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Demonstration of Soil Test Based NPS Fertilizer Rate Based on Calibrated for Teff in Girar Jarso District of North Shewa Zone, Oromia

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Abstract
The pre-extension demonstration of soil test based NPS fertilizer rate based on calibrated for Teff technology with its full packages practices was done to demonstrate and evaluate the newly adapted teff variety and thereby create awareness for farmers and agricultural extension agents. One improved teff variety (Dagim) was demonstrated Girar Jarso district in two kebeles (Wartu and Dire doyu) two peasant associations were selected purposely from the district based on teff production potential. The experiment was demonstrated on a simple plot with a size of 10 x 10 m. teff grain yield data, and farmer perceptions and preferences were collected and analyzed by simple descriptive statistics. The varieties showed remarkable variation in their yield potential across the testing areas. The average yield performance of the Dagim with soil test based (13.81 qt/ha) obtained from the farmer's field was relatively higher than Dagim without soil test based (10.12 qt/ha) variety and used local variety as a standard check. Similarly, the average yield performance recorded for Dagim with soil test-based technology was higher as compared to Dagim without soil test-based technology. Based on the procedure of variety evaluation and selection criteria, farmers set their criteria to evaluate and select the best variety following the real situation existing. Thus, against each of the criteria and weight attached, Dagim with soil test-based technology was selected for high yield, tolerance to disease and lodging, and early mature as compared to local variety. Therefore; it is important to scale up this variety/technology on a larger scale to improve yield. Thus, Dagim with soil test based NPS fertilizer rate based on calibrated technology Dagim with soil test based NPS fertilizer rate based on calibrated technology recommended for further scale-up.
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1. Introduction

Teff (Eragrostis tef) is a major staple food crop in Ethiopia. Teff is grown at middle elevations between 1,800 and 2,200 meters above sea level and in regions that have adequate rainfall. Compared to other cereals, teff is considered a lower risk crop as it can withstand adverse weather conditions (Fufa et al. 2011). While research on improved teff varieties has been done since the mid-1950s, investments have been limited and only a small number of improved varieties have been released, i.e., about 20 in total (Fufa et al. 2011). Its grain is mainly used for making enjera, a spongy flatbread, the main national dish in Ethiopia (as well as Eritrea). Teff is also valued for its fine straw, which is used for animal feed as well as mixed with mud for building purposes.

Teff is the most important crop in Ethiopia, as measured by a number of indicators. In 2011/12, it was estimated that teff made up 20 percent of all the cultivated area in Ethiopia, covering about 2.7 million hectares and grown by 6.3 million farmers. The second most important crop was maize at 15 percent of all cultivated area. However, given the relatively low yields of teff, the total national production of teff (3.5 million ton) was lower than maize (6.1 million ton) and sorghum (3.9 million ton) (CSA 2012).

When we look at the value of production of teff using a simple average of producer prices collected by the Central Statistical Agency (CSA) in a large number of producer markets in the country and compare it to other crops, we find that teff production in 2012 was valued at 1.6 billion USD, again the most important crop in the country. If we use the commercial surplus data for the period 2011/12, teff value was estimated to be 464 million USD or one quarter lower than coffee (599 million USD), Ethiopia's most important export product. The value of commercial surplus of teff is equal to the commercial surplus of the three other main cereals combined in the country (sorghum, maize, and wheat). By any standards, teff is an important crop, for farm income as well as food security.

However, Declining soil fertility, poor management practices and shortage of rainfall are among the major causes of low productivity of crops in Ethiopia. Hence, identification of proper fertilizer mix is beneficial the macroeconomic level by improving the efficiency of fertilizer procurement and resource allocation.

Despite these agronomical and nutritional benefits of tef, both the total production and productivity of tef is relatively low. The main reasons for inferior yield of tef are suboptimal genetic gain, low access to seeds of

improved varieties, poor agronomic practices and lodging (Kebebew et al., 2017; Mizan et al., 2016). Although 42 improved tef varieties have been released by the National Research System in Ethiopia (MoANR, 2017), their adoption by farmers is low (Kebebew et al., 2017).

Understanding the principles of soil fertility is vital to efficient nutrient management, crop production, as well as environmental protection. Nutrient management is indispensable for crop production and productivity increments on different soil types. So, soil nutrient calibration study is pertinent to increase efficiency use of inorganic fertilizer like DAP and Urea (Kefyalew *et al*, 2018). Profitable crop production requires adequate levels of phosphorus (P) and other nutrients. For this careful planning is required because of volatile grain and fertilizer prices. Soil test-based fertilizer recommendation plays a vital role in ensuring balanced nutrition to crops. Therefore, fertilizer application schedules should be based on the magnitude of crop response to applied nutrients at different soil fertility levels (Santhi *et al*., 2002).

Oromia region is the most important tef producing area in the country; and its share in total national production is estimated to be 48% as high (Ibrahim *et al.,* 2018). In the production year of 2019/2020, the total area covered by teff was 1,487,970.57 hectares with a production of 28,090,978.41 quintals and yield of 18.88 qt/ha from 2,742,049 holders.

Tef is the main crop produced in area of North Shewa zone. The total production of tef in North Shewa zone for the year 2019/20 was 2,578,684.86 quintals produced. The average productivity was registered as 18.95 qt/ha (CSA, 2020). Previously, Fitche Soil Agricultural Research Center was conducted on soil test-based crop response phosphorus calibration study and verification of soil test-based phosphorus recommendation on tef in Girar Jarso district from 2017-20 having different P and N levels and FiARC adapted dagim variety promising result was obtained.

Therefore; the result of soil test-based phosphorus critical value (18ppm) and phosphorus requirement factor (3.03ppm) for teff production in Girar Jarso district. The economic analysis also indicated that soil test-based phosphorus-fertilizer recommendation is economically feasible for Tef production in the district. Fertilizer application based on soil test was increased efficient use of fertilizer for improving agricultural production. This activity was demonstrated to evaluate yield performance and profitability of soil test based NPS fertilizer rate based on p-calibrated for tef under farmers' condition and create awareness on Soil test based NPS fertilizer rate based on p-calibrated for tef in Girar Jarso District.

2. Material and Methods

2.1. Description of the Study Area

The study was conducted in Girar Jarso district North Shewa Zone Oromia, Ethiopia. The district is located at 112 km from the capital Addis Ababa. Geographically location of the district is lies between $09^{0}38'52.8"N$ to $10^{0}00'10.8"N$ latitude and $38^{0}34'22.8"E$ to $38^{0}50'20.4"E$ longitude. The elevation ranged from 1300 and 3419 meters above sea level. The mean annual rain fall is 1200mm According to Fitche Station Meteorological data (Haile Mariam, 2014). The maximum and minimum mean temperature of the area is $35^{0}C$ and $11.5^{0}c$ respectively.

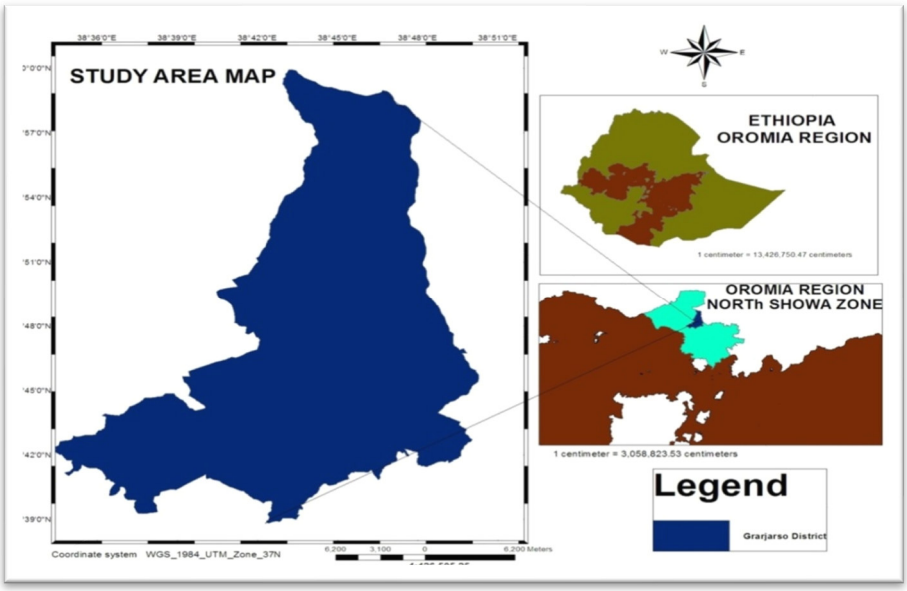

Figure 1: Location map of Girar Jarso district.

2.2. Site and farmers selection

Farmers were selected purposively based on soil sample result and their interest land provision for this pre-extension demonstration, interest in cost-sharing, willingness to share experiences for other farmers and studying their profile with the participation of DAs and community leaders. The selected farmers were grouped in form of Farmers Research Group (FRG) with the member of 15 farmers per PAs in consideration of gender issues (women, men and youth). In the establishment of FRG in the study areas total of 3FRGs (FRG/ PA) from one PA 15 farmers and a total of 45 farmers were grouped in 3 FRG. In the FRG 5 farmers target farmers (3 male trial farmers and 2 female target farmers) and the remaining farmers worked with targeted farmers. PAs was selected purposively based on the potentiality of tef, appropriateness of the area by considering lodging, slop's land escape, access to road, suit for repeatable monitoring and evaluation in progress of sowing to harvesting.

2.3. Research Design

One improved variety with different fertilizer application (soil test-based fertilizer recommendation) Dagim variety and one local check, were replicated across fifty trial farmers. One improved and one local check was planted on 9 farmers' land. 10m*10m plot size of land from individual trial farmer for each pre-extension demonstration of soil test based NPS fertilizer rate based on calibrated for Dagim varieties. Each variety sowing at the spacing of 20cm between rows on 10m*10m. Fertilizer rate NPS 92kg/ ha and UREA 92kg/ha, Seed rate 15 kg/ha

2.4. Technology evaluation and demonstration methods/technique

The evaluation and demonstration of the trials were implemented on farmers' fields to create awareness about the soil-test based NPS fertilizer rate based on calibrated for Dagim varieties. The evaluation and demonstration of the trials followed process demonstration approach by involving FRGs, development agents and experts at different growth stage of the crop. The activity was jointly monitored by FRGs, researchers, experts and development agents.

2.5. Data Collection

Both quantitative and qualitative data were collected through personal field observation and Focus Group Discussion. Types of collected quantitative data were number of farmers participated in FRG, yield performance, number of stakeholders participated in training and field days while qualitative data were farmers' perception toward the new technology, awareness created and farmers' technology selection criteria

2.6. Data analysis

Quantitative data was summarized using simple descriptive statistics (Mean, Frequency and Percentage) while the qualitative data collected using group discussion and key informant interviews, field observation and oral histories was analyzed using narrative explanation or PRA (Participatory Rural Appraisal) tools and argument. Finally, data from different sources were triangulated to get reliable information.

2.6.1. Economic Analysis

Partial budget analysis was done to identify economic feasibility among the Demonstration of soil test based NPS fertilizer rate based on calibrated for teff. The average open market price (Birr kg^{-1}) of teff, at field level and fertilizers was used for analysis. For a Demonstration of Soil Test based NPS fertilizer rate based on calibrated for to be considered a worthwhile option to farmer, the minimum acceptable rate of return MRR. This enables to make recommendations from marginal analysis. Marginal rate of return (MRR) was calculated by using the formula given blow;

$$\text{MRR} = \frac{\text{Net Income STB(dagim)} - \text{Net Income from blanket(dagim)}}{\text{Total Variable Cost of input}}$$

3. Results and Discussion

3.1. Training of target group (Farmers, DAs and Experts)

Multidisciplinary research team; crop, extension and socio-economic research team, soil fertility research team and other stakeholders (Offices of Agriculture and Natural Resource) actively participated by sharing their experience and knowledge. Development agents, experts and farmers were participated on the training given on soil test based NPS fertilizer rate based on calibrated for Tef and Dagim variety. Field day was also organized for more awareness creation.

Table 1: Type of profession and number of participants on the training at Girar district

		Girar/Pas		
No.	Participants	Male	Female	Total
1	Farmers	20	5	25
2	Das	6	-	6
3	District experts	3	1	4
	Total	29	6	35

Source: Own computation 2021/22

Among the training participant stakeholders, 71.43% were farmers. This showed that most of the training participants were farmers. From those farmers, 25% are female farmers' participant.

3.1.1. Mini-field day organized

Table 2: Type of profession and number of participants on the mini field day at Girar District

		Girar/Pas		
No.	Participants	Male	Female	Total
1	Farmers	32	7	39
2	Das	9	1	10
3	District experts	4	-	4
4	Others	5	2	7
	Total	50	10	60

Source: Own computation 2021/22

During mini- field days and farm visit, different questions, opinions and suggestion were raised and reacted from the concerned bodies. Most farmers showed high interest towards improved teff variety (Dagim) variety with Soil Test based NPS fertilizer rate based on calibrated technology production because of better yield and earned income by selling seeds for different stakeholders (neighbors' farmers) as compare to the local seeds. Generally, all farmers were very interested to have the technology for their future production. Therefore, all concerned bodies were shared their responsibility for the future intervention and wider reach out of the technology.

3.2. Agronomic and Yield performance

The following table describes the yield performances of the demonstrated dagim variety with Soil Test based NPS fertilizer rate based on calibrated technology across the study site. The yield performance of the improved varieties (Dagim and local) was 16.1qt/ha and 6qt/ha at wartu and statistically significant yield difference at 26.5% probability level was observed between Dagim and local one.

Table 3 yield performances of the demonstrated dagim variety with STB NPS fertilizer rate based on calibrated

District	**Varieties**	**Mean(qt/ha)**
Girar Jarso	Dagim with STB	13.81qt/ha
	Dagim blanket	10.12qt/ha
	Local	5.9qtl/ha

Data source: Own data

Table 4. Yield performance of improved Dagim variety across districts on Farmer's land.

PA	**Varieties**	**Mean (Qt/ha)**
Wartu	Dagim with STB	16.18
	Dagim blanket	12.65
	Local	6
Koticho	Dagim with STB	11.24
	Dagim blanket	8.5q
	Local	5.5
Dire Doyyu	Dagim with STB	14
	Dagim blanket	9.2
	Local	6.2

3.3. Summary of yield performance of the variety

The result indicated that demonstration of improved dagim varieties with soil test based NPS fertilizer rate based on calibrated technology and local obtained the higher yield advantage (16.18qt/ha) compared to local check (5.5qt/ha) respectively. The percentage increases of the improved varieties over the local check were 26.5% under farmer condition. This showed that improved tef varieties with Soil Test based NPS fertilizer rate based on calibrated technology had advantages over the local check.

Table 5: Summary of yield performance in study areas

Varieties	Average yield/ha	Yield difference	Yield advantage over the local check (%)
Dagim STBR	13.80	3.69	26.5
Dagim blanket	10.12	4.22	14.1
Local check	5.9		

Source: Own computation 2021/22

3.4. Farmers' perception/Opinion

Farmers in the study area also selected the best performing improved tef variety/Dagim with soil test based NPS fertilizer rate based on calibrated technology by using their own criteria. Farmers set these criteria after having know-how about the variety and using those criteria they could select the varieties at harvest time. The opinion of farmers on varietal preference was collected from participants during variety demonstration. The major criteria used by farmers were yield, diseases tolerance/rust, color, number of tiller and maturity period. Based on the above criteria's; farmers evaluated the varieties and ranked first Dagim with soil test based NPS fertilizer rate based on calibrated technology followed by Dagim with blanket over the local. Therefore, the most farmers selected Dagim with soil test based NPS fertilizer rate based on calibrated technology to reuse on their farm for the future. The following table describes farmers' selection criteria and their perception (feedback) toward the variety.

3.5. Partial budget analysis

To estimate the economical significant of soil test based NPS fertilizer rate based on calibrated technology, partial budget analysis was employed to calculate the Marginal rate of return (MRR) to investigate the economic feasibility of technology and variety. Based on actual unit prices during the year 2020/21 harvesting season farm gate price of 43 ETB (Ethiopian Birr) per kg of teff, 16.35 and 15.01 Birr per kg of DAP and Urea, respectively were used to calculate variable cost. The economic analysis showed that the highest net income (61106.35 ETB per ha) and marginal Rate of Return (393.64%) was obtained from soil test-based fertilizer recommendation (Table 3). Thus, the MRR showed that it would yield 3.94 birr for every birr invested. Therefore, soil test-based fertilizer recommendation records the highest MRR that is in acceptance range. So, farmers and other end users in the study area advised to use this soil test crop response-based recommended fertilizer which is cost effective, economically feasible and environmentally safe.

Table 6. Partial budget analysis for demonstration STB fertilizer recommendation of tef in Girar Jarso District

Treatment	Variable Input (Kg ha^{-1})		Unit price (ETB)		TVC	Output (Kg ha^{-1})	Unit price (ETB)	Gross Income (ETB ha^{-1})	Net Income (ETB ha^{-1})	MRR (%)
	DAP	Urea	DAP	Urea						
Local	100	100	16.3	15.01	3135.52	764	43	32852	32852.00	
Dagim Blanket	100	100	16.35	15.01	3135.52	1031	43	44333	41197.48	266.16
Dagim with STB	398.62	44.02	16.35	15.01	7177.65	1588	43	68284	61106.35	393.64

Where: ETB = Ethiopian Birr, TVC = Total Variable Cost, MRR = Marginal Rate of Return

4. Conclusion and Recommendation

One improved teff variety including soil test based NPS fertilizer rate with local check were demonstrated in one district of north Shewa zone for one year. Yield, disease/rust and lodging tolerance, early mature were identified and used as selection criteria across all the locations to select the best performing variety with technology. The overall mean yield of the Dagim with soil test based NPS fertilizer rate variety was 13.81 qt/ha which is relatively higher than the Dagim variety which gave 10.12 qt/ha.

Generally, this study indicated that Dagim with soil test based NPS fertilizer rate based on calibrated technology was higher yielding and the most preferred technology by farmers at Girar district. Local variety was the low yielding variety and also the least preferred varieties by farmers in the study district. Dagim with soil test based NPS fertilizer rate based on calibrated technology has 7.9qt/ha yield advantages over the local one in the study area. Therefore, based on these findings, could be recommended to teff growers in the north Shewa Districts for further promotion. Farmers also liked Dagim with soil test based NPS fertilizer rate based on calibrated technology for enhanced attractive color. Therefore, the Dagim with soil test based NPS fertilizer rate based on calibrated technology could be used by teff producers for scaling up.

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