers hastened days to panicle emergence, because plants were able to take up sufficient nutrients from the soil which encouraged early establishment, rapid growth and development of crop. This result agreement with Seifu [10], who stated that the highest (73 days) days to 50% panicle emergence, was recorded from the control plot, while the lowest (50 days) was recorded from the combined application of 138 kg N and 200 kg NPSZnB ha^{-1} blended fertilizer. The application of supplementary N hastened the days to heading possibly because the Tef plants were able to take up sufficient N from the soil and also because N may have enhanced the uptake of other nutrients such as P and S which might speed up growth and development of the crop [11].

3.2 Days to 90% Physiological Maturity

The main effect of varieties, blended NPSZnB fertilizer rates and interaction of the two factors had highly significant ($p<0.001$) effect on days to 90 % physiological maturity of Tef (Table 2). Improved variety (Tesfa and Negus) took the shortest (115 and 115.26 days) to reach 90% physiological maturity, while the longest (118.66 days) to reach 90% physiological maturity was recorded on local cultivar (Table 2). The significant difference in days to 90 % physiological maturity between the varieties might have occurred due to genetic differences and adaption of the varieties to different components of the environment (Temesegen, 2001).

Table 1. Interaction effect of varieties and blended NPSZnB fertilizer rates on days to 50% heading of Tef in Haro Limmu district

Varieties	NPSZnB fertilizer rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Negus	73.00^{bc}	56.33^{fgh}	55.33^{gh}	53.00^{h}	55.33^{gh}	58.60
Tesfa	74.30^{ab}	64.66^{d}	59.33^{ef}	60.66^{e}	57.00^{fg}	63.20
Local	77.00^{a}	70.00^{c}	70.00^{c}	62.00^{de}	62.00^{de}	68.20
Mean	74.76	63.66	61.55	58.55	58.11	
LSD (5%)			3.37			
CV (%)			3.18			

Means with the same letter(s) in the same columns and rows of each parameter are not significantly different at 5% probability level

Table 2. Interaction effect of varieties and blended NPSZnB fertilizer rates on days to 90% physiological maturity of Tef in Haro Limmu district

Varieties	NPSZnB fertilizer rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Negus	118.66^{abc}	116.33^{bc}	116.33^{bc}	112.66^{de}	111.00^{e}	115.00
Tesfa	117.66^{abc}	116.33^{bc}	115.66^{cd}	115.66^{cd}	111.00^{e}	115.26
Local	120.33^{a}	119.33^{ab}	117.33^{abc}	119^{abc}	117.33^{abc}	118.66
Mean	118.88	117.33	116.44	115.77	113.11	
LSD (5%)			3.34			
CV (%)			1.71			

Means with the same letter(s) in the same columns and rows of each parameter are not significantly different at 5% probability level

The longest (120.33 days) days of 90% physiological maturity of Tef was recorded from local cultivar at control plot. While, the shortest (111 days) days to 90 % physiological maturity was recorded from Negus and Tesfa varieties with application of 200 kg NPSZnB ha^{-1} fertilizer rates. An increase in blended NPSZnB fertilizer rates from 0 to 200 kg ha^{-1} decreased days to 90 % physiological maturity (Table 2). Application of 200 kg blended NPSZnB ha^{-1} on Tesfa variety gave higher enhanced maturity of 7.75% over the control with local cultivar. The early maturity of improved varieties might be due to application of blended NPSZnB fertilizer rate that enhance maturity could be due to the presence of balanced fertilizer in the blended fertilizer and treated with supplementary N show better vegetative growth and that treated with P fertilizer exhibit good root development to reach physiological maturity in time.

Phosphorus application could possibly shorten maturity date since it promotes rapid cell division. However, the delay of physiological maturity in unfertilized plots may be due to insufficient number of essential elements. Onasanya et al. [12] also reported that phosphorus plays an important role in many physiological processes that occur within a developing and maturing plants. To some extent the presence of Zn and B in blended fertilizer might have also helped in enhancing the days to attain early physiological maturity due to fact that Zn and B played an important role in protein synthesis, formulation of some growth hormones and promoted flowering and seed maturation as reported [13]. In alignment with this result, Seifu [10] reported that the shortest (95) days to physiological maturity of Tef were obtained from the application of 150 kg NPSB ha^{-1} and 69 kg N ha^{-1} and the longest (106) days from the control.

3.3 Plant Height

The main effect of varieties, NPSZnB fertilizer rates and interaction of the two factors had highly significant ($p<0.001$) effect on plant height of Tef. In case of variety, the highest (101.25 cm) plant height was obtained from Tesfa variety and the shortest (90.28 cm) plant height was recorded for Negus variety (Table 3). The difference in plant height of the varieties could be attributed to the difference in their genetic makeup [14].

The interaction of blended 150 kg NPSZnB ha^{-1} fertilizer rates with Tesfa variety gave higher plant height (118.2 cm) which was statistically at par with the same variety with 200 kg NPSZnB ha^{-1} and local cultivar with 200 kg NPSZnB ha^{-1} fertilizer rates respectively (Table 3). While the shortest (69.40 cm) plant height was recorded from Negus variety with unfertilized plots. Application of 150 kg blended NPSZnB ha^{-1} on Tesfa variety gave higher plant height of 32.80% over the control with local cultivar. The increase in plant height might be due to the adequate amount of nitrogen in the high rate of blended NPSZnB fertilizer; which promoted the vegetative growth of the Tef and due to the inherent genetic differences among varieties. Furthermore, the increase in plant height in response to the increased blended NPSZnB application rate might be due to the maximum vegetative growth of the plants under higher N, P and S availability. Plant growth and development may be retarded substantially if any of the nutrient elements is less than its threshold amount in the soil or not adequately supplemented with other nutrient elements [15].

Table 3. Interaction effect of varieties and blended NPSZnB fertilizer rates on plant height (cm) of Tef in Haro Limmu district

Varieties	NPSZnB fertilizer rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Negus	69.40^{h}	86.30^{d}	96.76^{d}	101.03^{cd}	97.93^{cd}	90.28
Tesfa	75.16^{gh}	95.73^{de}	104.63^{bcd}	118.20^{a}	112.53^{ab}	101.25
Local	79.43^{fg}	98.80^{cd}	100.86^{cd}	107.50^{bc}	112.50^{ab}	99.82
Mean	74.66	93.61	100.75	108.91	107.65	
LSD (5%)			9.75			
CV (%)			6.00			

Means with the same letter(s) in the same columns and rows of each parameter are not significantly different at 5% probability level.

Tamene et al. [16] reported that effect of N rates under blended fertilizer of PKSZnB had a highly significant effect on plant height as compared to negative control and standard control (92 N, 69 P_2O_5 kg ha^{-1}) when N levels increased from 0 - 222 kg ha^{-1}. Similarly, Fissehaye et al. [17] stating that Tef plant height could be higher due to increased amount of N fertilizer (92 kg N ha^{-1}). This result is also in agreement with Dagne [18] who reported that application of blended fertilizers and blanket NP recommendation significantly increased plant height as compared to the control. Similar result was reported by Teshome [19] where application of 200 kg NPSZnB ha^{-1} blended fertilizer combined with 138 kg N ha^{-1} significantly increased plant height of Tef.

3.4 Panicle Length

The main effect of NPSZnB fertilizer rates, varieties and interaction of the two factors had highly significant ($p<0.001$) effect on panicle length of Tef. The longest (38.75 cm) panicle length was recorded from local cultivar while the shortest (34.07 cm) panicle length was obtained from Negus variety (Table 4). This variation could be related to varietal difference in panicle length which is governed by genetic makeup of the genotype and the environmental effect (Shahzad et al., 2007).

The highest (44.53 cm) panicle length was recorded from local cultivar with 200 kg NPSZnB ha^{-1} blended fertilizer rate, which is statistically at parity with Tesfa variety with application 150 kg NPSZnB ha^{-1} blended fertilizer rate, whereas the lowest (28.13 cm) panicle length was recorded from Tesfa variety with unfertilized plots (Table 4). Application of blended 200 kg NPSZnB ha^{-1} fertilizer rates with the local cultivar increased panicle length by 36.36 % over the control with local cultivar. This might be due to the synergic effect of maximum rates of blended NPSZnB fertilizer and improved Tef variety.

This highest panicle length is due to efficient utilization of blended NPSZnB fertilizer with nitrogen which plays critical role in the structure of chlorophyll and other proteins which favor vegetative growth of Tef and results in taller Tef plants having relatively greater panicle length. Panicle length is an indicator of sink capacity which differed significantly with the varieties. Fayera et al. [20] reported that the longest (45.60 cm) panicle length was recorded from the application of 150 kg NPKSZnB ha^{-1} blended with 23 kg N ha^{-1} while the shortest (30.17 cm) was recorded from the control.

3.5 Total Number of Tillers

The main effect of varieties and blended NPSZnB fertilizer rates had highly significant ($P<0.001$) effect on total number of tillers, while, the interaction of the two factors was non-significant (Table 5). The highest (8.20) total number of tillers was recorded from Tesfa variety and the lowest (4.34) total number of tillers was recorded from local cultivar. Tesfa variety gave the maximum total number of tillers which exceed by 47.07 % over the local cultivar. The highest tillers difference might be due to inherent genetic variability of Tef varieties, thus resulted in early production of more number of tillers. In line with this result, Fayera et al. [20] reported that tillering capacity of the variety determines number of tillers produced per plant

Table 4. Interaction effect of varieties and blended NPSZnB fertilizer rates on panicle length (cm) of Tef in Haro Limmu district

Varieties	NPSZnB fertilizer rates (kg ha^{-1})					
	0	**50**	**100**	**150**	**200**	**Mean**
Negus	28.40^{h}	32.73^{fgh}	37.46^{cdef}	37.40^{cdef}	34.36^{efg}	34.07
Tesfa	28.13^{h}	34.30^{efg}	36.56^{defg}	42.46^{abc}	44.20^{ab}	37.13
Local	31.66^{gh}	37.53^{cdef}	39.10^{bcde}	40.93^{abcd}	44.53^{a}	38.75
Mean	29.40	34.85	37.70	40.26	41.03	
LSD (5%)			5.34			
CV (%)			8.72			

Means with the same letter(s) in the same columns and rows of each parameter are not significantly different at 5% probability level

The highest (10.10) total number of tillers was recorded with application of 150 kg NPSZnB ha^{-1} blended fertilizer rate and the lowest (2.43) total number of tillers was recorded from plots without application of fertilizer. Application of 150 kg NPSZnB ha^{-1} blended fertilizer increased total number of tillers by 75.94 % over the control. The possible reason for increment in number of total tillers might be due to the effect of balanced 150 kg NPSZnB ha^{-1} fertilizer rate in which readily soluble minerals help to the vegetative growth of the crop.

However, increasing the rate of the blended NPSZnB fertilizer with 150 to 200 kg ha^{-1} did not increase the total number and effective number of tillers. The total number of tillers formed is a major factor that affects grain yield in Tef. In alignment with this result, Mulugeta and Shiferaw [21] reported significantly higher number of tillers in response to the application of 36.8 kg N combined with 150 kg PKSZnB ha^{-1} fertilizer rate in Tef. Similarly, this result is in agreement with that of Fenta [22] who reported that application of blended fertilizer (69 kg N ha^{-1}+ 46 kg P_2O_5+ 22 kg S ha^{-1}+ 0.3 kg Zn ha^{-1}) brought significant increase in total tillers (15) of Tef as compared to (5) tillers per plant of unfertilized plot.

3.6 Effective Number of Tillers

The main effect of NPSZnB fertilizer rates and varieties had highly significant ($p<0.001$) effect on effective number of tillers, but interaction of the two factors was non- significant (Table 5). The highest (7.91) effective number of tillers was obtained from Tesfa variety and the lowest (3.90) effective numbers of tillers were recorded from local cultivar.

The highest (9.7) number of effective tillers was recorded with the application of 150 kg NPSZnB ha^{-1} blended fertilizer from Tesfa variety with improved Tef variety. While the lowest (2) number of effective tillers was recorded from plots without application of fertilizer. Application of 150 kg NPSZnB ha^{-1} blended fertilizer on Tesfa variety increased the number of effective tillers by 50.7% over the control. The highest productive number of tillers might be due to sufficient amount of growth and development of plants owing to the essential elements under blended NPSZnB fertilizer condition. Lower or unfertilized plots contribute for competition of tillers for growth factors that lead to the production of low numbers of productive tillers per unit area.

In agreement with, Fayera et al. [20] reported that the highest productive tillers of Tef under the application of 200 kg NPKSZnB ha^{-1}blended (14 N, 21 P_2O_5, 15 K_2O, 6.5 S, 1.3 Zn and 0.5 B) + 23 kg N ha^{-1} fertilizer. Likewise, Wakjira (2018) where productive tillers number of Tef was increase from 8.62 to 15.17 under the application of zero and 120 kg NPS ha^{-1} blended fertilizer rates, respectively.

Table 5. Main effects of varieties and NPSZnB fertilizer rates on total tillers and effective tillers of Tef in Haro Limmu district

Varieties	Total number of tillers	Effective number of tillers
Negus	6.60^{b}	6.28^{b}
Tesfa	8.20^{a}	7.91^{a}
Local	4.34^{c}	3.90^{c}
LSD (5%)	1.77	1.77
NPSZnB fertilizer rates(kg ha^{-1})		
0	2.43^{c}	2.00^{c}
50	3.87^{c}	3.44^{c}
100	7.47^{b}	7.18^{b}
150	10.10^{a}	9.70^{a}
200	8.04^{b}	7.81^{b}
Mean	6.38	**6.0**3
LSD (5%)	1.37	1.38
CV (%)	29	30

Means with the same letter(s) in the same columns and rows of each parameter are not significantly different at 5% probability level.

3.7 Grain Yield

Grain yield is the result of different inputs, agronomic practices, environment effects and genetic differences. The main effect of blended NPSZnB fertilizer rates and interaction of the two factors had highly significant ($P<0.001$) effect on grain yield of Tef and main effect of varieties had significant ($P<0.05$) effect on grain yield of Tef (Table 6). The highest (1.57 t ha^{-1}) grain yield was recorded from Tesfa variety while the lowest (1.27 t ha^{-1}) grain yield was obtained from local cultivar (Table 6). This is because of genotypic deferential in terms of yielding ability. As compared to other varieties and Tesfa is high yielding than local cultivar.

The interaction of blended NPSZnB fertilizer and varieties was significantly affected the mean grain yield of Tef. Significantly, a higher (2.62 and 2.34 t ha^{-1}) grain yield was recorded from Tesfa variety with application of 150 and 200 kg NPSZnB ha^{-1} blended fertilizer rates respectively; while the lowest (0.23 t ha^{-1}) grain yield was obtained from Tesfa variety at control plots (Table 6). Tesfa variety with 150 and 200 kg NPSZnB ha^{-1} blended fertilizer produced a higher grain yield, which exceeds by 91.22 % and 90.17 % over unfertilized Tesfa variety. Grain yield of Tef showed the progressive increments on all varieties with increased application of blended NPSZnB fertilizer rates up to 150 kg NPSZnB ha^{-1}. However, further application of beyond 150 kg NPSZnB ha^{-1} fertilizer showed a declining trend on Tef grain yield due to attributed to excess supply of the nutrient that favors more vegetative growth of plant parts leading to lodging before the translocation of dry matter to grain.

The higher Tef yield obtained might be due to the synergic effect of optimum level of nutrient and improved variety of Tef. These might have increased nutrients availability, photosynthesis, and greater mobilization of photosynthates towards reproductive structures of improved variety Tesfa, which contributed to respond and produce higher yields than unfertilized plots. In conformity Kinfe [23] reported that the highest grain yield (2269.80 kg ha^{-1}) was obtained from plots treated with 150 kg NPS ha^{-1} plus basal application of Zinc and Boron which increased over the control by 321.42% and lowest (538.60 kg ha^{-1}) was found from control. Likewise, Teshome [19] reported that application of 100 kg NPSZnB ha^{-1} fertilizer produced the highest (1386.5 kg ha^{-1}) grain yield of Tef, while the lowest (1085.8 kg ha^{-1}) grain yield was obtained under the control treatment.

3.8 Straw Yield

The straw yield of Tef was significantly affected by the main factors of varieties ($p<0.05$), blended NPSZnB fertilizer rate ($p<0.001$) and the interaction of blended NPSZnB fertilizer with varieties ($p<0.001$) (Table 7). The highest (5.75 t ha^{-1}) grain yield was recorded from Tesfa variety while the lowest (4.43 t ha^{-1}) grain yield was obtained from local cultivar (Table 7). This difference in straw yield might be due to the genetic makeup of the varieties.

The highest (7.42 t ha^{-1}) straw yield was recorded from Tesfa variety with application of 200 kg NPSZnB ha^{-1} blended fertilizer rate, which was statistically at par with 100 and 150 kg NPSZnB ha^{-1} on the same variety and Negus variety and local cultivar with 150 and 200 kg NPSZnB ha^{-1} fertilizer rate. While the lowest (0.23 t ha^{-1}) straw yield was obtained from local cultivar with unfertilized plots (Table 7). Application of blended 200 kg NPSZnB ha^{-1} fertilizer on Tesfa variety gave 96.78% higher straw yield over NPSZnB un-fertilized treatment with local cultivar. The increment of straw yield could be due to the vegetative growth as the result of high N-level from 200 kg NPSZnB ha^{-1} and the synergic effect with improved variety. The highest plant height and tillers also have great contribution to higher straw yield. Therefore, low straw yield in unfertilized plots might have been due to reduced leaf area development resulting in reduced radiation interception and, consequently, low efficiency in the conversion of solar radiation.

This result agreed with Teshome [19] who reported that straw yield of Tef was significantly affected by application of blended fertilizer which exceeds 7 % and 490 % over the recommended NP and control plots respectively. Similarly, Tekle and Wassie [24] reported that straw yield of Tef was found to be highest in blended fertilizers as compared to control treatments and recommended rate blanket NP applications. Likewise, Fayera et al. [20], who reported that the highest (5852.8 kg ha^{-1}) straw yield of Tef was obtained in response to the application of higher rates 200 kg NPSZnB $ha^{-1}$of blended fertilizer application. Straw yield of Tef has to be considered while evaluation of any agronomic practice as its importance has become as equal as its grain yield as it is preferred as animal feed during dry period and also sold at reasonable price.

Table 6. Interaction effect of varieties and blended NPSZnB fertilizer rates on grain yield (t ha^{-1}) of Tef in Haro Limmu district

Varieties	NPSZnB fertilizer rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Negus	0.39^{ef}	0.83^{de}	1.86^{c}	1.98^{bc}	1.70^{c}	1.35
Tesfa	0.23^{f}	0.87^{d}	1.78^{c}	2.62^{a}	2.34^{ab}	1.57
Local	0.39^{ef}	1.03^{d}	1.58^{c}	1.82^{c}	1.54^{c}	1.27
Mean	0.34	0.91	1.74	2.14	1.86	
LSD (5%)				0.43		
CV (%)				18.67		

Means with the same letter(s) in the same columns and rows of each parameter are not significantly different at 5% probability level.

Table 7. Interaction effect of varieties and blended NPSZnB fertilizer rates on straw yield (t ha^{-1}) of Tef in Haro limmu district

Varieties	NPSZnB fertilizer rates (kg ha^{-1})					
	0	50	100	150	200	Mean
Negus	0.26^{e}	4.44^{d}	5.79^{bcd}	6.35^{ab}	6.70^{ab}	5.18
Tesfa	0.27^{e}	4.64^{cd}	6.90^{ab}	7.02^{ab}	7.42^{a}	5.75
Local	0.23^{e}	4.76^{cd}	4.48^{d}	6.07^{abc}	6.62^{ab}	4.43
Mean	0.76	4.61	5.72	6.48	6.91	
LSD (5%)				1.43		
CV (%)				16.35		

Means with the same letter(s) in the same columns and rows of each parameter are not significantly different at 5% probability level.

4. CONCLUSIONS

Tef production is highly dependent on soil available nutrient, environmental factors and plant genotypes for plant growth and production. The current information on effect of blended NPSZnB fertilizer rates and improved variety of Tef is very important to come up with profitable and sustainable Tef production. The physico-chemical properties of the soil before sowing was indicated has poor soil fertility especially nutrients P, S Zn, which need amendments to increase crop production in the study area.

It is possible to conclude that varieties and blended NPSZnB fertilizer rates affect all phenology, growth, yield and yield related parameters of Tef. All agronomic data except phenological traits; panicle length, plant height, above ground biomass yield, lodging index, grain yield, straw yield, thousand seed weight and harvest index were increased as blended NPSZnB fertilizer rates increased. Growth parameters, total number of tillers, effective number of tillers, harvest index and Tef grain yield have showed increment up to blended 150 kg NPSZnB ha^{-1} fertilizer and showed again the reduction trend beyond this rate. The synergetic effect of blended 150 kg NPSZnB ha^{-1} rate fertilizer with improved variety showed improvement on grain yield and yield components of Tef in the study area.

The interaction effect of varieties and blended NPSZnB fertilizer rates showed significant difference in all agronomic data parameters. The highest (77 days), number of days to 50 % heading 90 % physiological maturity (120.33 days) was recorded from the unfertilized treatments and plant height (118.2 cm), total number of tillers (10.1), effective number of tillers (9.7), grain yield (2.62 t ha^{-1}), thousand seed weight (0.42 g) and harvest index of (27.1%) was recorded with 150 kg NPSZnB ha^{-1} blended fertilizer rate and highest panicle length (44.20 cm), straw yield (7.42 t ha^{-1}), grain yield (2.34 t ha^{-1}) and dry biomass yield (9.76 t ha^{-1}) was obtained with 200 kg NPSZnB ha^{-1} fertilizer rate. Among the varieties used for study Tesfa variety is the best performing in the study area.

Application of blended 150 kg NPSZnB ha^{-1} fertilizer rate on Tesfa variety improved growth, yield and yield components of Tef; and gave maximum yield (2.62 t ha^{-1}) with net benefit of ETB 83229.4 ha^{-1} and with a marginal rate of return (1553.71%) in the study area.

5. RECOMMENDATIONS

For Tef production in the western part of Ethiopia, increasing Tef yield with acceptable grain yield from different combined treatments with optimum application of NPSZnB fertilizer rate is very important in the future. Therefore, Tesfa variety with application of 150 kg NPSZnB ha^{-1} blended fertilizer rate was recommended for the study area. However, in the absence of Tesfa variety, Negus variety with 150 kg NPSZnB ha^{-1} fertilizer rate can be considered an alternative variety to be recommended for the farmers in Haro Limu district and other areas with similar agro-ecological conditions.

Moreover, emphasis and consideration should be given for the future research in similar topic; since the experiment was conducted only for one season and one site, repeating the trial at different sites as well as in the same trial site would be important in order to draw sound recommendations and blended NPSZnB fertilizer application did not give a clear response for yield and yield components of Tef without the additional application of urea fertilizer.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. CSA (Central Statistical Agency of Ethiopia). Agricultural sample survey 2020/21 (2012 E.C) report on area and production of major crops for private peasant holdings, Meher Season. 2020;I. Addis Ababa.
2. Tesfay T, Gebresamuel G. Agronomic and Economic Evaluations of Compound Fertilizer Applications under Different Planting Methods and Seed Rates of Tef [*Eragrostis tef (*Zucc.) Trotter] in Northern Ethiopia. Journal of the Dry lands. 2016; 6(1):409-422.
3. Abayu B. Agronomic and Economic Effects of Blended Fertilizers under Planting Method on Yield and Yield Components of Tef. M.Sc. Thesis, Mekelle University, Mekelle, Ethiopia; 2012.
4. MoA. Crop Variety Register. Issue No. 13, June 2010, Addis Ababa, Ethiopia. 2010; 227.
5. EthioSIS (Ethiopia Soil Information System). Soil Fertility Status and Fertilizer Recommendation Atlas for Tigray Regional State, Ethiopia Addis Ababa, Ethiopia; 2014.
6. SAS. SAS/STAT User's Guide, Version 9.0. SAS institute Inc., Cary, NC; 2002.
7. Gomez K, Gomez A. Statistical Procedure for Agricultural Research, 2nd ed. John Willey and Sons, New York. 1984;680.
8. Steel R, Torrie J, Dicky D. Principles and Procedures of Statistics, a Biometrical Approach. 3rd Edition, McGraw Hill, Inc. Book Co., New York. 1997;352-358.
9. CIMMYT (Centro International de Mejoramiento de Maiz y Trigo). From Agronomic Data to Farmer Recommendations: An Economics Work book. Mexico, D. F. CIMMYT; 1988.
10. Seifu K. Effect of rates of blended and N fertilizers on yield components and yield of Tef (*Eragrostis tef* (Zucc.) Trotter) in Hidhabu Abote ditrict, central Ethiopia. M.Sc Thesis Haramaya University, Ethiopia; 2018.
11. Temesgen K. Effect of sowing date and nitrogen fertilization on Yield and related traits of Tef [Eragrostis tef (Zucc.) Trotter] on Vertisols of Kobo area, Northern Wollo. MSc Thesis, Alemaya University, Alemaya, Ethiopia; 2001.
12. Onasanya R, Aiyelari O, Oikeh S, Nwilene F, Oyelakin O. Growth and yield response of Maize (*Zea mays* L.) to different rates of nitrogen and phosphorus fertilizers in southern Nigeria. World Journal Agricultural Science. 2009;5:400–407.
13. Tisdale L, Nelson L, Beaton D, Haulin J. Soil Fertility and Fertilizers Macmillan publishing campany. New York, Toronto. Oxford and Singapore. 2002;633.
14. Jemal A, Tamado T, Firdissa E. Response of Bread Wheat (*Triticum aestivum* L.)Varieties to Seeding Rates at Kulumsa, South Eastern Ethiopia. Asian Journal of Plant Sciences. 2015;14(2):50-58.
15. Landon J. Booker Tropical Soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. (Eds.) John Wiley and Sons Inc., New York. 1991;47.
16. Tamene D, Anbessa B, Legesse T, Dereje G. Refining fertilizer rate recommendation for maize production systems in Assosa, North WesternEthiopia. Advanced Techniques in Biology and Medicine. 2018; 6:253.

17. Fissehaye M, Mitiku H, Fassil K, Alemteshay T, Charles Y. Response of Tef [*Eragrostis tef* (Zucc) Trotter] to phosphorus and nitrogen on a Vertisol at North Ethiopia. Journal of the Dry lands. 2009;2(1):8-14.
18. Dagne C. Blended fertilizers effects on maize yield and yield components of Western Oromia, Ethiopia. Agriculture, Forestry and Fisheries. 2016;5(5):151-162.
19. Teshome M. Effects of Nitrogen and Blended Fertilizers on Yield and Yield Components of Tef [(*Eragrostis tef* (Zucc.) Trotter] in Ada'a District, Central Highlands of Ethiopia. MSc. Thesis Hawassa University College of Agriculture. 2018; 88.
20. Fayera A, Adugna D, Muktar M. Evaluation of Tef [Eragrostistef (Zuccagni) Trotter] Responses to Different Rates of NPK Along With Zn and B in Didessa District, Southwestern Ethiopia. World Applied Sciences Journal. 2014;32(11):2245-2249.
21. Mulugeta H, Shiferaw B. Influence of balanced nutrients on growth performance and yield of Tef (*Eragrostis tef* (Zucc.) Trotter) in the midland of Bensa, Southern Ethiopia, Journal of Scientific and Innovative Research. 2017;6(3):101-103.
22. Fenta A. Effect of Tef variety and rates of nitrogen fertilizer application on growth and yield components under Jimma condition. ARPN Journal of Agricultural and Biological Science. 2018; 13(3):34-42.
23. Kinfe T. Evaluation of NPSZnB fertilizer levels on yield and yield. Journal of Cereals oil Seeds. 2019;10(2):54–63.
24. Tekle L, Wassie H. Response of Tef (*Eragrostis tef* (Zucc.) Trotter) to Blended Fertilizers in Tembaro, Southern Ethiopia. Journal of Biology, Agriculture and Healthcare. 2018;8(13):34-39.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/72721