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Evaluation of different NPSB Blended Fertilizer on Yield and Yield Traits of Teff [*Eragrostis Teff* (Zuccagni) Trotter] in Tsegedie Western Tigray, Ethiopia

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ABSTRACT

Based on Ethiopian Agricultural Transformation Agency (ATA) and Ministry of Agriculture soil fertility status and fertilizer recommendation atlas, one of a new blended fertilizer NPSB containing 18.7% nitrogen (N), 37.4% P_2O_5 phosphorous (P) 6.9% sulfur (S) and 0.25% boron (B) is in recent times introduced aiming at substituting di ammonium phosphate (DAP) (18% N and 46% P_2O_5) for crop production. There is a need to optimize blended fertilizer for Teff production under farmers' conditions. Therefore field experiment was carried out for 2019 and 2020 main cropping seasons at Tsegedie Wereda in Tigray Regional State, Ethiopia. This study was carried out to investigate the optimum level of NPSB blended fertilizer for Teff production. The experiment was arranged in a randomized complete block design (RCBD) with three replications on farmers' field. The treatments were seven levels of NPSB (0, 50, 100, 150, 200, 250,300 kg ha^{-1}) adjusted with N to the recommended level. Recommended N and P fertilizers (64 kg N ha^{-1}, 46 kg P2O5 ha^{-1}) were also included as a positive control. Soil samples were collected before planting and analyzed for selected physicochemical properties. Application of different rates of NPSB blended fertilizer significantly influenced yield and yield components of teff. The highest grain and straw yields were obtained from plots that received 250 kg NPSB ha^{-1}. The economic analysis showed that applications of 150kg NPSB ha^{-1} were optimum for teff production and this rate could be recommended for area where this experiment conducted. Further study should be done on effects of NPSB in grain quality and single nutrient based experiment should also be carried out to evaluate the blended fertilizer for crop production.

Keywords: NPSB; Teff; Rec. NP; Yield; Fertilizer; Endaslasie; Ethiopia; Kg; Traits; Tigray.

1. Introduction

Teff [*Eragrostis teff* (Zuccagni) Trotter] is endemic to Ethiopia and its major diversity is found only in Ethiopia. As with several other crops, the location for the domestication of teff is at Axum. And it is a very ancient crop in Ethiopia, where domestication took place before the birth of Christ [17]. [20] Identified Ethiopia as the center of origin and diversity for teff. Hence, Ethiopia is the appropriate and most important center for the collection of teff germ plasm [16]. When compared with other food crops grown in the country, it is highly-valued by farmers and consumers. This is because of its importance in the national diet of Ethiopia [11].

Soil fertility reduction is one of the major challenges to crop production and productivity in Ethiopia [2]. Soil erosion, over cultivation of farm land, inadequate applications of organic and inorganic fertilizers and decreasing or abandoning of useful traditional soil restoration practices are also some of the causes of declining soil fertility.

Nutrient mining due to sub optimal fertilizer use coupled with agronomical unblended fertilizer uses have favored the emergence of multi nutrient deficiency in Ethiopian soils [1], [3], which in part explain fertilizer factor productivity decline and stagnant crop productivity conditions encountered despite continued use the blanket recommendation. Soil fertility depletion is the major constraint to sustainable agricultural production in Tigray [7]. Poor soil fertility and extreme exhaustion of plant nutrients from the soil are the major factor limiting crop production in both rain-fed and irrigated farms in different agro-ecological zones of Tigray [7]. NPSB blended fertilizer is one of the newly introduced fertilizers to improve crop production based on the ATA soil atlas map in the country [4]. New blended fertilizers such as NPSB are currently being used by the farmers in the study area.

1.1. Study Objectives

This study aims to determine and summarize the following specific objectives regarding the NPSB Blended fertilizer in Tsegedie Wereda of Tigray, Ethiopia. The specific objectives were: (i) to investigate the effects of blended NPSB fertilizer rate on yield and yield components Teff, (ii) to determine blended fertilizer NPSB for teff production, (iii) to determine the effect of blended fertilizers compared to blanket recommendation NP, and (iv) to assess economic feasibility of NPSB for teff production in the study area.

2. Materials and Method

2.1. Description of Experimental Sites

The field experiment was conducted under rain fed conditions in Endaslasie high land Tsegedie Wereda, district Western Tigray Ethiopia. The area is located at $13^0$14' 21" to 13^0 44' 46" N and 36^0 27' 44" to 37^0 45' 05" E longitudes with altitude of 1053 to 2889 m above sea level. The mean annual temperature of the area is 13.2 ^{o}C and the mean annual rain fall varies from 700-1800 mm. The dominant soil types in the Tsegedie highlands are mainly humic cambisols [13].

2.2. The Experiment

The experiment was carried out for the two consecutive rain fed cropping seasons (2019 and 2020) in Tsegedie district at Endaslasie farmers' field. The field was prepared well before sowing by plough twice with oxen and well leveled for seed bed. Seeds of Teff were planted in rows 3*3 m long with spacing of 0.2 m between rows. The trial was laid out in RCBD with three replications. The treatments were eight levels of (0, 50, 100, 150, 200, 250, 300, NPSB kg ha^{-1}) adjusted with N to the recommended level. Recommended N and P fertilizers (64 kg N ha^{-1}, 46 kg P_2O_5 ha^{-1}) were also included as a positive control. The equivalent of N was adjusted to the quantity of added nutrient for the blended fertilizer for each treatment. The amount of nitrogen was applied in split application form 1/3 at sowing and the remaining at week following sowing. All agronomic operations were done.

2.3. Soil and plant sampling

Top soil (0-20 cm) was collected from the experimental sites, air dried, sieved through a 2 mm diameter mesh and analyzed for texture, pH, organic matter, total N, available P, exchangeable aluminum, exchangeable Acid and CEC following standard procedures at Mekelle Soil Research Center.

Sowing and thinning time in July second week and harvesting time November first week was conducted each year. Data collections were plant height, head length, number of tillers per plant and number of effective tillers per plant from ten randomly selected plants per plot. Furthermore, grain yield and biological yield were obtained by harvesting an area of 3m* 3mfrom the middle of each plot.

2.4. Statistical analysis

GenStat® 18th Edition (VSN International, HemelHempstead, UK) was used to perform analyses of variance (ANOVA). Differences between means of significant variables were Duncan's Multiple Range Test (DMRT) at the 5% significance level. For profitability of Teff production using different fertilizer level, marginal rate of return

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(MRR) was calculated as the change in net revenue (NR) divided by the change in total variable cost (TVC) of the successive net revenue and total variable cost levels [6].

3. Results and Discussion

3.1. Selected Physicochemical Properties of Soils of the Experimental Sites

The analytical results of the experimental soil indicated that the soil textural class at Endaslasie was Sandy loam (Table 1).

Table 1. Initial Surface (0-20 cm) physical and chemical property of the experimental field

					Exchangeable ($cmol^{+}$ $^{kg-}$)	
Texture	**P^{H}**	**OM (%)**	**TN (%)**	**Av.P(mg $^{kg-1}$)**	**Acid**	**CEC**
Sandy loam	5.1	5.01	0.11	3.15	3.17	24.38

Note: OM= Organic Matter; TN= Total Nitrogen Av.P =Available phosphors; CEC= Cation Exchange Capacity.

According to the rating made by [12] (Table 1) the soil reaction of the experimental site was strongly acidic. According to [8] the pH in the experimental site is not within the preferable range for most productive soils (5.5 to 7.5). Thus, the pH of the experimental soil needs soil reclamation. Compared to the soil organic matter rating of [19], the organic carbon content of the soil was moderate (Table 1). Hence, amending the soils with organic fertilizers would be required to enhancing crop yields and soil health.

According to the classification of [19] the soil analysis result indicated that total N is a limiting factor for optimum crop growth. Therefore, the soils need amendment with N source. The available soil phosphorous (Olsen P) was low according to [19].

According to the rating of [12], the soil at the experimental site was medium CEC values (Table 1). The medium CEC probably facilitates the capacity of the soil in the site to retain nutrients against leaching but needs improvement.

3.2. NPSB Fertilizer effect on agronomic traits of Teff

3.2.1. Plant height

Plant height for treatments showed no significant difference ($P<0.05$) at the experimental site. The result indicated that the highest plant height (84.47 cm) was recorded from the plot treated with 250 kg ha^{-1} NPSB rate, while the shortest plant height (59.41 cm) was obtained from control plot (Table 2). The highest plant height obtained at the higher blended fertilizer levels might be due to the vital role of N applied for elongation and vegetative growth. This result is also in agreement with that of [15] where they obtained the highest plant height in treatment that received the highest nitrogen than control on teff crop. Similarly, [21] reported significant increase in plant height barley as application of N from 0 to 69 kg ha^{-1}enhanced and recorded the maximum plant height. Nevertheless, in disparity with this result, rising the rate of NPSB application from 0 to 300 kg ha^{-1} did not significantly affect the height of teff plant.

3.2.2. Head length

Head length showed no any statistical difference between the treatments except with control plot. Accordingly, the plots treated with 250 kg ha^{-1} NPSB had the maximum head length (31.97 cm) over the control but it was at par with preceding rates (Table 2). The control produced minimum (24.13cm) head length. Likewise, [9] reported that nitrogen fertilization have significant effect on head length obtained from the application of 69 kg N ha^{-1} while the shortest was recorded from control..

3.2.3. Number of tillers and effective tillers

As observed from the ANOVA, the treatments effect was statistically not significant (P<0.05) on the number of tillers per plant, however, over the control have showed significant effect compared to applied blend fertilizer the highest number of tillers (11.83) was recorded from 250 kg NPSB ha^{-1}. The control produced relatively lowest (6.21) number of tillers per plant (Table 2).

Similarly, it was observed that the number of effective tillers per plant was not significantly influenced by the treatments rates, though; over the control have showed significant effect. Effective tillers (8.83 plants) were obtained at the plot that received 250 kg NPSB ha^{-1}. The lowest Effective tillers (3.83 plants) were obtained at the control plot. This finding is also supported by the results of [5] who revealed that the 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}) bring significant boost in total tillers of teff as compared to unfertilized plot.

Table 2. Effect of NPSB on yield and yield components of teff

Treatments (NPSB-NP kg ha^{-1})	PH (cm)	HL (cm)	NT	NET
Control (0)	59.41d	24.13b	6.21c	3.83c
Rec.NP (46-46)	76.86bc	30.66a	9.75ab	7.56ab
50	79.52ab	30.8a	9.15abc	7.05ab
100	79.85ab	30.94a	7.28bc	5.37bc
150	77.28bc	30.33a	10.69ab	8.31a
200	80.78ab	31.64a	10.64ab	8.68a
250	84.47a	31.97a	11.83a	8.87a
300	81.29ab	30.47a	10.15a	8.73a
P-value	<.0001	0.002	0.0009	<.0001
CV (%)	2.71	6.06	12.89	12.23

3.2.4. Grain yield

In this study the treatment effect shown statistically significant (P<0.05) effect on the grain yield (Table 2). The highest mean grain yield was obtained (1681.85 kg ha^{-1}) with the application of 250 kg ha^{-1} NPSB. The mean grain yield advantage obtained was varied in all the treatments compared with the control. The lowest yield (630.66 kg ha^{-1}) was obtained from the control plot. The highest yield had 52.28% yield increment over control and 37.49% over the blanket recommendation. [14] Reported that application of blended fertilizer and urea significantly increased the N, P, K, Zn, Mg and S concentration of teff grains and increased grain yield. This result is parallel with [18] reported maximum grain yield from plots treated with fertilizer, while minimum grain yield was recorded from control plots on wheat.

3.2.5. Straw yield

The effect of fertilizer rates have demonstrated significant (P<0.05) effect the teff straw yield (Table 2). The lowest straw yield (929.82kg ha^{-1}) was recorded in the control treatment the mean highest straw yield (4639.34 kg ha^{-1}) was recorded from plots applied with 250 kg NPSB ha^{-1} which is significantly different from those recorded the other treatments. In concurrence with this finding, [10] establish increasing biomass with the increasing rate of N with the highest biomass yield of teff in response to the application of 69 kg N ha^{-1}.

Table 3. Effect of NPSB on grain yield and straw yield of teff

Treatments (NPSB-NP kg ha^{-1})	GY (kg ha^{-1})	SY (kg ha^{-1})
Control (0)	630.66^{e}	929.82^{f}
Rec.NP (46-46)	1120.57^{c}	2579.7^{d}
50	803.50^{d}	1997.16^{d}
100	978.98^{c}	2441.28^{d}
150	1372.86^{b}	3527.58^{c}
200	1413.82^{b}	3626.58^{c}
250	1690.85^{a}	4639.34^{a}
300	1581.85^{ab}	4538.7^{ac}
P-value	<.0001	<.0001
CV (%)	4.27	4.93

3.3. Partial Budget Analysis

The result of MRR of the treatment levels is presented in (Table 4). The highest net revenue was obtained from plots fertilized with a rate of 250 kg NPSB ha^{-1} (55860). The highest marginal rate of return was also obtained from plots treated with 150 kg NPSB ha^{-1} (3831.2%). As indicated in the table 4 the rates assigned as D were found dominated treatments, negative MRR. The negative marginal rate of return values obtained was rejected. According to the manual for economic analysis of [6] the recommendation is not necessarily based on the treatment with the highest marginal rate of return compared to that of neither next lowest cost, the treatment with the highest net benefit, and nor the treatment with the highest yield. The identification of a recommendation is based on a change from one treatment to another if the marginal rate of return of that change is greater than the minimum rate of return (100%). According to the marginal rate of return the rate of 150 kg NPSB ha^{-1} was found economically profitable compared to other treatments.

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Table 4. Partial budget analysis of NPSB blended fertilizer rates for grain and straw yield of tef

Treatments (NPSB-NP kg ha^{-1})	Adjusted GY	Adjusted SY	TVC	Grain revenue	Straw revenue	Total revenue	Net revenue	MRR (ratio)	MRR (%)
Control (0)	567.5	836.8	0	17027.8	2677.7	19705.5	19705.5	0	0
50	723.1	2197	1260.2	30255.3	7030.4	37285.7	36025.5	12.9503	1295.03
100	1008.5	3175	1733.3	21694.5	10160	31854.5	30121.2	D	D
Rec.NP (46-46)	881.0	2322	1859.3	26432.4	7430.4	33862.8	32003.5	14.9393	1493.93
150	1235.5	3264	2206.5	37067.2	10444.8	47512.0	45305.5	38.3120	3831.20
200	1272.4	3542	2679.6	38173.1	11334.4	49507.5	46827.9	3.2179	321.79
250	1521.7	4175	3152.8	45652.9	13360	59012.9	55860.1	19.0875	1908.75
300	1423.6	4122	3626	42709.9	13190.4	55900.3	52274.3	D	D

* GY = Grain yield; SY = straw yield; TVC = Total variable cost, MRR = Marginal rate of return.

4. Conclusion

Application of different rates of NPSB blended fertilizer significantly influenced yield and yield components of teff at the experimental site. The highest grain and straw yields were obtained from plots that received 250 kg NPSB ha^{-1}. However, economic analysis showed that application of 150kg NPSB was promising. Hence, for teff production this rate could be recommended for area where this experiment conducted and demonstration need to be conducted around the study area through involvement of as many farmers as possible and agricultural experts for further validation and verification of the study. Moreover, further study should be done on effects of NPSB in grain quality and single nutrient based and experiment should also be carried out to evaluate each nutrient contribution for Teff production

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

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