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Evaluation of different rates of NPS and NPSB fertilizers for better production of teff in Bensa district, Sidama Region

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Abstract

One of the main constraints for sustainable teff production is lack of information on the use of multi-nutrient fertilizer involving the actual limiting nutrients for specific site. An experiment was conducted in 2017 and 2018 cropping season to identify the best fertilizers formulae for production of teff at Bensa district in Southern Ethiopia. Two fertilizer types (NPS and NPSB) at different rates were considered. The experiment consists of seven treatments including no fertilizer (control), three NPS and three NPSB rates: (1) control, (2) NPS = 46 N, 54 P, 10 S, (3) NPS = 69 N, 72 P, 13 S, (4) NPS = 92 N, 90 P, 17 S, (5) NPSB = 46 N,54 P,10 S, 1.07 B, (6) NPSB = 69 N,72 P,13 S, 1.4 B and (7) NPSB = 92 N,90 P,17 S, 1.7 B /ha. In addition, except the absolute control all plots were received 30 kg K/ha. The trial was conducted on two farms and treatments were laid out in a randomized complete block design replicated three times in each farm. Measured data were analyzed using Proc GLM procedures in the SAS 9.3 program. Economic analysis was also performed to investigate the economic feasibility of the fertilizers for teff production. Based on the present result the grain yield and other yield components of teff were influenced by the applied treatments. Significantly lower plant height, number of tillers, biomass and grain yield were recorded from the control compared to all fertilizer treatments. However, almost all fertilizer treatments were not statistically differ each other on yield and other parameters. The economic analysis exhibited that application of 142 kg NPS +42 kg Urea/ha top dressing (46N + 54P + 10S kg/ha) was economically feasible with 419% MRR compared to all other treatments tested in this study. Therefore, farmers can use this rate for teff production in the area.

Keywords: *fertilizer rate, soil nutrient, teff, fertilizer types, benefit*

Background and Justification

Teff is the most important economic crop cultivated by 43 percent of small holder farmers in Ethiopia (Birrara, 2017). It is cultivated in an area of about 2.8 million hectares which taking up about 28.5% of the total grain crop area (Wato, 2019).

In Ethiopia, teff accounts first in area coverage and second in total annual production next to maize and ranks the lowest yield compared with other cereals grown in Ethiopia (Lakew and Berhanu, 2019; Tesfahun, 2018). Teff productivity in the country is very low (1.48 t ha^{-1}) as compared to other major cereals (Central Statistical Authority (CSA), 2016). According to Fenta (2018) some of the factors contributing to low yield of teff are low soil fertility, suboptimal use of mineral fertilizers, weeds, uneven rainfall distribution in lower altitudes, lack of high yielding cultivars, lodging, water-logging, and low moisture. Sakatu and Legesse (2018) reported that farmers in Ethiopian highlands apply N fertilizer in the form of Urea at sub-optimal blanket rates mostly only once at the time of sowing, and this limits the potential productivity of cereal crops (Tamirat and Tilahun, 2020). Therefore, optimal endorsements irrespective of taking the soil physicochemical characterizations as well as the application of full dose at one time during sowing/planting, do not lead to an increase in the teff production and productivity.

Soil fertility reduction is one of the major challenges to crop production and productivity in Ethiopia (Amsal and Tanner, 2001). However the unparalleled rise in population is the root cause of the soil fertility reduction, soil erosion, over cultivation of farm land, inadequate applications of organic and inorganic fertilizers, decreasing or deserting of useful traditional soil restoration practices are also some of the causes of declining soil fertility (Hirpa et al., 2009).

The soil fertility mapping project in Ethiopia reported that deficiency of K, S, Zn, B and Cu other than addition to N and P in major Ethiopian soils were common (Ethio-SIS, 2014).

Balanced fertilizers containing these deficient nutrients in blend form have been recommended to solve site specific nutrient deficiencies and thereby increase crop production and productivity (ATA, 2014). Apart from the blanket recommendation of nitrogen and phosphorus, the effect of other fertilizers on yield, yield components, and overall performance of teff were unknown. Therefore, this study was initiated to provide site and crop specific balanced fertilizer recommendations for better teff production in Bensa district of Sidama region.

Materials and Methods

Two years field trial was conducted with teff in Bensa district of the Sidama region in the main cropping season of 2017 and 2018 GC. The experimental site was located between 6.0586^{o} N latitude and 36.7273^{o} E longitudes at an altitude of 2569 meters above sea level. The experiment was designed based on the nutrient deficiency of the area which indicated in the soil fertility map of Ethiopia produced by Agricultural Transformation Agency (ATA) (2016). Accordingly, two types of fertilizers (NPS and NPSB) were used in different rates. The experiment consists of seven treatments: (1) no fertilizer (control), (2) NPS: 46,54,10 (142 kg NPS+42 kg urea urea-top dress/ha), (3) NPS: 69, 72, 13 (189 kg NPS +72 kg urea urea-top dress/ha), (4) NPS: 92, 90, 17 (237 kg NPS+ 102 kg urea-top dress/ha), (5) NPSB: 46,54,10, 1.07 (150 kg NPSB+41 kg urea - top dress/ha), (6) NPSB: 69,72,13, 1.4 (200 kg NPSB+72 kg urea-top dress/ha) and (7) NPSB: 92,90,17, 1.7 (250 kg NPSB+102 kg urea-top dress/ha). 50 kg potassium chloride (30 K) ha-1 was applied uniformly for all treatments except the control one.

Experimental layout

The experiment was conducted on two farms in each year and laid out in a randomized complete block design using 4 m by 4 m plot size and replicated three times in each farm. To avoid mixing up of treatments the plots were separated by 1 and 1.5 m space between plots and blocks, respectively. All doses of NPS and NPSB fertilizers were applied at planting time and urea was

top dressed 45 days after planting. Improved teff variety (Cross- 37) was planted and other crop management practices were used as recommended for the crop.

Agronomic and economic analysis

Agronomic data for teff, including plant height, tiller number, total biomass and grain yield, were collected. Analysis of variance for all data was done using Proc GLM procedures in the SAS 9.3 program (SAS Institute Inc., Cary, NC USA). The least significant difference (LSD) at 5% probability level was used to establish the significance of differences between the means.

An economic analysis was used to investigate the economic feasibility of the two fertilizer types (NPS and NPSB) for teff production. The partial budget, dominance and marginal rate of return were calculated. For partial budget analysis averages yield that was adjusted downwards by 10% was used, assuming that farmers would get ~10% less yield than is achieved on an experimental site. The average open market price for teff (42 Ethiopian Birr (ETB)/kg) and the official prices for NPS (10.9 ETB/kg), NPSB (10.28 ETB/kg), and N as Urea (8.76 ETB/kg) were used for the analysis. For a treatment to be considered a worthwhile option for farmers, the minimum acceptable marginal rate of return should be over 50% (CIMMYT, 1988). However, Gorfu et al. (1991) suggested a minimum acceptable rate of return should be 100%. Therefore, the minimum acceptable marginal rate of return considered in this study is 100%.

Result and discussion

The study analysis result indicated that there was statistically significant difference between the treatments. All fertilizer treatments significantly ($P < 0.05$) increased teff plant height, grain and biological yield compared to the control (no fertilizer). Significantly higher plant height and grain yield were obtained from almost all treatments except the untreated plot (table 1). Higher above ground total biomass and straw yield were recorded from treatment 4 (NPS: 92, 90, 17 (237 kg NPS+102 kg urea /ha and treatment 7 (NPSB: 92, 90, 17, 1.7 (250 kg NPSB+102 kg urea /ha) compared to treatment 2 (NPS: 46, 54, 10 (142 kg NPS+42 kg urea/ha) and treatment 5 (NPSB: 46,54,10, 1.07 (150 kg NPSB+41 kg urea/ha). Higher tiller number was recorded from treatment 7 compared to treatment 6 (NPSB: 69, 72, 13, 1.4 (200 kg NPSB+72 kg urea /ha). However, almost all fertilizer treatments were not statistically differ each other on yield and other parameters, higher mean straw yield, tiller number, above ground biomass and grain yield was recorded from

treatment 7 (NPSB: 92, 90, 17, 1.7 (250 kg NPSB+102 kg urea /ha). In line with this Jafer (2018) reported that application of NPSB fertilizer significantly increased maize grain yield compared to the control (no fertilizer).

Table 1.Yield of teff as influenced by NPS and NPSB fertilizer at different rates in Bensa district

Treatments	Plant height (cm)	Tiller No	Straw (kg/ha)	Biomass yield (t/ha)	Grain yield (kg/ha)
1. Control	55.2b	3.0c	1.1d	1.5d	378.8b
2. NPS: 46,54,10 (142 kg NPS+42 kg urea/ha)	84.9a	3.8ab	3.6bc	4.4bc	854.3a
3. NPS: 69, 72, 13 (189 kg NPS +72 kg urea/ha)	87.3a	4.1ab	3.9ab	4.8abc	841.2a
4. NPS: 92, 90, 17 (237 kg NPS+102 kg urea /ha	80.0a	4.1ab	4.2a	5.1a	920.7a
5. NPSB: 46,54,10, 1.07 (150 kg NPSB+41 kg urea/ha)	82.0a	3.8ab	3.4c	4.2c	840.3a
6. NPSB: 69,72,13, 1.4 (200 kg NPSB+72 kg urea /ha)	84.1a	3.7b	4.0ab	5.0ab	917.8a
7. NPSB: 92,90,17, 1.7 (250 kg NPSB+102 kg urea /ha)	86.5a	4.3a	4.2a	5.2a	929.1a
LSD at 0.05	17.16	0.5599	0.4808	0.613	214.14
CV (%)	8.497	18.59	12.128	10.829	12.770

Note: Values followed by the same letter are not significantly different at P < 0.05.

Economic analysis

The dominance analysis (Table 2) indicated that except treatment 2, and 6, other treatments were dominated by the treatments with lower variable cost with higher net benefit. Treatment 2 had the lowest total variable costs and higher net benefits than the treatment with the next lowest total variable costs, treatment 5. Treatment 6 had lower total variable cost and gave high net benefit compared to treatment 4. Based on the dominance analysis treatment 2, and 6 were a potential options (Table 2). Therefore, treatments 3, 4, 5 and 7 were eliminated from further economic analysis and only the dominant treatments were considered further in the partial budget analysis (Table 3).

Based on the partial budget analysis (Table 3), the treatment with the higher net benefit was treatment 6 (29,670.1ETB/ha) compared to treatment 2. However, the marginal rate of return in treatments 2 was 53.85947%. This means that for each 1 ETB investment, the producer get less than 100%. Since the minimum acceptable rate of return assumed in this experiment was 100%, treatment 2 only can give an acceptable marginal rate of return (419.0778%) for the extra investment.

Table 2. Partial budget analysis of fertilizers for teff production in Bensa district

Treat	NPS (kg/ha)	NPSB (kg/ha)	N (kg/ha)	K (kg/ha)	Av. Yield (kg/ha)	Adj.Yield (kg/ha)	TVC (EB/ha)	GB (EB/ha)	NB (EB/ha)	MRR%
1	0	0	0	0	378.8	340.9	0.0	14318.6	14318.6	
2	142	0	42	50	854.3	768.9	3462.7	32292.5	28829.9	
5	0	150	41	50	840.3	756.3	3721.9	31763.3	28041.4	D
3	189	0	72	50	841.2	757.1	4651.8	31797.4	27145.6	D
6	0	200	72	50	917.8	826.0	5022.7	34692.8	29670.1	
4	237	0	102	50	920.7	828.6	5856.7	34802.5	28945.8	D
7	0	250	102	50	929.1	836.2	6308.5	35120.0	28811.5	D

AY= average yield, Adj Y= Adjusted yield by 10%, TVC = total variable cost ETB/ha, GB = gross benefit in ETB/ha, NB = net benefit ETB/ha, D indicates dominated treatments that were rejected, MRR = marginal rate of return, Fertilizers NPSB, NPS, Urea and Potassium are indicated in Kg/ha

Table 3. Economic (partial budget and marginal rate of return) analysis for fertilizer rates applied to teff in Bensa district

Treat	NPS (kg/ha)	NPSB (kg/ha)	N (kg/ha)	K (kg/ha)	Av. Yield (kg/ha)	Adj.Yield (kg/ha)	TVC (EB/ha)	GB (EB/ha)	NB (EB/ha)	MRR %
1	0	0	0	0	378.8	340.9	0.0	14318.6	14318.6	
2	142	0	42	50	854.3	768.9	3462.7	32292.5	28829.9	419.0778
6	0	200	72	50	917.8	826.0	5022.7	34692.8	29670.1	53.85947

Conclusion and Recommendation

This study revealed that applying the deficient soil nutrients, nitrogen, phosphorus, sulphur and boron, indicated in the soil fertility map of the area (Bensa) was improved teff yield. Treatment 7 (NPSB: 92, 90, 17, 1.7 (250 kg NPSB+102 kg urea /ha)) gave higher teff yield and yield components.

However, the highest net benefit was obtained from treatment 2 with acceptable marginal rate of return. However, treatment 6 resulted in less than the required return. Therefore, NPS: 46, 54, 10 (142 kg NPS+42 kg urea/ha) could be recommended for teff production in Bensa area.

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