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Research Article

Pre-extension Demonstration of Soil Test Crop Response Based Recommended Phosphorus Fertilizer Rate for Tef in Burka Jiren Watershed of Gechi District, Oromia

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Abstract

The pre-extension demonstration trial was conducted during the 2024 main rainy season in Burka Jiren Community Watershed of Gechi District, Buno Bedele Zone. The objectives were to evaluate grain yield, economic profitability and collect farmers' feedback. The study evaluated soil test crop response based fertilizer recommendation against blanket recommendation for tef (Dursi variety) across three demonstration sites. Data were collected on yield, cost incurred, profit gained, and farmers' feedback. The analysis involved descriptive statistics, independent t-test, and benefit-cost ratio. The descriptive analysis result revealed that, the mean grain yield of 15.1 and 9.9 qt ha^{-1} were obtained from soil test crop response based fertilizer recommendation and blanket recommendation for tef respectively. There was statistically significant mean grain yield difference at ($P<.05$) between soil test crop response based fertilizer recommendation and blanket recommendation for tef with 69.7% yield advantage. Soil test crop response based fertilizer recommendation for tef was also favored by the farmers due to having a number of productive tillers per plant, plant height (biomass), spike length, seed quality and higher grain yield compared to blanket recommendation for tef. Likewise, higher net benefit of 136,884 ETB ha^{-1} was obtained from soil test crop response based fertilizer recommendation for tef with benefit-cost ratio of 3.1 compared to blanket recommendation. This implies, farmers can recover all the incurred costs and gain an additional 3.1 ETB for every 1 ETB they invest when using soil test crop response based fertilizer recommendation for tef. The overall result showed that soil test crop response based fertilizer recommendation for tef had a significant yield advantage, net benefit, and were favored by farmers, leading to the recommendation for scaling up this technology in similar agro-ecologies.

Keywords

Demonstration, Farmers, Tef, Fertilizer, Soil Test, Yield

1. Introduction

Tef is one of the most stable food crop originated and diversified in Ethiopia [5]. Currently, about 30% of Ethiopia's total cultivated land and 20% of the nation's grain production are derived from this single crop [1]. It is widely recognized for its nutrient-dense and gluten-free nature, stress tolerance, long storage life, and climate-smart properties and is preferred by both producers and consumers [9].

Despite its importance, there are a number of tef yield re-

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ducing factors like poor soil fertility, soil acidity, lack of improved seeds and disease [10]. The findings of Gete*et al*. [2] confirmed that, the decline of agricultural production is attributed to poor soil health, low soil fertility, and crop nutrient imbalances that resulted from widespread use of biomass as fuel, depletion of macro and micronutrients, removal of top soil by erosion, and change of soil physical properties.

Irrespective of crop and soil types, blanket recommended rate of 100 kg ha^{-1} UREA (46-0-0 kg ha^{-1} N- P_2O_5- K_2O) or 50 kg ha^{-1} (23-0-0 kg ha^{-1} N- P_2O_5- K_2O) + 100 kg DAP ha^{-1} (18-46-0 N-P2O5- K_2O) were used since early of 70s in Ethiopia [3]. Soil test based fertilizer recommendation plays a vital role in ensuring balanced nutrition to crops where fertilizer application schedules is based on the magnitude of crop response to applied nutrients at different soil fertility levels [7].

Accordingly, soil test based crop response phosphorus calibration study was conducted where the promising tef yield was obtained at optimum P and N fertilizer rate in Chora and verified in Gechi district. However the involvement of farmers in activity implementation and technology evaluation that has a direct proportion within the future farmers' technological adoption is neglected.

2. Objectives

1) To evaluate yield performance of soil test crop response based recommended fertilizer rate for tef under farmers' condition.
2) To evaluate economic profitability of soil test crop response based recommended fertilizer rate for tef.
3) To collect farmers' feedback on soil test crop response based recommended fertilizer rate for tef.

3. Research Methodology

3.1. Descriptions of the Study Area

The watershed is situated in the Gechi district of Buno Bedele zone, southwestern Ethiopia (Figure 1). The specific place of the watershed is Bido Jiren Kebeles, and so the local communities named the watershed Burka Jiren Community Watershed. The watershed lies between 8°12'50.4" and 8°14'52.8 N latitudes and between 36°25'27.48" and 36 °26'52.8" E longitudes. Burka Jiren Community Watershed is about 15 km from Gechi town in Gechi district and about 35 km from Bedele town in Buno Bedele zone. The watershed covers about 535.13 hectares, and 148 smallholder households benefit from the watershed. According to the Google Earth Pro software, the length of the Burka Jiren Community Watershed is about 6 kilometers from the watershed in-late to the outlet. Based on slope gradient, Burka Jiren Community Watershed is characterized mostly by slop, gently slop, and strongly slop. The dominant soil type of the watershed is nitosols, and the common crops produced by the communities are tef and wheat.

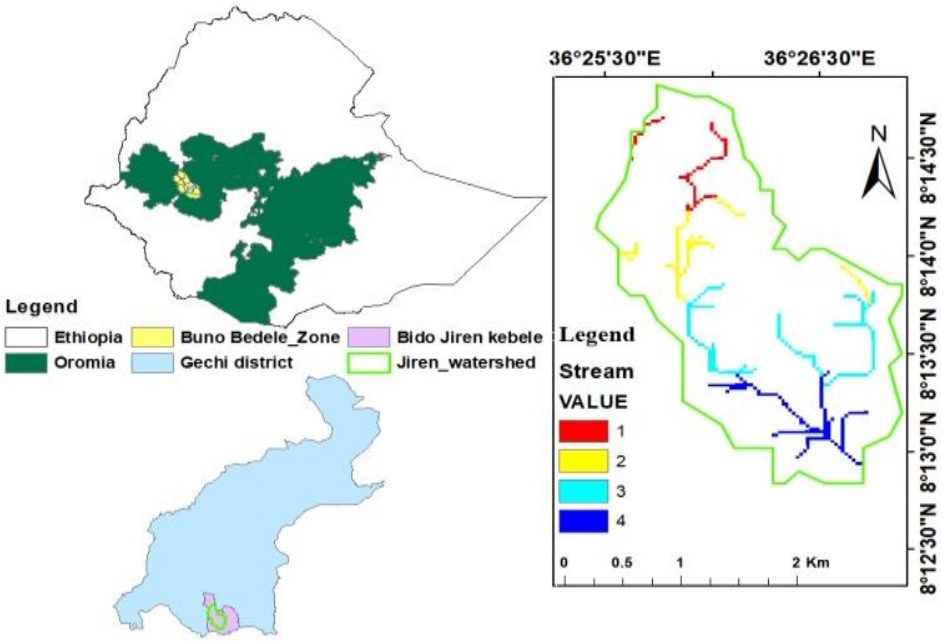

Figure 1. *Map of Burka Jiren Community Watershed.*

3.2. Site and Farmers Selection

The activity was carried out in Burka Jiren Community Watershed of Gechi district. The watershed was selected based on the prioritized constraint of poor soil fertility and low crop yield due to high soil acidity, being part of previ-

ously conducted soil test based recommended fertilizer rate verification study and the project targeted area. For effective activity implementation and representation, the watershed was classified into upper, middle and lower strata where a total of three interested and committed farmers were selected (one farmer per strata) in collaboration with DAs. One FRG having 15 members comprising both male and female was established as the watershed.

3.3. Research Design, Treatment and Procedure

The gross land size of 10 m x 20 m was used for both soil test crop response based recommended fertilizer rate (STCRBFR) and blanket recommendation/farmer practice treatments replicated across three individual farmers field. Dursi, a well-adapted tef variety with the recommended seed rate of 15 kg ha^{-1} was used as a test crop and sown by broadcasting. The determined N fertilizer rate of 46 kg ha^{-1} during calibration study for tef was used.

About one month before planting, one composite soil sample per three experiment hosting farmers' field was collected at the depth of 0-20 cm to analyze available phosphorus in the soil with standard laboratory procedures. Depending on the initial phosphorus status in the soil, rate of fertilizer to be applied was calculated by the formula P (kg ha^{-1}) = (Pc-Po)*Pf, where: Pc = Critical P value, Po = Intial P values for the site and Pf = P requirement factor. Recommended nitrogen was applied at 30 days after planting with the necessary agronomic and management practices. All necessary inputs were provided by Bedele Agricultural Research Center (BeARC). Land was prepared by the experiment hosting farmers; whereas activities such as sowing, first and second weeding, harvesting, threshing were handled by FRG members with researchers close supervision.

3.4. Technology Promotion Methods

Technology promotion events were used to facilitate further under-limed food barley promotion and dissemination. Accordingly, experience sharing and mini-field day were organized with the involvement of FRG members' on soil test based recommended fertilizer rate for tef at crop maturity stage.

3.5. Data Type and Methods of Data Collection

All necessary data like experimental initial phosphorus status, number of farmers participated on mini-field day, farmers' feedback, tef grain yield, cost-incurred and profit gained were collected through both quantitative and qualitative methods of data collection.

Yield advantage

The yield advantage of soil test based recommended fertilizer rate over blanket recommendation was calculated by the following formula.

Yield advantage (%)=Yield of lime treated Adoshe variety-Yield of untreated Adoshe variety/yield of untreated Adoshe variety*100

3.6. Method of Data Analysis

Simple descriptive statistics like mean, standard deviation, and independent t-test were used for quantitative data analysis. Benefit-cost analysis was employed for cost incurred and benefit obtained. The host farmers and FRG members' feedbacks towards soil test based recommended fertilizer rate and blanket recommendation were narrated.

4. Result and Discussion

4.1. Phosphorus and Nitrogen Fertilizers Status Per Demonstration Site

During calibration study; optimum nitrogen rate of 46 kg N ha^{-1}, P-critical level of 4 (ppm) and P requirement factors of 11.71 were determined for tef production in Chora and verified in Gechi district. Based on this report the rate of phosphorus and N-fertilizers required for each demonstration sites were determined. As a result, soil test crop response based recommended fertilizer rate treatment was implemented using the recommendation of calibration study whereas blanket recommendation (BR) treatment was implemented using 1:1 ratio that was 100 kg ha^{-1} of NPS and 100 kg ha^{-1} of Urea recommended by the Ethiopian Ministry of Agriculture and Rural Development.

Table 1. *The status and requirement of P and N-fertilizers per demonstration sites.*

Demonstration Sites	P_0 (Initial P value) (ppm)	P_C (Critical P value) (ppm)	Pf (P requirement factor) (ppm)	Rate of P-fertilizer applied kg/plot		Rate ofN-fertilizer applied kg/plot	
				STCRBFR	BR	STBFR	BR
Site 1	0.92	4	11.71	2.17	1	1	1
Site 2	0.74	4	11.71	2.3	1	1	1
Site 3	0.98	4	11.71	2.13	1	1	1

Demonstration Sites	P_0 (Initial P value) (ppm)	P_C (Critical P value) (ppm)	Pf (P requirement factor) (ppm)	Rate of P-fertilizer applied kg/plot		Rate ofN-fertilizer applied kg/plot	
				STCRBFR	BR	STBFR	BR
Mean	0.88	4	11.71	2.2	1	1	1

Note: STCRBFR=soil test crop response based fertilizer recommendation; BR=Blanket Recommendation.

The result presents at Table 1 indicated that the values of available phosphorous content within the composite soils of the demonstration sites were inconsistent. The observed variation of initial P values between the sites may be due to the low soil organic carbon content, removal of total crop residues, soil erosion and limited application of animal manure. Mamo *et al.* [4] reported that the low available phosphorus content could be due to low amount of organic materials applied to the soil and complete removal of biomass from the field.

4.2. Technology Promotion Method

Table 2. *The number and categories of mini-field day participants at Burka Jiren Community Watershed.*

No.	Participants categories	Sex		Total
		Male	Female	
1	Farmers	12	3	15
2	Development Agents (DAs)	1	1	2
3	Agricultural Experts	5	1	6
Total		18	5	23

The field day creates an opportunity for farmers to share information, observe performance, and deliberate on technological attributes. Accordingly, mini-field day was organized at tef maturity stage. During this technology promotion event different categories of FRG members, development agents and district agricultural expertise were participated. As a result, participants appreciated soil test crop response based recommended fertilizer rate for tef (Dursi variety) technology because of better physiological maturity compared to blanket recommendation.

4.3. Yield Performance

The following Table 3 describes with the application of 46 kg ha^{-1} N and site specific recommended fertilizer the minimum and maximum yield of 12.5 and 18.0 qt ha^{-1} were obtained respectively from the demonstrated soil test crop response based fertilizer recommended rate hereafter STCRBFR for tef technology. Simple descriptive result revealed that the mean grain yield performance of STCRBFR and blanket recommendation (BR) were 15.1 and 8.9 qt ha^{-1} respectively. The current result was agreed with the findings of Reda [6] who reported, the optimum N which is 46 kg N ha-1 and site specific fertilizer recommendation rate was influenced Teff grain yield and the mean maximum grain yield was 1421 kg ha-1 with a 26.42% grain yield advantage over the blanket type fertilizer recommendation rate.

Table 3. *Grain yield performances of the demonstrated STCRBFR and blanket recommendation for tef (qt ha^{-1}).*

Treatments	N	Minimum	Maximum	Mean	Std. Deviation
STCRBFR	3	12.5	18.0	15.1	+2.77
BR	3	7.8	10.1	8.9	+1.10

As indicated on Table 4 below, independent t-test was conducted to compare the grain yields of STCRBFR and blanket recommendation rate for tef. There were statistically significant mean grain yield difference at t (df) = 4, p = 0.023) in scores for STCRBFR (M = 15.1, SD = +2.7683) was higher than blanket recommendation (M = 8.9 SD = +1.1015).

Table 4. Independent samples t-test result of grain yield per STCRBFR and blanket recommendation for tef.

Test for equality of variance and means			Grain yield of STCRBFR and blanket recommendation for tef	
			Equal variances assumed	Equal variances not assumed
Levene's Test for Equality of Variances	F		1.891	
	Sig.		.241	
T-test for Equality of Means	t		3.566	3.566
	df		4	2.618
	Sig. (2-tailed)		.023	.047
	Mean Difference		6.1333	6.1333
	Std. Error Difference		1.7201	1.7201
	95% Confidence Interval of the Difference	Lower	1.3575	.1780
		Upper	10.9092	12.0887

Table 5. The yield advantage of STCRBFR rate for tef.

Treatments	Mean grain yield (qt ha^{-1})	Yield difference (qt ha^{-1})	Yield advantage (%)
STCRBFR rate for tef	15.1	6.2	69.7
BR	8.9	-	-

Source: Own computation 2024

4.4. Economic Profitability

The benefit-cost ratio was employed to compare the profit gained from STCRBFR rate for tef and blanket recommendation by following [8]. The result revealed that, STCRBFR for tef was more than one (>1) implying that using soil test crop response based recommended fertilizer rate for tef was economically feasible. Accordingly, farmers those prefer to use soil test crop response based recommended fertilizer rate for tef could get the net benefit of 136,884 ETB ha^{-1}. The comparative advantage of using STCRBFR for tef over the blanket recommendation was 79,572 ETB ha^{-1}.

Table 6. The result of benefit-cost ratio.

Variables	Treatments	
	STCRBFR	BR
Yield obtained (qt ha^{-1})	15.1	8.9
Sale price (ETB/qt)	13,500	13,500
Total Revenue (Price * Qt)	203,850	120,150
Variable Costs/ha in ETB.		
Land preparation	3,800	3,800
Seed purchase	12,000	12,000
Fertilizers purchase	9,165.66	7,638.31
Cost of labor for weeding	4,000	2,200
Cost of Labor for harvesting	3,500	3,200
Cost of Labor for threshing	4,500	4,000
Total Variable Costs	36,966	32,838
Cost of Land ETB/ha	30,000	30,000
Total cost (TVC + TF C)	66,966	62,838
Gross Margin (GM)=TR-TVC	166,884	87,312
Net Profit=TR-TC or GM-TFC	136,884	57,312
Benefit-cost ratio=Total Revenue/Total Cost	3.1	1.9

4.5. Stakeholders' Feedback

Different agricultural stakeholders participated on mini-field day were provided a feedback related to the performance of STCRBFR and BR for tef. The summarized feedback indicated STCRBFR was favored due to having a number of productive tillers per plant, plant height (biomass), spike length, seed quality and higher grain yield compared to blanket recommendation for tef. Acknowledging the convinced performance of soil test crop response recommended fertilizer rate for tef, FRG members stressed that if agricultural expertise supported us on the procedure of taking soil sample and its on-time result recommendation, we are ready to use STCRBFR rate for tef technology.

5. Conclusion and Recommendation

Soil test crop response based recommended fertilizer rate for tef was demonstrated on three farmers' fields. The two treatments; that were soil test crop response based recommended fertilizer rate and blanket recommendation for tef (Dursi variety) were used. The result indicated that, soil test crop response based recommended fertilizer rate for tef had more yield/yield advantage, net benefit and was favored by the farmers due to having a number of productive tillers per plant, plant height (biomass), spike length, seed quality and higher grain yield compared to blanket recommendation for tef. Therefore, soil test crop response based recommended fertilizer rate for tef was recommended for further scaling up in Burka Jiren Community Watershed of Gechi district and other similar agro-ecologies.

Abbreviations

BeARC	Bedele Agricultural Research Center
Kg	Kilogram
P	Phosphorus
N	Nitrogen
DA	Development Agent
STCRBFR	Soil test crop response based fertilizer recommendation
m	Meter
Pc	P-critical
Po	P-initial
Pf	P-requirement
FRG	Farmers research group
M	Mean
SD	Standard deviation
ETB	Ethiopian birr
qt	Quintal
TVC	Total variable cost

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Author Contributions

Dechasa Mengistu: Data curation, Formal Analysis, Writing – original draft

Suleiman Aman: Data curation, Methodology, Writing – original draft

Conflicts of Interest

The authors declare t no conflicts of interest.

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