Pre-Extension Demonstration of Soil Test Based Recommended P-Fertilizer Rate for Maize in Jimma and Ilu Ababor Zones, Oromia Regional State, Ethiopia

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Abstract

Pre-extension demonstration of soil test based recommended p-fertilizer rate for maize was conducted in Mana and Darimu districts of Jimma and Ilu Ababor Zones, respectively, with the objectives of demonstrating and creating awareness on soil test based crop response p-fertilizer recommendation rate for maize under farmers' conditions in the 2020 cropping season. Two treatments; blanket recommendation/farmers' practice and soil test based crop response p- fertilizer recommendation rate were used with improved maize (BH 661) variety. The demonstration was under taken 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 x25 m area for each treatment with the spacing of 80cm and 50cm between rows and seeds respectively using recommended seed rate of 25kg/ha and recommended N-fertilizer rates of 138kg/ha and 92 kg/ha for Darimu and Mana districts, respectively. One FRG consisting of 15 members was established per each kebele. *A total of 114 participants were participated on field visit held during physiological maturity of the crop. The average yield gained from soil test based fertilizer recommendation rate was more economical than that of farmers' practice. Likewise, the economic analysis result shows that the highest average net income (51,848.75 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 maize should be carried out in the coming main cropping season in the study areas.*
Key Words: Demonstration, Soil Test Based, Farmers' Practice, p-fertilizer, maize

Introduction

Maize (*Zea mays L.*) is one of the most important food crops worldwide (Christian *et al.*, 2012). It is the principal component of human diet and feed constituent for domestic animals. In Ethiopia, maize is one of the most important cereal crops grown`. Among all cereals, maize ranks second to teff (*Eragrostis teff*) in area coverage but first in productivity and total production (CSA, 2018/19). The national area coverage and average yield of maize is 18.60% (about 2,367,797.39 hectares) and 30.08% (94,927,708.34 quintals), respectively. The area coverage and average yield of maize in Oromia regional state is 137,868.06 hectares and 58,887,064.26 Quintals, respectively (CSA, 2020/21).

However, there are a number of factors that causing the low production and productivity of maize. Among these factors, inappropriate cropping systems, mono-cropping, nutrient mining, unbalanced nutrient application, removal of crop residues from the fields and inadequate re-supplies of nutrients have contributed to decline in crop yields (McDonald *et al.*, 2005). One of the major problems constraining the development of an economically successful agriculture is nutrient deficiency (Fageria & Baligar, 2005). Nutrient mining due to sub optimal fertilizer use in one hand and unbalanced fertilizer uses on other have favored the emergence of multi nutrient deficiency.

The role of fertilizers is to increase yield and ensure healthy produce by supplying the right balance of nutrients to the soil**. Fertilizers accounted for more than 50% of the increase in yield (Yazıcı & Korkmaz, 2020).** Fertilizer recommendations should take into account the existing nutrient availability in the soil and should be developed specifically for different crops in different agro-ecologies (Bermudez & Mallarino, 2007). The use of chemical fertilizer through soil test based crop response to overcome nutrient deficiencies is a practice that is receiving a wide acceptance in the country. Besides, site specific soil test based recommended usage of fertilizer provides macro and micro nutrients that is needed by the crop to provide the maximum yield and which is economically feasible for the producers. Keeping in view of the above facts, the study was conducted to overcome the over-or under-application of fertilizers associated with the use of blanket recommendations, which results in reduced nutrient use efficiency or losses in yield, unnecessary input costs, and reduced profitability in the study areas.

The objectives of this study

- To evaluate yield performance and profitability of p-fertilizer recommendation under farmers' condition,
- To enhance knowledge and skills on 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.

Research Methodology

Description of the study areas

Mana District is located at 373.83 km from capital city of Ethiopia, Addis Ababa and 20 km west of Jimma town. The administrative center of this district is Yebu. It is geographically located between 7°44´59.99´´ N latitude and 36°44´59.99´´ E longitude and the altitude of the district ranges from 1470 to 2610 m. a.s.l. The mean minimum and maximum temperatures are 13.0^0C and 24.8^0C, respectively with the average annual rainfall of 1523 mm. The land in this district shows that 89.1% is arable or cultivable (86.1% is under annual crops), 2.7% pasture, 2.8% forest, and the remaining 5.4% is considered swampy, degraded or otherwise unusable. Mixed cropping system is mainly practiced in the District. Maize, tef, sorghum, barley, wheat, coffee, chat and horse bean are the most widely cultivated crops in the district. Chat and coffee are important cash crops.

Darimu District is one of districts of Ilu Ababor Zone in Oromia regional state and the district is subdivided in to 45 rural and 2 urban kebeles. The district administrative center is Dopa, located 64 km away from Zonal town Ilu Ababor (Metu) and 664 km to the South west from Addis Ababa. It is located at latitude of 8^o 36'0" N and longitude of 36^o11'0'' E and altitude of the area ranges from 792-1800 meter above sea level. The climatic condition of the Darimu district fluctuates with long summer rainfall (June to September), short rainy seasons (March to April) and winter dry seasons (December to February) and the mean annual rainfall ranges from 1172-1740 mm. Agriculture is the main stay of livelihood of people with mixed farming system among which maize, teff, sorghum, barley and beans are the dominant crops in the study area.

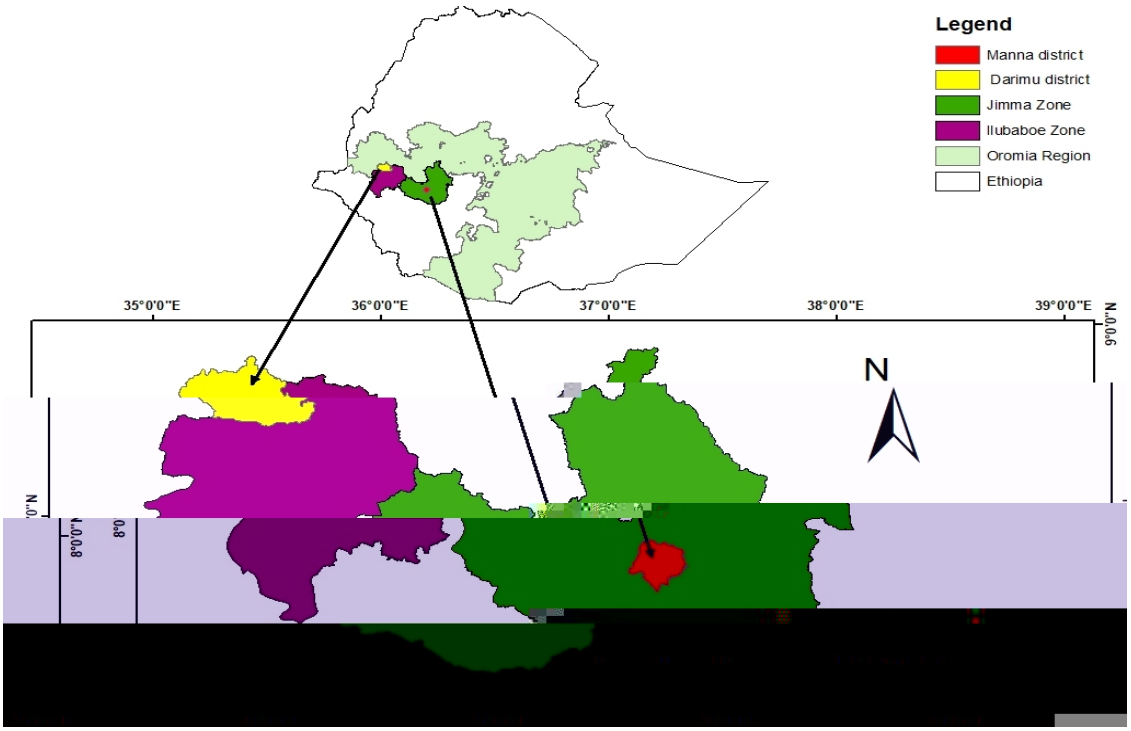

Figure 1: map of Mana and Darimu districts

Site and farmers' selection

Pre-extension demonstration of soil test based recommended p-fertilizer rate for maize (BH 661) was conducted in two districts of Jimma and Ilu Ababor Zones, Mana and Darimu, respectively. Purposive sampling method was applied to select two representative districts and three kebeles from each district on the basis of maize production potential, accessibility, completed calibration and verification study in the districts. 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.

The farmers were purposively selected based on their eagerness toward acceptance of new technologies, land provision for activity implementation and willingness to share experiences for other farmers in collaboration with community leaders, DAs, and SMS. The selected farmers were grouped in the form of farmer research groups (FRGs). One FRG with the member of 15 farmers per Kebele in consideration of gender issues and a total of ninety (90) farmers were formed. In each FRG, three hosting farmers were selected with the rest being participant farmers. Accordingly, the demonstration trial was conducted on two FTCs and 18 hosting farmers' field by considering both FTCs and farmers field as replication.

Field design and materials

Two treatments: blanket recommendation (farmers' practice) and soil test based crop response p- fertilizer recommendation rate for maize were set side by side on adjacent plots of 12 m * 25 m each and 24 m * 25 m of whole plot size. Recommended agronomic practices, spacing of 80 cm and 50 cm between rows and plants, respectively using recommended seed rate of 25 kg/ha were used.

Before conducting the trial, composite soil samples were collected following the zigzag soil sampling pattern using auger from a depth of 0-20 cm. The importance of composite sampling in a zigzag pattern is relatively inexpensive, easily tracked and reproducible result might be obtained (Hardy *et al.*, 2008). Soil parameters such as available P and pH of the experimental soil were analyzed with standard laboratory procedures. Depending on initial phosphorus status in the soil, rate of fertilizer to be applied was calculated by the formula (kg P/ha) = (Pc-Po)*Pf, where: Pc = critical P-value which was 10 ppm and 5.5 ppm, Pf = P requirement factor which was 7.49 and 13.89 in Darimu and Mana districts, respectively and Po = Initial P values for the site. 138kg/ha and 92 kg/ha of recommended N fertilizer (urea) rate for Darimu and Mana districts, respectively was 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 in accordance with conventional farming practices followed by the farming community in the area. Thus, experimental field operations (preparation) were 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

FRGs members (those who are engaged in farming activities, farmers with Maize variety background and interested to work in groups) and follower farmers (farmers who are organized under each FRG to enhance farmer-farmer technology dissemination and co-learning) were encouraged to participate on different extension events such as trainings, and field visits/tours organized at the representative site. Training was provided for farmers', agricultural experts and DA's with the aim of creating awareness on the soil test based fertilizer application technology. Field visit was organized during the crop maturity stage for the farmers, experts and the concerned stakeholders to convince sound variability between the treatments in the areas.

Method of Data Collection

Both quantitative and qualitative data were collected through personal field observation, individual interview, Focus Group Discussion by using checklist and data sheet tools. Types of collected quantitative data were number of farmers participated in FRG, yield performance, economic analysis and number of stakeholders participated on the training. While qualitative data were farmers' opinions towards the new technology.

Methods of Analysis

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

Results and Discussions

Yield performance of demonstrated technologies

The result obtained from the trial conducted at Mana and Darimu Districts indicates that fertilizer application based on site specific soil test produced higher maize grain yield and performed the best(sound yield variability between the treatments and within the sites) over blanket recommendation. 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 use of site specific fertilizer application enhanced the overall mean maize grain yield from 52.45 qt ha^{-1} (blanket recommendation) to 75.8 qt ha^{-1} (soil test crop response based p-fertilizer recommendation) with 44.5% yield advantage.

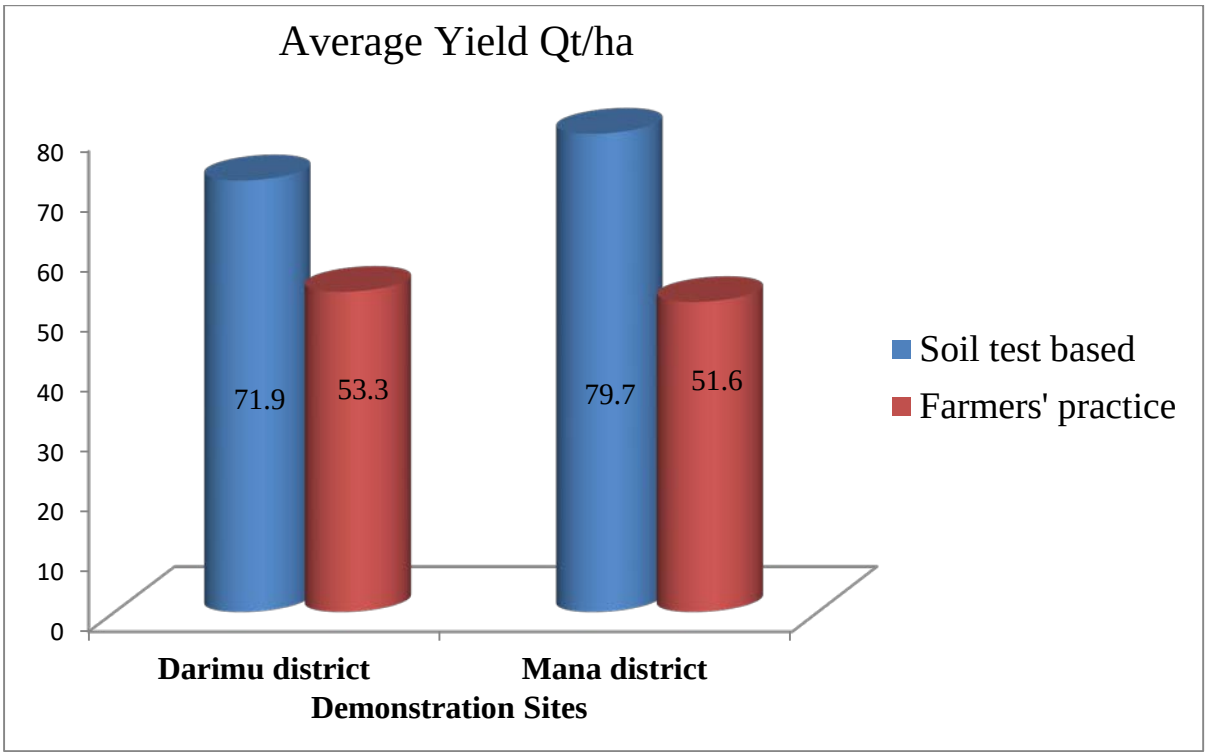

Figure 1: Mean yield data of the Maize technologies in the Districts

Yield advantage were calculated using the formula

$$\text{Yield advantage \%} = \frac{\text{Yield of STCRBFR (qt ha}^{-1}\text{) - Yield of FP (qt ha}^{-1}\text{)}}{\text{Yield of FP (qt ha}^{-1}\text{)}} \times 100$$

Where, STCRBFR = Soil test crop response based fertilizer recommendation

FP = Farmers' practice

Table 3**:** Yield advantage of the STCRBFR over the farmers' practice

The above table 3 indicates that the hosting farmers had obtained more than 40% yield advantage from soil test crop response based fertilizer recommendation over the blanket recommendation.

Economic Analysis

Gross margin analysis was employed to identify economic feasibility of the fertilizer recommendation rate among farmers' practice and Soil test crop response based -fertilizer recommendation. All variable costs with the assumption that the rest of costs incurred are the same for all treatments and benefits were calculated on hectare basis in Ethiopian birr by using the prevailing market prices for variable inputs at planting and for outputs at the time the crop was harvested. Likewise, the price of variable inputs: NPS, Urea and labour were 1622 ETB qt^{-1}, 1581.51 ETB qt^{-1} and 75 ETB per day whereas maize grain out12 142.56 454i0 Td ( )Tj3

participants. Field visit was prepared for creating an opportunity for farmers to learn from each other, share experiences especially on how to practice the trial as all FRG members practice on their farm.

Table 1: Gender composition number of stakeholders' participated field visit

Districts	Participants	Male	Female	Total
Darimu	Farmers	30	7	37
	DAs	8	1	9
	Other stakeholders	11	1	12
Mana	Farmers	27	8	35
	DAs	7	2	9
	Other stakeholders	10	2	12
Total		**93**	**21**	**114**

Source: Own Data, 2020

The recommended Phosphorus and Nitrogen fertilizers in the study areas

As reported by Dagne *et al.*, (2013) at calibration study for maize in Mana district, 5.5 ppm of P-critical value and 13.89 of P-requirement factor was determined for phosphorus fertilizer recommendation and 92 kg ha^{-1} of N-fertilizer recommended for the study area. Similarly, 138 kg ha^{-1} of N-fertilizer (Urea), 10 ppm of Phosphorus critical level, and 7.49 of P-requirement factor for maize production were recommended in Darimu District (Dagne *et al.*, 2018). Consequently, the calibration recommendation was used for implementation of soil test crop response based Phosphorus fertilizer recommendation treatment whereas farmers' practice/blanket recommendation treatment was implemented using fertilizer recommended by the Ministry of Agriculture and Rural Development that is 100kg ha^{-1} of NPS and urea.

Table 2: Mana and Darimu Districts recommended P and N fertilizer rate

Sites	***P_o (initial p values) (ppm)***	***P_c (P critical level) (ppm)***	***Pf (Requirement factor)***	***Rate of P-fertilizer applied Kg/plot(300 m^2)***		***Rate of N-fertilizer (urea)applied Kg/plot(300 m^2)***	
				Fp	STCRBFR	Fp	STCRBFR
site 1	1.29	5.5	13.89	3	10.6	3	6
site 2	1.785	5.5	13.89	3	9.3	3	6
site 3	1.775	5.5	13.89	3	9.4	3	6
site 4	1.702	5.5	13.89	3	9.5	3	6
site 5	1.481	5.5	13.89	3	10.1	3	6
site 6	0.976	5.5	13.89	3	11.4	3	6
site 7	1.199	5.5	13.89	3	10.8	3	6
site 8	2.75	5.5	13.89	3	6.9	3	6
site 9	1.152	5.5	13.89	3	10.9	3	6
site 10	1.738	5.5	13.89	3	9.4	3	6
Average	**1.5848**	**5.5**	**13.89**	**3**	**9.83**	**3**	**6**
Darimu district recommended P and N fertilizer rate per farmers' entire field of experiment							
Site 11	1.5	10	7.49	3	9.5	3	9
Site 12	1.9	10	7.49	3	9.2	3	9
Site 13	1.8	10	7.49	3	9.0	3	9
Site 14	0.9	10	7.49	3	10.2	3	9
Site 15	0.8	10	7.49	3	10.3	3	9
Site 16	0.7	10	7.49	3	10.4	3	9
Site 17	1.4	10	7.49	3	9.7	3	9
Site 18	2.0	10	7.49	3	8.9	3	9
Site 19	0.9	10	7.49	3	10.2	3	9
Site 20	1.1	10	7.49	3	10.0	3	9
Average	**1.3**	**10**	**7.89**	**3**	**9.74**	**3**	**9**

Note: Fp = farmers' practice; STCRBFR=soil test crop response based fertilizer recommendation.
Source: Own Computing Data, 2020

As indicated from the results presented in Table 2 there were varying available Phosphorus level within the demonstration sites. The lowest the available P of the demonstration sites (0.7 and 0.976 ppm), the highest it desired the recommended P-fertilizer rate (10.4 and 11.4 kg/plot) and the highest the available p of the demonstration sites (2.0 and 2.75 ppm) the lowest it desired the recommended P-fertilizer rate (8.9 and 6.9 kg/plot) based on determined P_c and Pf across Darimu and Mana 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. Participants also request technical support to be benefitted from technologies with soil laboratory accessibility with affordable charge.

Conclusion and Recommendations

The variability in yield performance between and within the demonstrated sites might have originated from differences in the status of soil fertility and site specific varying weather conditions. For this reason, site specific soil test crop response determines the soil's nutrient status before a crop is planted which encourages plant growth by providing the best fertilizer recommendations and results predictable yield variability within sites over blanket fertilizer recommendation which is lacks of consideration for soil and crop variability.

The overall average yields gained from soil test based fertilizer recommendation rate were more economical than that of farmers' practice. Farmers were perceived soil test based fertilizer recommendation rate positively because it improves crop yield and identifies nutrient deficiency in soil. So, Soil laboratory should be more functional with affordable charge so that farmers will get access to test their soil. Hence, the pre-scaling up of soil test based fertilizer recommendation rate for Maize should be carried out in the coming main cropping season in the study areas.

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