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Evaluation of Different Blended Fertilizers Types and Rates for Better Production of Teff (*Eragrostis tef*) Yield and Yield Components in Tembaro District Kembata Tembaro Zone Southern Ethiopia

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Abstract:

The current study was conducted for two consecutive years (218 and 2019) on clay particle dominated soils of Bohe and Bachira kebele in Temabro district kembata Tembaro Zone southern Ethiopia. The main objective of the study was to evaluate different blended fertilizer types and rates for better production of Teff in the study area. The trial have nine treatments (0), (34.5- 37.7-0- 6.95-0.1-0), (46- 55.05-0-10.425-0.15-0), (69-75.4-0-13.9-0.2-0), (34.5-37.7-0-6.95-0.1-0.4), (46-55.05-0-10.425-0.15-0.4), (69-75.4-0-13.9-0.2-0.4), (34.5-37.7-30-6.95-0.1) and (34.5-37.7-30-6.95-0.1-0.4) from NPKSBCu fertilizer sources. The experimental design was randomized compete block design (RCBD) across farmers field and repeated three times per farmer. The highest teff grain yields were recorded with application of 100kg NPSB+ 15.6 kg Urea (T2), 100kg NPSB+30 kg potassium fertilizer (K) (T8), 150kg NPSB+ 38.4 kg Urea (T3) and 200kg NPSB + 67.83 kg Urea per hectare (T4) as compared to T1, T5, T6, T7 and T9. Based on this finding four treatments (T2, T3, T4 and T8) were showed better yield response and those could be suggested as alternative fertilizer sources and soil management options for teff production in the study area. Finally the application of 100kg NPSB+30 kg Potassium fertilizer (34.5-37.7-30-6.95-0.1) and 150 kg NPSB (46- 55.05-0-10.425-0.15) were recommended as first and second options. Economic analysis also reviled that the highest marginal rate return of 16.72 and 7.24 were recorded respectively. The soils of the study area were strongly acidic and poor in available soil nutrient content. Therefore it needs integrated soil fertility management practices for further production of crops in the study area.

Keywords: *Blended fertilizers, Teff (Eragrostis tef), Tembaro district, Grain yield.*

Introduction

Agriculture contribute largest share to national economy of Ethiopia which is relatively high, its productivity is low; these are mainly due to declining of soil fertility, low use of improved technologies (Wakene et al., 2012). Agriculture is the leading sector in the economy of Ethiopia, contributing 41.4% of GDP, 83.9% of the total exports, and 80% of all employment (Matousa and Mojoc, 2013). Assessment of the nutrient requirement of different crops for desired yield levels in a cropping sequence is the first issue in developing sound fertilizer management practices (Mollah and Sarkar, 2011). Up-to-date and spatially explicit information about the condition and trend of soil fertility clearly showed that N and P were not the only yield determining factors, and S, Zn, B, Fe, Cu and K deficiency are also common in many soils of the Ethiopia (ATA, 2016). Therefore, there is a need for a comprehensive study to critically evaluate the combinations of fertilizers, the location and rate that would provide the highest return (Tamene *et al.*, 2017). Use of appropriate varieties and balanced fertilizer application are major agronomic practices to improve the productivity and quality of crops (Abera, Tana, & Dessalegn, 2020).

Teff is one of major food crop grown in Ethiopia that contributes 3,016,062.75 hectare in land coverage and 47,506,572.79 quintal in production with average productivity of 15.75 quintal ha^{-1}. The Kembata Tembaro zone contributes 9590.27 hectare in land coverage and 135,114.76 quintal in production with average productivity of 15.75 quintal ha^{-1} (CSA, 2014/15). Tembaro District has about 30% in land coverage and production share of a zonal teff production.

This research was conducted based on the fertilizer need assessment for teff production in Tembaro district. Biophysical characterization and trend analysis information's are also considered to initiate and conduct the research. Major constraints identified during survey and assessment suggested that to develop an appropriate research proposals and developmental work plan to solve the identified constraints in the study area. The main aim of this study was to identify blended fertilizers type and rate for better production of Teff crop in Tembaro district.

Materials and Methods

Description of Study Area

This study was conducted in Tembaro district at Bachira and Bohe kebele of Kembata Tembaro Zone in southern Ethiopia. The study area was situated to the North eastern side of Omo River which feeds Gibe III Hydro Electric Power Dame (GHEPD). Geographically the study area is located between 7.14^0 - 7.15^0 N (latitude) and 37.31^0- 37.32^0 E (longitude) with the elevation ranging from 1320m above sea level (m.a.s.l.) to 2045m above sea level.

Mixed farming system (crop production, Livestock production, daily laborers and small goods retailers) was a common agricultural practice in the study area. Major crops growing in the area were: Teff, Maize, Sorghum, Common bean, Faba bean, Enset, Banana, Coffee, Taro, Ginger are potentially can be grown well. Topography of the area is dominated by rolling hills and steeply slopes. Most of the district's land coverage 60% is midland (*Woynedega)*, 10 % is highland *(Dega)* and 30 % is low land (k*ola*) climate (Hurni et al., 2016). The annual rainfall ranges between 700-1200 mm and the daily mean temperature ranges between 18^0C - 30^0C. The rainfall is bi-modal type: the main rains (called '*Kremt*' rains) occur in the months of June, July and August and the short rainy season (called the '*Belg*' rains) occurring from mid-February to mid-May. *Keremt* is the main production season of major crops such as teff, faba-bean common bean and field pea, but the occurrence of rain during the *Belg* season is equally important, as it has significant implications on the food security of households.

Experimental Procedures, Layout and Treatment Arrangements

The experiments were arranged in RCBD design across farmers' field and have 9 treatments of NPKSBCu (0, 34.5- 37.7-0- 6.95-0.1-0, 46-55.05-0-10.425-0.15-0, 69-75.4-0-13.9-0.2-0, 34.5-37.7-0-6.95-0.1-0.4, 46-55.05-0-10.425-0.15-0.4, 69-75.4-0-13.9-0.2-0.4, 34.5-37.7-30-6.95-0.1-0, and 34.5-37.7-30-6.95-0.1-0.4). Fertilizers sources KCl for K_2O, Borax for

Boron, and $CuSO4.5H_2O$ for Cu, NPSB and Urea were used.

Field experiment was laid out in randomized completed design (RCBD) replicated across three farmers' fields and similarly on replicated three times on three farmers' fields. Plot size 3*4m planted in rows apart 20cm between rows by drilling method. Teff crop variety Areka-1 was used with seed rate of 15kg hectare base and land preparation and planting was done per recommended for the crop. Urea fertilizer applied by top dressing 30 days after planting at development stage and while copper fertilizers applied by foliar spray at development stage near blooming stage of the crop.

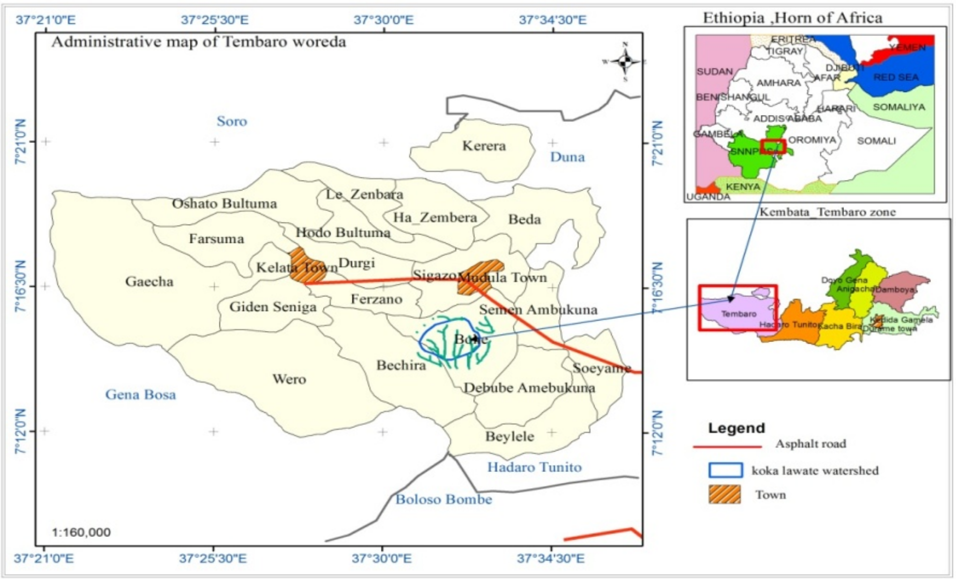

Figure 1. Administrative area map of study area

Data Collection

Soil data

Composite soil samples (0-20 cm depth) were collected by zigzag manner before planting and subjected for laboratory analysis for Bulk density (g/cm^3), soil pH (H_2O), organic carbon (%), cation exchange capacity (meq/100g), total nitrogen (%TN), available phosphorous av.P (ppm) and available potassium (ppm) and particle size analysis, the soil analysis was conducted following a soil laboratory analysis manual (Sertsu, & Bekele, 2000).

Crop data

Common teff growth and yield parameters considered in this experiment include agronomic and plant growth parameters such as plant height (cm), number of tillers/plant, spike length (cm) above ground biomass yield and grain yields were collected. Plant height (cm): Determined by measuring the height from five samples from base to apex of main stem plants per plot excluding border rows near maturity stage. Number of effective tillers per plant was recorded by taking five sample plants per plot excluding border rows as average plant population per hill at near maturity stage. Above ground biomass determined by weighing after harvested and sun drying. Grain yield was determined by measuring the cleaned grain seed after trashing.

Economic Analyses

Partial budget analysis evaluates the changes from one technology to another by comparing the change in cost and net benefits associated with each treatment (CIMMYT, 1988). The calculations of the average yield for each treatment was reduced by 10% adjustment factor down to arrive at the yield which the farmer can achieve under his own conditions. The local price in Ethiopian Birr per 100 kg of teff grain yield at harvesting was considered for the analysis as suggested by Crawford (1988). All costs and benefits were calculated on hectare basis in Ethiopian birr (4000 ETB per 100 kg). To make a rational choice of alternative blended fertilizers based on their economic benefit the partial budget and marginal rate of return (MRR) were analyzed for teff production (CIMMYT, 1988). A dominance analysis was carried out by listing the treatments in ascending order. Any treatment that has net benefits less than or equal to those treatments with lower costs that vary is dominated (CIMMYT, 1988).

$$MRR\ (\%) = (NB/\ TVC)*100 \qquad (1)$$

Where: NB= Net benefit and TVC =Total variable cost

Statistical Analysis

Data on growth parameters yield and yield components were subjected to analysis of variance (ANOVA) by using SAS software (version 9.1). ANOVA was conducted at individual site variances of the two locations independently. Generalized Liner Model (GLM) procedure was employed to detect variation among treatments. Mean separation of significant treatments were carried out using the least significant difference (LSD) test at $P \leq 0.05$ level (SAS Institute Inc, 2002).

Results and Discussion

Selected soil chemical and physical properties before planting

Physical properties of the soils

The soils of the study area were clay dominated in particle distribution with bulk density ranges 1.14 to 1.32 g/cm^3 of soils that implies the soils are slowly compacted and ideal for crop production in the area (USDA, 2008). The particle size distribution of study area was analyzed by standard methods and the average percentage of clay, silt and sand was 79, 13 and 8 for Bohe and 68, 18 and 14 for Bachira location respectively and textural class of soil fall at clay using textural triangle at both location (USDA, 2008).

Table1. Selected Physical and Chemical Properties of Soils of Testing Sites Before Planting

Sample site	BD (g/cm^3)	pH (H_2O)	OC (%)	CEC (%)	TN (%)	P (ppm)	Av.K (ppm)	Clay (%)	Silt (%)	Sand (%)	Textural class
Bachira	1.14	4.88	3.39	24.6	0.29	8.7	98.5	68	18	14	clay
Bohe 1	1.03	5.35	1.19	25.2	0.1	8.6	130	82	10	8	clay
Bohe 2	1.16	5.25	1.19	16.6	0.1	7.6	109	76	16	8	clay
Mean	1.11	5.2	1.9	22.1	0.2	8.3	112.5	75.3	14.7	10	
CV Sign	6.3 **	4.8 **	66.0 NS	21.7 **	67.2 NS	7.3 ***	14.3 ***	9.3 **	28.4 *	34.6 **	

Chemical properties of the soils

Soil pH was analyzed by soil to water with 1:2.5 ratio and ranges from 4.88 to 5.35 with mean of 5.16 soil pH (H_2O) that rated as strongly acidic soils (ATA, 2016; Benton Jones 2003). The soil organic carbon contents (SOC) was analyzed by wackily and blackly methods (wackily and blackly, 1934) and ranges from 1.19% to 3.39% with mean of 2.29% which is categorized under low to medium organic carbon in the soils solutions according to Takelign 2017 rating (Mamo.et al., 2017). The total nitrogen of soil analyzed by Keldjal digestion and distillation followed by titration and percentage of TN was ranged 0.10 to 0.29 and rates under medium to high with mean of 0.195% which was categorized as with high TN in the soils (Benton Jones, 2003). The CEC of the sampled soils varies from 16.6 to 25.2 meq/100g which was ranging from low to medium CEC in the soils solutions (Benton Jones, 2003). Available Phosphorous (P) and potassium (K) were also categorized in high and vary low categories respectively (Clark, 2005). This implies that the soils of the study area were strongly acidic, poor in available soil nutrient content, and in cation exchange capacities. This suggests that there is a need for addition of fertilizers and integrated soil fertility management activities for further production of crops in the study area.

Teff yield and yield components

The results (Table 2) for both yield and yield components have showed a significant difference between treatments for both grain and biomass yields with applied blended fertilizers. The combined analysis for two years results effective tiller, spike length, plant height, above ground biomass and grain yield of teff crop have showed a significant difference between treatments. Statically no significant differences were recorded in treatments between T3, T4, T6 and T7 in both years as compared to control (T1), T2, T5, T8 and T9 treatments for both yield and yield components. No significant differences were recorded in number of effective tiller within treatments T1, T2, T5 and T8; but significant differences were showed as compared to T3, T4, T6, T7 and T9. A significant plant height difference was recorded in treatments T4 and T7 as compared to T1, T2, and T5 whereas there was no differences were recorded in the remaining fertilizer treatments.

Table 2. Teff Yield and Yield Components as Affected by Blended Fertilizer Type and Rates

No	Treatments	Tiller (no)	PlHt (cm)	Splt (cm)	Biomass (kg ha^{-1})	Grain Yield (kg ha^{-1})
1	Control	2.19^{d}	71.00^{d}	27.57^{c}	1192.46^{e}	327.69^{d}
2	100kg NPSB (34-5 37.7-6.95- 0.1)	2.13^{d}	83.83^{c}	30.22^{b}	2713.63^{d}	780.00^{c}
3	150kg NPSB (46-55.05-10.425- 0.15)	2.68^{ab}	89.28^{ab}	31.38^{ab}	4228.84^{ab}	1158.98^{a}
4	200kg NPSB (69-75.4-13.9-0.2)	3.00^{a}	90.70^{a}	31.02^{ab}	4440.04^{a}	1222.41^{a}
5	100kg NPSBCu (34.5-37.7-6.95, 0.1-0.4)	2.47^{bcd}	84.22^{bc}	29.88^{b}	3096.56^{ab}	887.04^{bc}
6	150kg NPSBCu (46 -55.05, 10.425, 0.15-0.4)	2.63^{abc}	88.67^{abc}	30.75^{b}	4084.00^{ab}	1124.26^{a}
7	200kg NPSBCu (69-75.4, 13.9, 0.2-0.4)	2.85^{ab}	89.92^{a}	32.65^{a}	4662.04^{a}	1198.98^{aa}
8	100kg NPKSB (34-37.7-30-6.95- 0.1)	2.45^{bcd}	89.40^{ab}	31.63^{ab}	3669.31^{bc}	1045.83^{ab}
9	100kg NPKSBCu (34-37.7-30-6.95- 0.1 -0.4)	2.77^{ab}	87.23^{abc}	31.08^{ab}	3027.56^{cd}	828.98^{bc}
	LSD ($p<0.05$)	0.45	5.43	1.77	698.64	217.24
	CV (%)	21.87	7.78	7.13	24.9	28.10
	Mean	2.57	86.07	30.68	3457.16	952.58

Note: * PlHt= plant height, Splt=spike length, LSD= list significant difference, CV= coefficient of variation, kg ha^{-1} =kilogram per hectare, NPKSBCu=Nitrogen, phosphorous, potassium, sulfur, boron and copper nutrient sources. * Means with the same letter are not significantly different.

The results (Table 2) indicated that the application of potassium fertilizer has a positive effect on crop grain yield, but foliar application of copper fertilizer did not show significant yield variation for both yield and yield components within treatments. Relatively the highest above ground biomass and grain yield was recorded with application of 150kg NPSB (46-55.05-10.425- 0.15) + 38.4 kg Urea top-dress and 200kg NPSB (69-75.4-13.9-0.2) + 67.83 kg Urea top-dress) fertilizers with and without Copper fertilizer. This result is in line with (Habte & Bok, 2017) reported that application of 150 kg NPS + 34.5 kg N ha-1 is recommended to use by farmers as an alternative soil management option for teff production. The application of 150kg NPSB (46-55.05-10.425- 0.15) + 38.4 kg Urea increased by 254.63 and 253.68 percentages above ground biomass and grain yield respectively as compared to control treatment. The application of 200kg NPSB (69-75.4-13.9-0.2) + 67.83 kg Urea increased by 272.34 and 273.04 percentages in above ground biomass and grain yield respectively as compared to control treatment.

Partial budget analysis for teff grain yield

The economic analysis for teff grain yield (Table 3) agree that the application of different blended fertilizers type with the rate of 100kg NPSB+ 15.6 kg Urea per hectare (T2), 100kg NPSB+30 kg potassium fertilizer (K) per hectare (T8), 150kg NPSB+ 38.4 kg Urea per hectare (T3) and 200kg NPSB + 67.83 kg Urea per hectare (T4). Analysis for marginal rate return also reviled that these treatments were not dominated; that means with investment of one (1) Ethiopia Birr the farmers will gain the lowest value of 3.65 birr per 1 birr investment with 100kg NPSB+ 15.6 kg Urea fertilizer application. The highest of marginal rate of return of 16.72ETB gain per 1 birr investment was obtained with application of 100kg NPSB+30 kg K fertilizers. So that the application of those four fertilizer treatments (100kg NPSB+ 15.6 kg Urea per hectare (T2), 100kg NPSB+30 kg potassium fertilizer (K) per hectare (T8), 150kg NPSB+ 38.4 kg Urea per hectare (T3) and 200kg NPSB + 67.83 kg Urea per hectare (T4)) were 3.65, 16.72, 7.24 and 4.79 birr returns recorded respectively per 1 birr investments better beneficiary for investment.

Table 3. Partial budget and Dominance analysis for teff grain yield

No	Treatment	AMTY (Kg ha^{-1})	10%ATY (Kg ha^{-1})	GFB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	MRR (%)
1	Control	327.69	294.92	11796.8	0	11796.8	
2	100kg NPSB+ 15.6 kg Urea	780	702	28080	3500	24580	3.65
8	100kg NPSB+30 kg K	1045.83	941.25	37650	4040	33610	16.72
5	100kg NPSB+ 15.6 kg Urea +Cu	887.04	798.33	31933.2	4300	27633.2	D
9	100kg NPSB+K + Cu	828.98	746.08	29843.2	4840	25003.2	D
3	150kg NPSB+ 38.4 kg Urea	1158.98	1043.08	41723.2	6280.8	35442.4	7.24
6	150kg NPSB+ 38.4 kg Urea+ Cu	1124.26	1011.83	40473.2	7080.8	33392.4	D
4	200kg NPSB + 67.83 kg Urea	1222.41	1100.17	44006.8	7691.2	36315.6	4.79
7	200kg NPSB + 67.83kg Urea+ Cu	1198.98	1079.08	43163.2	8491.2	34672	D

**NB: AMTY = average marketable tuber yield, AY = Adjusted Tuber yield, GFB =Gross field benefit, TVC= Total variable cost, MRR= Marginal rate of return, B: C =Benefit cost ratio D=Dominated.*

Conclusion and Recommendations

The field experiment carried out to evaluate the effects of blended fertilizers (nitrogen, phosphorus, potassium, sulfur, boron and copper (NPKSBCu) rates and type on yield and yield components teff (Areka-1 variety). It was conducted on farmers' field in randomized complete block design (RCBD) with three replications. Composite soil samples analysis shows that the soil was strongly acidic areas due to that low plant nutrient such as SOC, phosphorus and total nitrogen at both locations. Economic analysis was done to determine economic feasibility of fertilizers with relatively high grain yield of teff.

Application of different blended fertilizers type with the rate of 100kg NPSB+ 15.6 kg Urea (T2), 100kg NPSB+30 kg potassium (K) fertilizer (T8), 150kg NPSB+ 38.4 kg Urea (T3) and 200kg NPSB+ 67.83 kg Urea per hectare (T4) were statically showed significant yield differences and economically feasible. The current study indicated that application of different blended fertilizers type with the rates of 100kg NPSB+ 15.6 kg Urea (T2), 100kg NPSB+30 kg potassium fertilizer (K) (T8), 150kg NPSB+ 38.4 kg Urea (T3) and 200kg NPSB + 67.83 kg Urea per hectare (T4) were suggested as fertilizer options for teff producing farmers in Tembaro district. Partial budget analysis for teff grain yield showed that the highest MRR of 16.72 and 7.24 as 1st and 2nd returns with application of 100kg NPSB+30 kg potassium fertilizer (K) (T8) and 150kg NPSB+ 38.4 kg Urea per hectare (T3) respectively. This result in relation to fertilizer type it is in line with fertilizers type suggested by EthioSIS for the study area (ATA, 2016).

Therefore base on this study integrated soil fertility management practices plus fertilizer applications could be suggested with rate of 100kg NPSB + 30 kg ha^{-1} potassium followed by 150kg NPSB+ 38.4 kg Urea ha^{-1} as 1st and 2nd options for teff production in Tembaro district. Further study is suggested with integrated soil fertility management practice that the soils of the study area were depleting and crop production was below agronomic potential.

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