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Evaluation of Teff [*Eragrostistef* (Zuccagni) Trotter] Responses to Different Rates of NPK Along With Zn and B in Didessa District, Southwestern Ethiopia

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Abstract: Teff (*Eragrostistef* (Zuccagni) Trotter) is a major food crop in Ethiopia. It is well adapted to highland soils of the country. Yields are low (in average about 1280 kg ha^{-1}) even though nitrogen and phosphorus fertilizers were applied at a recommended rate. The experiment was conducted during 2013 main cropping season in Didessa District of Southwestern Ethiopia, with the objectives of determine the response of teff to different rates of NPK and blended fertilizers on grain yield and yield components. The local variety Gero at seed rate of 25 kg ha^{-1} as a test crop and 14 treatments (eleven different rates of NPK, two-blended fertilizer and control) were used and laid out in randomized complete block design (RCBD) with four replications. Result of different rates of NPK and blended fertilizers showed significant differences and enhanced yield and yield components. The largest panicle length, highest productive tillers, heaviest panicle grain weight and 1000-grain weight, highest biomass and grain yield (2147.7 kg ha^{-1}) were recorded under the application of 200 kg ha^{-1} of Zn + B blended fertilizer containing 14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B + 23 kg N ha^{-1}. Therefore, to produce high yield of teff at Didessa District as well as at area of Zn and B deficient soils in Ethiopia, application of 200 kg ha^{-1} of Zn + B blended (14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B) + 23 kg N ha^{-1} fertilizer is the promising choice than application of Urea and DAP alone practiced in the area.

Key words: Teff · Zinc · Biomass · Blended fertilizer · Panicle · Tillers

INTRODUCTION

Teff (*Eragrostistef* (Zuccagni) Trotter) is a panicle bearing C_4 cereal crop originating from Ethiopia [1]. It is considered as one of the most important cereal crops in the country. It accounts for about a quarter of the total cereal production of the country [2]. During the 2012 cropping season teff occupied the largest area 22.6% of the cultivated land from the total area of cereals (86.06%). In spite of the significant growth in terms of area cultivated under teff production, yield is still very low [3]. However, 4600 kg ha^{-1} yield was considered as a good approximation of the yield potential of teff under rain fed conditions of Ethiopia [4]. This implies the quantity of yield currently produced in the country is below this expected potential of the crop.

Some of the major causes of low teff yield are inability of farmers to use the required quantities of mineral nutrition and unbalanced chemical fertilizer application [5, 6]. Besides, decline in soil organic matter and insufficient attention to crop nutrient studies greatly contributed to the loss of soil fertility resulting in severe nutrient reduction of soils [7]. It is known that Ethiopia has the highest soil nutrient outflow rates of 10 kg ha^{-1} while inflows from application of fertilizers are very low (<10kg ha^{-1}) [8].

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Fertilizer usage is one instrument implemented as a means of raising production and income of farm households [9]. However, the extent to which fertilizers are used still differs considerably between various regions of the world [10]. In Ethiopia, DAP (diammonium phosphate) and urea are the only chemical fertilizers used for crop production with initial understanding that nitrogen and phosphorus are the major limiting nutrients of Ethiopian soils [11]. There are many studies to improve agricultural productivity using urea and DAP in Ethiopia. Plant growth and crop production require an adequate supply and balanced amounts of all nutrients but the use of urea and DAP are totally neglected the use of micronutrients [10]. Since deficiency of micronutrients is reported in tropical soils, necessitate the application of nutrient sources that reduce such deficiencies [12]. This can only be achieved if the nutrient content of the fertilizer fits to the needs of the crops. Blended fertilizers containing both macro- and microelements may possess this characteristic. Therefore, the present study was initiated with the objective of determine the response of teff to different rates of NPK and Zn and B blended fertilizers.

MATERIALS AND METHODS

The experiment was conducted at Didessa District of Illubabor Zone, Southwestern Ethiopia on farmers' field from July - October during the main rain season of 2013. The area lies between 7°50'- 8°10' N and 36°30' -36°45' E and is located at an altitude of 2260 masl with varying mean annual rainfall of 1800-2200 mm. The mean daily temperature ranges from 13 and 28°C. The soil type of the area is clay loam. The experiment was laid out in a randomized complete block design (RCBD) with four replications. The size of each plot was 5m wide and 10m long ($50m^2$ area) with 0.5m space between plots. Urea, TSP (triple superphosphate), KCl and blended fertilizers (Zinc + Boron blended and Zn blended) were used as a treatment source for the experiment (Table 1). The chemical composition of Zn + B blended fertilizer comprised 14N, $21P_2O5$, $15K_2O$, 6.5S, 1.3Zn and 0.5B whereas Zn blended fertilizer contains 23N, $23P_2O_5$, 8.2S and 1.2Zn in percentage. In both blended fertilizer 23kg N ha^{-1} was added to make up for the shortfall of N fertilizer. Teff local variety Gero @25 kg seed ha^{-1} was used and sown in broadcast.

Growth variables, yield components and yield data were collected following procedures developed for each of the variable. The collected data were statistically analyzed by ANOVA using SAS vr. 9.2 statistical software [13]. The treatment means were separated using LSD at 5% level of probability.

RESULTS AND DISCUSSIONS

Panicle length is one of the yield attributes of teff, which contributes to high grain yield as well as biomass yield. Crops with high panicle length could have higher

Table 1: Treatments and fertilizer combinations used in the experiment.

Treatment code	Treatments
T1	64kg N + 20kg P: fertilizer rate recommended by ministry of agriculture (MOA)
T2	96kg N + 43kg P: fertilizer rate recommended by CASCAPE project at study area
T3	200kg of Zn + B blended (14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B) + 23kg N
T4	200kg of Zn blended (23N 23P_2O_5 8.2S 1.2Zn) + 23kg N
T5	138kg N [1]+55kg P +75kg K
T6	138kg N
T7	55kg P
T8	75kg K
T9	55kg P + 75kg K
T10	138 kg N + 75 kg K
T11	138kg N + 55kg P
T12	69kg N + 55kg P + 75kg K
T13	92kg N + 55kg P +75kg K
T14	Control

Where, N: Nitrogen, P: phosphorus, K: potassium, Zn: zinc and B: boron

Table 2: Growth variable, Grain yield and yield components of teff as affected by different rates of NPK and blended fertilizers.

Treatment code	PL(cm)	NPT(no)	PGW kg ha^{-1}	TGW kg ha^{-1}	BY kg ha^{-1}	GY kg ha^{-1}	LP(%)
T1	40.13^{g}	18.38^{g}	4.80^{e}	0.28^{f}	5858.50^{j}	1608.90^{f}	54.76^{d}
T2	38.05^{h}	18.47^{g}	4.62^{e}	0.28^{f}	5881.50^{i}	1607.99^{f}	55.8^{c}
T3	45.60^{a}	26.10^{a}	6.10^{a}	0.34^{a}	8000.50^{a}	2147.70^{a}	14.99^{g}
T4	44.13^{b}	24.24^{b}	6.62^{a}	0.31^{c}	7118.50^{c}	1922.00^{b}	29.72^{f}
T5	43.08^{cd}	18.95^{f}	4.49^{g}	0.31^{c}	6205.50^{f}	1574.55^{g}	79.74^{a}
T6	38.07^{h}	15.08^{i}	3.38^{j}	0.28^{f}	6003.75^{h}	1518.20^{h}	17.25^{h}
T7	37.65^{hi}	18.92^{f}	5.04^{d}	0.29^{e}	4649.25^{l}	1383.90^{j}	11.75^{j}
T8	32.28^{j}	3.03^{j}	2.66^{l}	0.26^{g}	3820.0^{m}	958.13^{k}	8.00^{k}
T9	37.19^{i}	19.89^{e}	5.12^{c}	0.28^{f}	4707.50^{k}	1471.20^{i}	14.25^{i}
T10	40.50^{fg}	20.86^{d}	3.46^{i}	0.28^{f}	6809.86^{d}	1671.57^{e}	29.00^{fg}
T11	41.68^{e}	17.81^{h}	4.62^{f}	0.30^{d}	6106.75^{g}	1568.64^{g}	78.25^{a}
T12	43.50^{c}	23.08^{c}	5.67^{b}	0.31^{c}	7360.25^{b}	1886.10^{c}	44.75^{e}
T13	40.88^{f}	23.12^{c}	4.41^{h}	0.32^{b}	6431.25^{e}	1728.21^{d}	58.34^{b}
T14	30.17^{k}	2.95^{j}	3.41^{j}	0.25^{h}	3764.50^{n}	953^{k}	8.00^{k}
Mean	39.49	17.92	4.602	0.29	5908.40	1571.44	36.04
LSD(0.05)	0.0944	0.178	0.024	0.001	11.043	9.7654	0.039
CV (%)	0.1672	0.694	0.363	0.258	0.13067	0.43449	0.076

Means sharing the same letter do not differ significantly at P =0.05 according to the LSD test. PL: panicle length, NPT: Number of productive tillers, PGW: panicle grains weight, TGW: thousand grains weight, BY: biomass Yield, GY: grain yield, LSD: least significant difference and CV: Covariance.

economical yield (grain yield, straw yield and biomass yield). The result of this experiment indicated that the longest panicle length (45.60cm) was recorded from Zn + B blended (14N 21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B)treatment being followed by Zn blended (23N 23P_2O_5 8.2S 1.2Zn) fertilizer, 44.13cm while the shortest panicle length (30.17 cm) was obtained from unfertilized plot (Table 2). Application of balanced fertilizer and efficient utilization of nutrients leads to high photosynthetic productivity and accumulation of high dry matter, which ultimately increases panicle length and grain yield. In some other research studies [14] highest grain yield and longest panicle length were observed to be correlated positively and significantly.

The analysis of variance result has also showed that number of productive tillers counted at 0.09 m^2 was highly significantly (P<0.05) affected by different rates of applied NPK and blended fertilizers (Table 2). The highest number of mean productive tillers (26.10) was obtained from Zn + B blended (14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B) fertilizer application followed by blended Zn (23N 23P_2O_5 8.2S 1.2Zn)with a tiller number of 24.24. The minimum number of mean of productive tillers (2.95) was obtained from unfertilized plot. The application of 200 kg ha^{-1} blended Zn + B (14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B) fertilizer increased tiller number by 72% as compared to fertilizer application practices of the area. This marked increment in this variable was observed due to incorporation of Zn and B in blended fertilizer. Similarly, [15] observed the highest tiller number in teff by the application of Zn and B blended fertilizer in teffproduction.

Teff crop that received 23N 23P_2O_5 8.2S 1.2Zn blended fertilizer gave the highest panicle grains weight (6.62g/plant) (Table 2). Because of this treatment, panicle grain weight exceeded the minimum panicle grain weight by about 7.54%. The increase in seed yield is associated with the increase in number of seeds per head. Thousand grains weight is an important yield-contributing variable for cereal crops that helps a lot in the grain yield estimate due to its relation to grain yield. The analysis of variance of this experiment showed that thousand-grain weight was highly and significantly (P<0.05) affected by different rates of NPK and blended fertilizers (Table 2). The zinc + boron blended (14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B) fertilizer gave the highest thousand grain weight (0.335g) than all other treatments. The marked increase in this parameter was observed due to appropriate integration of micronutrients (zinc + boron) with macronutrients in blended form of fertilizer. This is because boron nutrition increases head diameter and 1000-seed weight [16]. Generally, the increase of 1000-grain weight with applied of Zn + B blended fertilizer might be due to the positive effects of Zn and B on assimilates translocation, activation of photosynthetic enzymes, chlorophyll formation and improvement of plant growth [17].

Significant increase in biomass yield was also observed for application of different rates of NPK and blended fertilizers (Table 2). The highest biomass (8000.5kg ha^{-1}) was recorded from application of Zn + B blended (14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B). The application of this blended fertilizer increased the biomass yield by 112.52%. This might be due to better crop nutrition through applied blended micronutrients (zinc and boron) with macronutrients, which may result in improved vegetative growth of crops by reducing lodging, which is a major constraint in production of teff.

Grain yield was also highly and significantly ($P<0.05$; Table 2) influenced by different rates of NPK and blended fertilizers. The highest grain yield (2147.7 kg ha^{-1}) was recorded from the application of Zn + B blended (14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B) fertilizer followed by Zn (23N 23P_2O_5 8.2S 1.2Zn) blended fertilizer which gave1922 kg ha^{-1}. From the result, blended fertilizer increased teff grain yield by about 12% of the yield obtained from the application of NPK fertilizer alone practiced in the area (Table 2). Some studies eg. [18, 19, 20] reported that application of NPK macronutrients mixed with Zn and B fertility significantly enhanced yield and yield contributing parameters in crops (e.g. Sunflower and soybean). Microelements (Zn, B and etc.) if found in a reasonably balanced level, give fertilizers a good opportunity to play an important role in the physiological activities of a plant and increase photosynthesis and dry matter production to increase yield [21].

Lodging is the serious problem of teff production that causes high yield reduction because of the use of high amount and unbalanced different rates of NPK fertilizers practiced in the country. On average, it accounts about 11-22% total grain yield losses [22]. In this study, the highest lodging percentage (79.74%) was recorded from application of 138 kg N ha^{-1} + 55 kg P ha^{-1} + 75 kg K ha^{-1} followed by 138 kg N ha^{-1} + 55 kg P ha^{-1} whereas, the lowest lodging percentage (8%) recorded from application of 75 kg K ha^{-1} alone and unfertilized plot (Table 2). However, using 200 kg of 21P_2O5 15K_2O 6.5S 1.3Zn 0.5B blended fertilizer reduced lodging percentage by about 66-74% compared to fertilizer rates practiced for teff production in the study area, by strengthens the skeleton parts of teff plants.

CONCLUSIONS

This study confirmed the importance of Zn and B blend with macronutrients fertilizer in increasing yield and yield components in teff production. From the result of the experiment, application of 200kg ha^{-1} of Zn + B blended (14N21P_2O_5 15K_2O 6.5S 1.3Zn 0.5B) + 23kg N ha^{-1} can be recommended for teffproduction particularly in the study area. This blended fertilizer can solve the problem of the area by increasing teff yield that the farmers usually opting for. This will greatly help farmers get better yield and improve their economic wellbeing. Application of Zn and B blended fertilizer greatly improve the soil fertility and improve Zn and B content of the soil.

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