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Verification of Soil Test Crop Response based Calibrated Phosphorus for Tef in Gechi District of Buno Bedele Zone, Oromia, Ethiopia

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Research Article

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ABSTRACT

Verification of soil test crop response based calibrated phosphorous recommendation for tef was conducted in the Gechi district, Western Oromia in 2023. The study aimed to verify the recommended nitrogen (46 kg N ha^{-1}), determined P critical level (4 ppm) and P-requirement factor (11.71) for tef. The treatments consisted of control (without fertilizer) (T1), blanket recommendation 100/100 kg ha^{-1} urea and DAP) (T2) and Soil Test Crop Response Based Phosphorus Recommendation (STCRBPR) (T3). The treatments were simply arranged side wise and replicated over farmers. The results of the study revealed that the analyzed surface soils were strongly acidic in reaction, with low available phosphorus, low organic carbon, low TN and low to moderate CEC. The analysis of variance among treatments showed significant differences ($P \leq 0.05$) in tef height, biomass and grain yields. The result also showed that the soils of the study areas were poor in chemical nutrient contents (soil fertility); hence, integrated soil fertility management practices can improve the current situation.

Keywords: P-critical level; P-requirement factor; Tef; Fertilizers

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INTRODUCTION

Soil is a critically important natural resource in the world. Hence, efficient management of which is vital for economic growth and development. African soil nutrient balances are often negative due to low level of fertilizer inputs, and soil nutrient depletion that is a major reason for decreasing or stagnation of agricultural productivity. Mbah indicated that soil fertility is a major overriding constraint that affects all aspects of crop production. As the case in other regions in Africa, Ethiopian farmers use inadequate nutrient inputs, inappropriate quality and inefficient combinations of fertilizers, which in the end proved to be nutrient mining due to sub optimal fertilizer use coupled with unbalanced fertilizer use favored the emergence of multi nutrient deficiency in Ethiopian soils [1].

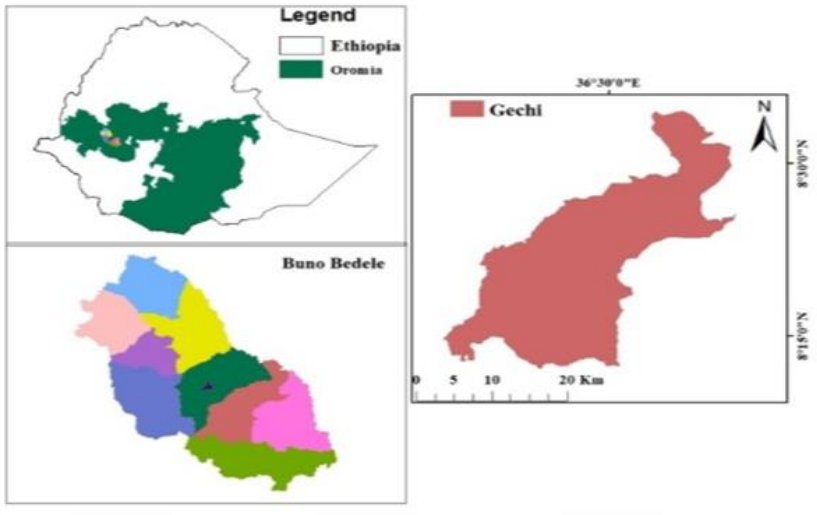
In Ethiopia, low soil fertility is one of the factors limiting the yield of crops, including tef. It may be caused as a result of removal of surface soil by erosion, crop removal of nutrients from the soil, total removal of plant residue from farmland, and lack of proper crop rotation program. The results of several studies conducted on the status of P in Ethiopian soils indicated that most of the soils studied require addition of P fertilizer for profitable crop growth. The demand for fertilization is evident, as growers around the world have already recognized the return, which can be realized from added plant nutrients [2].

MATERIALS AND METHODS

Description of the study area

A verification trial was conducted on farmers' fields in Gechi district, Buno Bedele zone of Oromia. Gechi district is located at latitude at 08°24‘40.0" to 08°25‘12.0" N and longitude 036°25‘61.0" to 036°33‘20.0" E with altitude ranged from 1013 to 2390 masl (Figure 1). The 18 years weather information at the nearby study area (Ethiopian Metrology Agency Bedele District Branch) indicated that a uni-modal rainfall pattern with average annual rain fall of 1945 mm. The rainy season covers April to October and the maximum rainfall is received in the months of June, July and August. The minimum and maximum annual air temperatures are 12.9 and 25.8°C, respectively. The predominant soil type in Southwest and Western Ethiopia in general and the study area in particular, is Nitisols according to the soil classification system. Its vernacular name is “Biyyee Diimaa” meaning red soil. On the average, the soil is deep and relatively highly weathered, well drained, clay in texture and strongly to moderately acidic in reaction. Nitisols are highly weathered soils in the warm and humid areas of the west and Southwest of Ethiopia [3].

Figure 1. Map of the study area (Gechi district).



Soil sampling and analysis

Eight farmers' fields were selected purposively based on their willing and initial soil P-value. Composite surface soil samples (0-20) cm depth were collected from each experimental sites before planting to analyze soil pH (H_2O), Exchangeable acidity, available P, OC, TN and CEC. The collected soil samples were prepared and analyzed following standard laboratory procedures at soil analysis laboratory of Bedele Agricultural Research Center [4].

Experimental materials

Urea (46%) and DAP (46%) were used as sources of N and P fertilizers, respectively using tef Dursi variety as test crop.

Design and experimental procedures

The experiment was laid out in simple adjacent plots and replicated over locations. Each gross plot size was 10 m × 10 m (100 m^2). The experimental fields were prepared by using oxen plow in accordance with conventional farming practices followed by the farming community in the area where, the fields were plowed four times. Full dose of phosphorous as per the treatment and one-half of N was applied at sowing. The remaining one-half of N was top dressed at 35 days after planting in the form of urea. The field was kept free of weeds by hand weeding during the period of the experiment. All other recommended agronomic management practices disease and insect pest control was done [5].

Yield components and yield

Plant height (cm): Plant height was measured above the soil surface to the tip of a spikelet from three randomly tagged plants from the net plot area at physiological maturity [6].

Above-ground dry biomass yield: The aboveground dry biomass yield was determined from plants harvested from the net plot area after sun drying to a constant weight and expressed in kg ha^{-1}.

Grain yield: The grain yield was obtained by harvesting and threshing the grain yield from the net plot area and expressed as yield in kg ha^{-1}.

Statistical analysis

The data was subjected to Analysis of Variance (ANOVA) as per the experimental design using SAS software (version 9.3). The Least Significance Difference (LSD) at 5% level of probability was used to determine differences between treatment means [7].

RESULTS AND DISCUSSION

Soil analysis result indicated that strongly acidic in reaction, low available phosphorus, low organic carbon, low TN and low to moderate CEC (Table 1) [8].

Table 1. Soil data before planting in Gechi district.

Sites	pH (H_2O)	Exch. A (cmol $^{(+)}$/kg soil)	Av. P (ppm)	OC (%)	TN (%)	CEC (cmol $^{(+)}$/kg soil)
1	4.8	0.16	0.79	1.63	0.14	14
2	5.27	0.24	0.97	2.25	0.28	18.4
3	5.02	0.2	1.44	1.95	0.17	15.9
4	4.7	1.12	0.81	1.63	0.14	8.4
5	5.12	0.12	0.67	2.34	0.2	15
6	5.37	1	1.32	2.45	0.3	17
7	4.8	1.44	1.3	2.23	0.25	16.5
8	5.27	1.04	2.1	1.25	0.28	12.1
Note: Av.P=Available Phosphorus, OC=Organic, TN=Total Nitrogen, CEC=Cation Exchange Capacity						

Mean plant height, grain yield and biomass yield of tef in Gechi district

The analysis of variance indicated that plant height, grain and biomass yields were significantly different ($p<0.05$) among treatments (Table 2).

Plant height: The analysis of variance showed that plant height was significantly influenced by the effects of recommended NP fertilizers soil test crop response based fertilizer application resulted the highest plant height (142.33 cm). While the shortest plant height was recorded for the unfertilized plot. The increase in plant height with soil test crop response based fertilizer application could be attributed due to sufficient supply of nutrient which in turn facilitates plants growth since nitrogen plays a crucial role in the structure of chlorophyll and P involved in the energy transfer for cellular metabolism. This result was in agreement with the findings [9].

Biomass yield: The maximum tef biomass yield (5783.3 kg ha^{-1}) was recorded for the soil test crop response based fertilizer application treatment and followed by the blanket recommendation (4716.7 kg ha^{-1}), which are statistically at par. The lowest biomass yield (2633.3 kg ha^{-1}) was recorded from the control, which was significantly inferior to all other treatments. On its report stated that the increase biomass yield is due secondary branch and leaf number and size which were grown during grain filling period beside panicle length and plant height. These results are also strengthened by the report of Tareke who got higher number of productive tillers and heavy panicle bearing culms,

which contributed to increase biomass and straw yield.

Grain yield: The analysis of variance indicated that grain yield, ($p<0.05$) was influenced by the effect of fertilizer application methods (Table 2). Grain yield has been increasing as the methods of fertilizer application vary from control to soil test-based. The result showed that grain yield ranged from (312.50 to 1325.00) kg ha^{-1}) for unfertilized plot and soil test crop response based fertilizer recommendation respectively. Soil test crop response based fertilizer recommendation increases tef grain yield by 52% over the blanket fertilizer recommendation. These results are in line, who indicated that commercial fertilizers can increase 30–50 percent crop production. Improvement in yield due to fertilizer application has been also reported.

Table 2. Mean plant height, grain yield and biomass yield of tef in Gechi district.

Treatments	PLH (cm)	BMY (kg ha^{-1})	GY (kg ha^{-1})
Without fertilizer	103.61^{c}	2633.3^{b}	312.50^{c}
Blanket Rec.	125.39^{b}	4716.7^{a}	635.42^{b}
STCRBPR	142.33^{a}	5783.3^{a}	1325.00^{a}
Mean	123.77	4377.77	757.63
CV (%)	6.87	26.42	14.79
LSD	10.95	1488	144.23
Note: BMY: Biomass Yield; Blanket Rec: Blanket Recommendation; GY: Grain Yield; PLH: Plant Height; STCRBPR=Soil Test Crop Response Based Phosphorus Recommendation			

Economic analysis

The partial budget analysis was employed to calculate the Marginal Rate of Return (MRR) to investigate the economic feasibility of treatments. To identify treatments with the optimum return to the farmers. The partial budget analysis indicated that the highest (389%) marginal rate of return with the highest net benefit 61945.00 Birr ha^{-1} was recorded for the plot that was treated with soil test crop response based phosphorus fertilizer. While, the lowest net benefit 14587.50 Birr ha^{-1} was obtained from the control plot.

Table 3. Partial budget analysis for the verification of Pc and Pf for tef in Gechi district.

Treatments	Av.GY (kg ha^{-1})	Adj.GY (kg ha^{-1})	TVC (Birr)	Gross benefit (Birr)	Net benefit (Birr)	MRR (%)
Without fertilizer	312.5	281.25	10725	25312.5	14587.5	-
Blanket Rec.	635.4	571.86	33970	51467.4	17497.4	12
STCRBPR	1325	1192.5	45380	107325	61945	389
Note: Av.GY=Average Grain Yield; Adj.GY: Adjusted Grain Yield 10%; TVC: Total Variable Costs; MRR: Marginal Rate of Return; STCRBPR=Soil Test Crop Response Based Phosphorus Recommendation						

CONCLUSION

The surface soils of the study areas before planting were low in chemical properties. Tef agronomic characters tested were significantly affected by soil test crop response based calibrated phosphorus. Fertilizer use of soil test crop response based on calibrated phosphorus has significantly increased yield components, grain and biomass yield of tef compared to other treatments. The highest marginal rate of return and net return were obtained from the use of soil test crop response based calibrated phosphorus. To improve the current unbalanced fertilizer application and soil mining of the study sites, preventative actions such as adopting a sustainable soil fertility replenishment strategy, soil conservation practices and avoiding unbalanced fertilizers can help to rebuild the soil conditions to increase tef productivity.

RECOMMENDATIONS

Soil test crop response based calibrated phosphorus for tef production in the Gechi district found to be agronomically and economically feasible treatment. Therefore, recommended nitrogen (46 kg N ha^{-1}), determined P critical level (4 ppm) and P-requirement factor (11.71) for tef could be demonstrated for tef producers in Gechi district.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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