Pre-Extension Demonstration of Soil Test Based Recommended P-Fertilizer Rate for Bread Wheat at Gechi and Chora Districts of Buno Bedele Zone, Oromia Regional State, Ethiopia

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Abstract

*Pre-extension demonstration of soil test based recommended fertilizer rate for bread wheat was conducted in Gechi and Chora districts of Buno Bedele Zone in 2020 cropping season. The main objectives of the study were to evaluate yield performance and profitability of soil test crop response based phosphorus fertilizer recommendation and to create awareness on site specific crop response fertilizer recommendation rate of bread wheat under farmers' condition. Two treatments: blanket recommendation/farmers' practice and soil test based crop response P-fertilizer recommendation rate were used with improved bread wheat (Liban) variety. The demonstration was conducted on two FTCs and 18 hosting farmers' fields by considering both FTCs and farmers' fields as replication. The trial was conducted on a single plot of 12 m x 20 m area for each treatment with the spacing of 20cm between rows using recommended seed rate of 125 kg/ha and recommended N-fertilizer rates of 92 kg/ha and 138 kg/ha for Gechi and Chora Districts respectively. Field visit was organized for a total of 118 participants during physiological maturity of the crop. The highest mean grain yield was obtained from soil test based fertilizer recommendation rate with more than 60 % yield advantage over blanket fertilizer recommendation. Similarly, the economic analysis result shows that the highest average net income (*34,262.7 *ETB) was obtained from the soil test based fertilizer recommended rate. Hence, the pre-scaling up of soil test based P-fertilizer recommendation rate for bread wheat should be carried out in the coming main cropping season in the study areas.*

Key Words: *Pre-extension demonstration, Bread wheat, Soil test, Blanket recommendation, FRG, FTC, fertilizer*

Introduction

Bread wheat is one of the major crops predominantly grown by small-scale farmers under rain fed condition in the highlands of Ethiopia (Bishawa and Alemu, 2017). In terms of caloric intake, wheat is the second most important food crop in the country next to maize (FAO, 2014). However, In Ethiopia, agriculture is still characterized by low productivity, a high level of nutrient mining, low use of external inputs, traditional farm management practices and limited capacity to respond to environmental shocks (Assefa *et al*., 2013; Amante *et al*., 2014; Agegnehu *et al*., 2016). As reported by Shiferaw (2014), Ethiopian soils lack most of the macro and micronutrients that are required to sustain optimal growth and development of crops. Phosphorus is one of primary concern in the appraisal of the soil resources of Ethiopia since most of the soils in the highland areas of the country are reported to be deficient in phosphorus (Agegnehu *et al.*, 2015; Brady & Weil, 2008). Thus, crop growth in such area needs application of N and P containing fertilizer. However, the rates applied differ with diverse factors such as soil types, agro-ecology, farmers' perception to fertilizer and resource endowment. In contrast to this, variability to fertilizer application, blanket fertilizer recommendations have been adapted through extension program in the

Ethiopia. The blanket recommendations are regardless of considering the physical and chemical properties of the soil as well as does not taken to account climatic condition and available nutrient present in the soil (Taye Bekele *et al.,* 2000).

As indicated by (Kenea *et al.,* 2001) 100 kg ha^{-1} of DAP and 100 kg ha^{-1} of urea were set by the Ministry of Agriculture and Rural Development and these blanket recommendation lead to excess or low application of chemical fertilizers, that aggravates stunted growth of plants due to toxicity or deficiency of the essential elements (Abreha and Yesuf, 2008). Consequently, fertilizer recommendations should take into account the available nutrient already present in the soil. However, for many years no studies have been conducted on site specific fertilizer recommendation rate.

To come up with solution, soil test based crop response phosphorus recommendation and verification trial was conducted in Gechi and Chora Districts and determination of optimum N-fertilizer, P-Critical level and P-requirement factor were completed and promising result was obtained. Therefore, the trial was conducted to undertake participatory demonstration of soil test crop response based phosphorus fertilizers recommendation rate for bread wheat under farmers' condition.

The objectives of study:

- To evaluate yield performance and profitability of p-fertilizer recommendation under farmers' condition,
- To create awareness on the importance of site specific crop response based p-fertilizer recommendation and
- To collect feedback on the yield of soil test crop response based p-fertilizers recommendation rate for maize under farmers' condition.

Methodology

Description of the study areas

Chora is one of the Districts in the Buno Bedele Zone of Oromia Region of Ethiopia. Chora is bordered on the south by the Jimma Zone, on the west by Yayo, on the north by Dega, and on the east by Bedele and its major town is Kumbabe. The district is located at 519 km and 36 km from the capital city of Ethiopia, Addis Ababa and Buno Bedele zonal capital town, Bedele, respectively. It is located at an average elevation of 2000 m.a.s.l and located at $08^0$13'33.7" to $08^0$33'55.0" N latitude and $035^0$59'59.7" to $036^0$15'15.8" E longitude. It is characterized by warm climate with a mean annual maximum temperature of 25.5°C and a mean annual minimum temperature of 12.5°C. The annual rainfall ranges from 1000-1500mm. The economy of the area is based on mixed cropping system and livestock raring agricultural production system among which dominant crops are maize, teff, sorghum and wheat.

Gechi District is located in Buno Bedele Zone of Oromia Region, south western Ethiopia. It is , respectively at about 462 km road distance southwest of Addis Ababa. The area has an altitude between 1500-2100m above sea level and humid agro ecology. The average annual rainfall ranging from 1000 to 1200 mm and the minimum and maximum daily temperature of 13ºC and 18°C. There are diversified economic activities in this District. Crop cultivation and animal rearing are the most known activities that the societies practice. The major crops grown are: maize, tef, sorghum, barley, wheat, pulses and coffee.

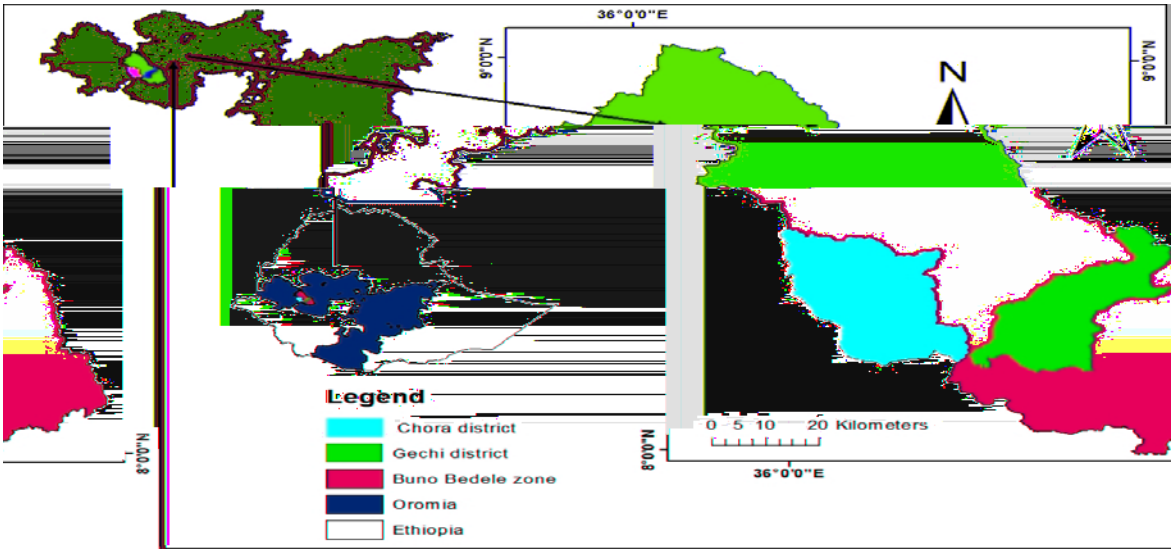

Figure 1: Map of Chora and Gechi Districts

Site and farmers' selection

Purposive sampling method was employed to select Chora and Gechi Districts from the Buno Bedele Zone based on wheat production potential, completed calibration and verification studies. From each District, three representative kebeles were selected purposively by considering road accessibility and production potentialities and two well-represented farmers' training centers (one FTC per District) were used to simplify the demonstration process and enhance the participation of follower farmers and other stakeholders during technology extension events.

Availability of suitable and sufficient land to accommodate the trials, willingness to contribute the land, vicinity to roads to facilitate the chance of being visited by many farmers, initiatives to implement the activity in high-quality, good in field management and willingness to explain the technologies to others were the criteria used to select the hosting farmers. One FRG having 10-12 members including hosting farmers were established in each kebele in collaboration with community leaders, DAs, SMS, and FRG members. Accordingly, the experiment was carried out on two FTCs and 18 farmer's fields (three hosting farmers per kebele), which are used as replication.

Field design and materials

The trial was conducted on soil test crop response based recommended Phosphorus fertilizer rate for bread wheat (Liban) and blanket recommendation on 12 m x 20 m experimental plot size for each treatment with the spacing and seed rate of 20 cm between rows and 125 kg ha^{-1}, respectively.

Surface composite soil samples were collected from the experimental fields at a depth of 0-20 cm by using an auger to analyze available P and pH with standard laboratory procedures before planting time. The rate of fertilizer applied was calculated by the formula (kg P ha) = (Pc-Po)*Pf, where: Pc = Critical P-value, Po = Initial P- values for the site and Pf = P requirement factor based on initial phosphorus status in the soil. The recommended N fertilizer rate that was 92 and 138 kg ha^{-1} in Gechi and Chora Districts respectively were applied in split application of 1/3 at planting time and 2/3 at one month after planting with the necessary agronomic and management practices. The experimental fields were prepared by using oxen plow following conventional farming practices followed by the farming community in the area. Thus, experimental field preparation was carried out by hosting

farmers whereas activities such as planting, first and second weeding, harvesting and threshing were handled by FRG members with close supervision of the researchers.

Technology demonstration approaches

The extension events such as training and field visits/tours were organized at the representative site to enhance farmer to farmer learning and experience sharing. FRGs members and concerned stakeholders were motivated to participate on these different extension events. Field visit was arranged for farmers, DAs, and experts to create awareness on the soil test based fertilizer application technology.

Data collected and

The grain yield data and the total number of farmers participated on field visit and training were recorded. The cost incurred and profits gained data were collected.

Methods of data analysis

Simple descriptive statistics were also used to analyze quantitative data; while qualitative data were analyzed using narrative explanation. The economic related data were analyzed using gross margin analysis.

Results and Discussions

Yield performance of Wheat technologies

Application of site specific p-fertilizer recommendation and optimum N-fertilizer causes higher yield performance over blanket fertilizer recommendation/farmers' practice. Fertilizer application based on soil test also correct the imbalances in nutrients according to crop requirements, increases produce and efficient use of fertilizer for improving wheat production. Farmers were observed different experimental sites and appreciated the performance of Wheat technologies. Participants reflect their feedback as soil test crop response based fertilizer recommendation generates higher return and yield over blanket recommendation/farmers' practice based on variability between treatments of demonstration sites. Soil testing is the most reliable tool for making good economic and environmental decisions about applying fertilizers; hence it is helpful for efficient and effective use of urea and P-fertilizers. The result obtained from the trial conducted at Chora and Gechi districts indicates that fertilizer application based on site specific soil test was higher bread wheat grain yield over blanket recommendation. The use of site specific fertilizer application enhanced the mean bread wheat grain yield from 13.5 and 21.6 qt ha^{-1} (blanket recommendation) to 24.9 and 32.3 qt ha^{-1} (soil test crop response based p-fertilizer recommendation) in Chora and Gechi districts respectively.

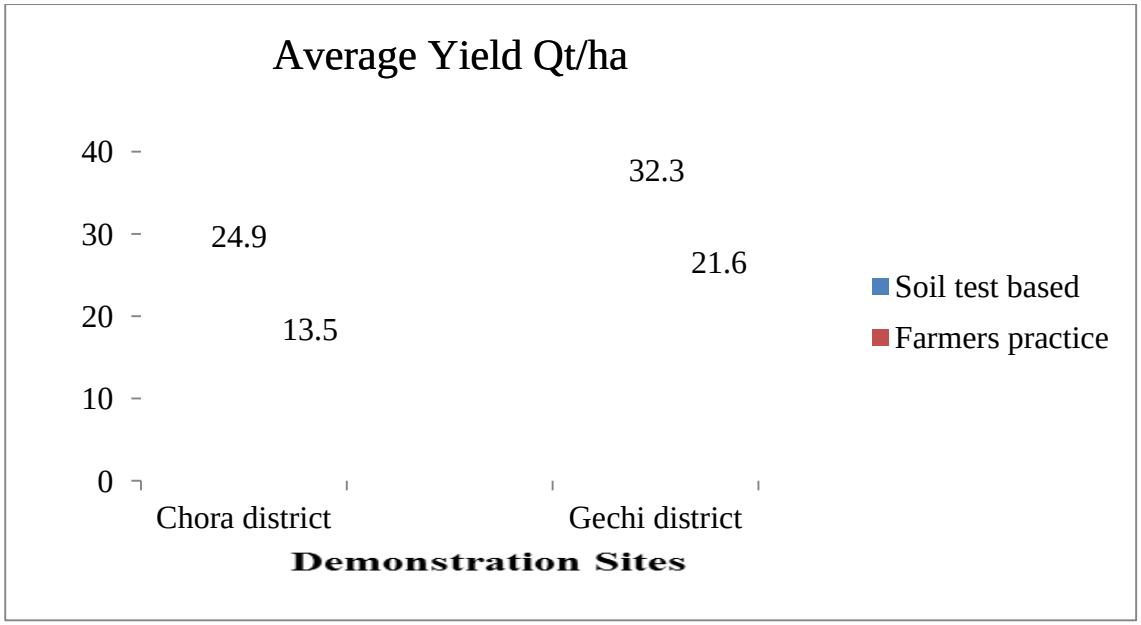

Figure 1: Mean yield data of the demonstrated technologies in the districts

Yield advantage of the districts were calculated using by formula
Where**,** STCRBFR = Soil test crop response based p- fertilizer recommendation

Yield advantage % = Yield of STCRBFR (qt ha-1) - Yield of FP (qt ha-1) X 100
Yield of FP (qt ha-1)

FP = Farmers' practice

Table 3: Yield advantage of STCRBFR over farmers 'practice

Treatment	**Mean yield (qt ha^{-1})**	**Yield advantage (%) over Farmers' practice**
Farmers' practice	17.55	-
soil test crop response based fertilizer recommendation	28.6	63

As the result of the above table 3 indicates STCRBFR is more strategic toward increment of farmers production and hosting farmers had obtained more than 60% of yield advantage from soil test crop response based p- fertilizer recommendation over the blanket recommendation (farmers' practice).

Economic Analysis

Economic analysis was done using gross margin analysis at prevailing market value of the grain and inputs during the cropping period. Only total costs that varied were used to compute costs. All costs and benefits were calculated on hectare basis in Ethiopian birr (ETB ha^{-1}). Accordingly, inputs that vary like NPS, N-fertilizer and labor price were 1622 ETB qt^{-1}, 1581.51 ETB qt^{-1} and 75/day whereas, bread wheat grain output was 1500 ETB qt^{-1} at farm gate price. The economic analysis result shows that the highest net income (34,262.7 ETB) was obtained from soil test based fertilizer recommended rate in Gechi and Chora districts.

Table 3: Economic analysis for bread wheat technologies

Locations: Gechi and Chora districts		
Parameters	Treatments	
	FP	STCRBFR
Yield (Y) obtained (t ha^{-1})	1.76	2.84
Unit Price (ETB qt^{-1})	1500.00	1500.00
Total variable costs (ETB ha^{-1})	4028.51	8337.3
Gross Return	26,400	42,600
Net Return (GR-TVC)	22,371.49	34,262.7

Source: Own computing Data, 2020

Note: STCRBFR = soil test crop response based P-fertilizer recommendation, ETB = Ethiopian Birr

Training and Field visit

Training was given to the participants on the concepts of FRG establishment, role and responsibility of FRG members in executing the trial, importance and method of soil sampling and significance of soil test based crop response P-fertilizer recommendation. A total of 68 farmers' (57 Male and 11 Female), 18 DAs (14 Male and 4 Female) and 9 Experts (7 Male and 2 Female) were participating on training. In addition to the training, participatory field visit was arranged in Gechi and Chora districts of Buno Bedele Zone for a total of 118 participants with the aims of sharing experiences especially on how to practice the trial and as all FRG members practice on their own farm.

Table 1: Gender composition stakeholders participated on field visit

Districts	Participants	Male	Female	Total
Gechi	Farmers	27	9	36
	DAs	7	2	9
	Other stakeholders	13	1	14
Chora	Farmers	29	7	36
	DAs	5	4	9
	Other stakeholders	12	2	14
Total		**93**	**25**	**118**

Source: Own Data, 2020

The recommended Phosphorus and Nitrogen fertilizers in the study areas

As Dagne *et al.,* (2017) reported during the calibration study, 3.8 ppm of P-critical level and 30.28 of P-requirement factor was determined and 138 kg ha-1 of nitrogen fertilizer was recommended for the study area. Likewise, the calibration study on bread wheat at Gechi district indicated that a P-critical level of 2.5 ppm and P-requirement factor of 46.06 was determined, and 92 kg ha-1of nitrogen fertilizer was recommended (Dagne *et al.,* 2019). Soil test crop response based Phosphorus fertilizer recommendation treatment was implemented using calibration recommendation whereas farmers' practice was implemented using blanket fertilizer recommendation set by the Ministry of Agriculture and Rural Development that is 100kg ha^{-1} of NPS and urea.

Table 2: Gechi and Chora Districts recommended P and N fertilizer rate

Sites	P_o (initial pvalues)(ppm)	P_c (P critical level) (ppm)	Pf (Requirement factor)	Rate of P-fertilizer applied Kg/plot(240)		Rate of N-fertilizer (urea)applied Kg/plot(240)	
				Fp	STCRBFR	Fp	STCRBFR
site 1	1.04	2.5	46.06	2.4	9.77	2.4	4.8
site 2	1.24	2.5	46.06	2.4	8.34	2.4	4.8
site 3	1.96	2.5	46.06	2.4	3.6	2.4	4.8
site 4	1.44	2.5	46.06	2.4	7.019	2.4	4.8
site 5	1.9	2.5	46.06	2.4	3.98	2.4	4.8
site 6	2.04	2.5	46.06	2.4	3.03	2.4	4.8
site 7	1.68	2.5	46.06	2.4	5.5	2.4	4.8
site 8	1.04	2.5	46.06	2.4	9.77	2.4	4.8
site 9	1.4	2.5	46.06	2.4	7.3	2.4	4.8
site 10	1.46	2.5	46.06	2.4	6.9	2.4	4.8
Average	**1.52**	**2.5**	**46.06**	**2.4**	**6.52**	**2.4**	**4.8**
Chora district recommended P and N fertilizer rate per farmers' entire field of experiment							
Site 11	1.16	3.8	30.28	2.4	11.62	2.4	7.2
Site 12	2.64	3.8	30.28	2.4	5.12	2.4	7.2
Site 13	1.38	3.8	30.28	2.4	10.62	2.4	7.2
Site 14	0.96	3.8	30.28	2.4	12.42	2.4	7.2
Site 15	1.3	3.8	30.28	2.4	10.90	2.4	7.2
Site 16	1.34	3.8	30.28	2.4	10.81	2.4	7.2
Site 17	1.16	3.8	30.28	2.4	11.57	2.4	7.2
Site 18	1.1	3.8	30.28	2.4	11.85	2.4	7.2
Site 19	1.44	3.8	30.28	2.4	10.34	2.4	7.2
Site 20	2.35	3.8	30.28	2.4	6.35	2.4	7.2
Average	**1.483**	**3.8**	**30.28**	**2.4**	**10.16**	**2.4**	**7.2**

Note: FP = Farmers' practice; STCRBFR=soil test crop response based fertilizer recommendation.

Source: Own Computing Data, 2020

The result presented in Table 2 indicates there was a varying available phosphorus level within the demonstration sites. The highest the available p of the demonstration sites (2.64 and 2.04 ppm) the lowest it desired the recommended p-fertilizer rate (5.12 and 3.03 kg/plot) and the lowest available p of the demonstration sites (0.96 and 1.04 ppm) the highest it desired the recommended p-fertilizer rate (12.42 and 9.77 kg/plot) based on determined P_c and Pf across Chora and Gechi districts respectively.

Farmers' Feedback

On the exchange visit demonstration site, the participants exchanged their views, opinions and shared their experience. During this time an assessment was made to know how the farmers perceived the technology. Result of the assessment revealed that soil test crop response based fertilizer recommendation was appreciated by farmers in terms of its efficient use of fertilizers and advanced yield advantage over blanket recommendation. Farmers'

requests for soil laboratories accessibility with affordable charge and they also ask technical support to be benefitted from technologies.

Conclusion and Recommendation

As a result of conducted pre-extension demonstration on bread wheat in study areas indicates, the highest mean bread wheat grain yield was obtained from soil test based fertilizer recommendation rate with more than 60% yield advantages over blanket fertilizer recommendation. Similarly, net of return gained from soil test based p-fertilizer recommendation was more profitable than that of blanket recommendation. Due to these results, the farmers reflect their opinion as fertilizer application based on soil tests is an efficient and effective use of fertilizers over blanket recommendations. So, Bedele Agricultural Research Center (BeARC) soil laboratory should be more functional with free/in low charge so that farmers will get access to test their soil. BeARC, Zonal and districts Bureau of Agriculture should work and harmonize on the transfer of the technology to end users/farmers'. Therefore, the pre-scaling up of soil test based p-fertilizer recommendation rate for bread wheat should be conducted for further dissemination of technology in the study areas.

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