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Cluster Based Pre-scaling Up of Soil Test Fertilizer Recommendation Rate for Maize in Selected Districts of Buno Bedele Zone, Southwestern Ethiopia

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Abstract: Ethiopia is grappling with overwhelming challenges to produce more food for a fast-growing population due to fragmented land with low soil fertility status owned by poor smallholder farmers who are unlikely to afford adequate input use. Given this, Bedele Agricultural Research Center with the support of AGP-II conducted; cluster based pre scaling up of soil test fertilizer recommendation rate for maize in selected districts of Buno Bedele zone, Southwester Ethiopia with the objectives of popularizing soil test fertilizer recommendation rate for maize through enhancing farmers' knowledge and skill and strengthening stakeholders' linkage in the study areas during 2019 cropping season. Bedele and Chora districts were selected purposively for being maize production potential in the zone and the conducted soil test calibration studies in which two clusters having 52 farmers (45 male and 7 female) were established in collaboration with different level agricultural stakeholders for the sustainability of technology transfer. The total land size used for cluster approach was 15 hectare in which the two maize varieties Shone and BH661 were planted with the site specific soil test based fertilizer application. For technology transfer; training and field day consisting 283 stakeholders (253 male and 30 female) were held. In general, the attained yield of Shone variety in Bedele was 7.3 tons ha^{-1}, whereas BH661 in Chora district was 5.2 tons ha^{-1} that exceeds the attained average national maize yield 3.7 tons ha^{-1} in 2019 cropping season. Therefore, scaling-up of the soil test fertilizer recommendation rate for maize should be carried out in the study areas and similar maize potential agro-ecological zones with strong stakeholders' participation.

Keywords: Cluster Approach, Pre-scaling up, Soil Test, Fertilizer Recommendation, Maize, Farmers

1. Introduction

In Ethiopia, agriculture is the engine of economic growth contributing 40% to the country's gross domestic product (GDP), 60% to exports earnings, and employs greater than 80% of the population [1]. With almost 85% of its population living in rural areas and depending on agriculture for its livelihoods, agriculture has assumed a steering role in enhancing economic growth and importantly in reducing poverty and food insecurity in the country. It is an essential player in the conservation of natural resources and cultural landscapes [2].

However, 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 [3-5]. The country is grappling with overwhelming challenge to produce more food for a fast-growing population due to fragmented land with low soil fertility status owned by poor smallholder farmers who are unlikely to afford adequate input use.

Low soil fertility is among the major limiting factors of agricultural production and productivity. It is the major environmental challenge that threatens agricultural productivity and the livelihoods of millions of rural households in Ethiopia [6]. The projected soil fertility decline by Mahmud et al. [7], indicates that about106, 000 km2 (9.6% of the total area of the country) was not able to sustain arable cropping in 2010. Stoorvogel et al. [8], estimated that about 41 kg of N, 6 kg of P and 26 kg of K is lost per hectare per year from

Ethiopian highlands. On top of this, approximately 41% of the total farmland of the country is acidic, of which nearly one-third faces the problem of aluminum toxicity [9]. The loss of P and N resulting from the use of dung and crop residues for fuel is equivalent to the total amount of commercial fertilizer use [10]. The direct cost of these soil fertility depletion was estimated to be 3-7% of agricultural GDP [11].

Designing cost-effective site and context-specific fertilizer recommendations requires an understanding of the effects of fertilizer application on crop yield. Calibration is a means of establishing a relationship between a given soil test value and the yield response from adding nutrient to the soil as fertilizer. It provides information how much nutrient should be applied at a particular soil test value to optimize crop growth without excessive waste and confirm the validity of current P recommendations [12, 13]. Once the existing nutrient levels are established, producers can use the data to best manage what nutrients are applied, decide the application rate and make decisions concerning the profitability of their operations [14].

Bedele Agricultural Research Center (BeARC) has been made remarkable efforts through assessing potential effects of inorganic fertilizers on crop yield for different agricultural commodities in southwestern parts of the country. Maize (*Zea mays* L.) is among potential agricultural commodities in Buno Bedele zone for which BeARC was conducted soil calibration study so far. Meanwhile, the activity is promising in the study areas and Agricultural Extension Research team encouraged transferring the technology/practice from research to smallholder farmers by using cluster approach.

Cluster approach is a path of technology transfer through educational and experience sharing that improve smallholder farmers' production skills and market linkage opportunities. Cluster approach may different things to different people, organizations and countries. According to Smith [15], clusters are geographic concentrations of firms in related industries that benefit not only from agglomeration economies derived from their spatial proximity but also from the increased competitive pressure as a result of the co-location. According to Brsier et al [16], clusters are concentrations of firms or businesses that are located in relatively close proximity, and usually, compete with each other in similar markets and cooperate to enhance technical skills and market access support, through social networks, growth, and development of individual businesses.

Having almost shared definition, agricultural cluster is a key approach in poverty reduction through increasing agricultural production and productivity, strengthening stakeholders' linkage, improving the new technology related working and information sharing ability of geographically concentrated smallholder farmers. It is the approach where organized farmers produce same agricultural commodities on their adjacent land with the same management practice through helping one another.

Soil test fertilizer recommendation rate for maize through cluster approach was the promising technology that enhances sustainable development in terms of social-equitability, economical-viability and environmental-bearably. Therefore, cluster based pre-scaling up was conducted with the intention of popularizing soil test fertilizer recommendation rate for maize through enhancing farmers' knowledge and skill and strengthening stakeholders' linkage in the study areas.

2. Materials and Methods

2.1. Description of the Study Areas

The activity was conducted in Bedele and Chora districts of Buno Bedele zone in 2019 main rainy season (Figure 1). The districts were selected purposively for being maize production potential in the zone and the conducted soil calibration studies.

2.1.1. Bedele District

Bedele is one of the districts in Buno Bedele zone and located in Southwestern parts of Ethiopia. The district lies between 08°14'28.6" to 08°37'52.8" N (latitude) and 036°13'22.0" to 036°35'09.1" E (longitude) at the distance of 483 km from Addis Ababa the capital city of the country. The area has an altitude ranging from 1920 to 2012 meters above sea level and mean annual rainfall of 1965.9 mm. The rainy season extends from April to October and the maximum rain is received in the months of May, June, July, August and September with the mean monthly rainfall exceeding 302.5 mm. The soil of the area is almost Nitisoils. The economy of the area is based on mixed cropping system which is livestock raring and crop production dominantly like maize, teff, sorghum, finger millet soybean, haricot bean and coffee.

2.1.2. Chora District

Chora is the second district of Buno Bedele zone and located in Southwestern parts of Ethiopia.

The district is bordered on the south by Setema, on the west by Yayo and Dorani, on the north by Dega, and on the east by Bedele. The administrative center of this district is Kumbabe and located 519 km away from the capital city of the country and 36 km away from Bedele town of the zone. The district is located at an average elevation 2000 masl and located at 08°13'33.7" to 08°33'55.0" N (latitude) and 035°59'59.7" to 036°15'15.8" E (longitude). It is generally 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 1440 mm. The soil of the area is Nitisoils. The economy of the area is based on mixed cropping system which is livestock raring and crop production dominantly like coffee, maize, teff, sorghum, wheat and haricot bean.

2.2. Site and Farmers Selection

Two districts were selected purposively for the implementation of the activities based on maize production potential, the conducted soil test calibration study and being AGP II areas. From both districts two potential kebeles were selected by considering land slope (soil fertility gradient),

farmers adjacent land, road accessibility for input (seed, fertilizer and lime) provision, supervision, monitoring and evaluation and representativeness of the areas for smallholder farmers so as the target clustered, non-clustered farmers and other stakeholders contribute in the implementation of the activities.

Cluster based per-scaling up approach was followed for technology/practice execution as it strengthens stakeholders' linkage, accelerate technology transfer, information dissemination, create sense of competition and mutual support and then increases production and productivity that maximize profit. Accordingly, Clustered farmers having fifty-two (52) members with the composition of men (45) and women (7) each contributing at least more than 0.25 hectares of land were selected based on willingness to participate in the activity, commitment to share their ideas and the concept of gender disaggregation in collaboration with community leaders, DAs and agricultural experts in both districts. In general, the activity was conducted on 15 hectares of land.

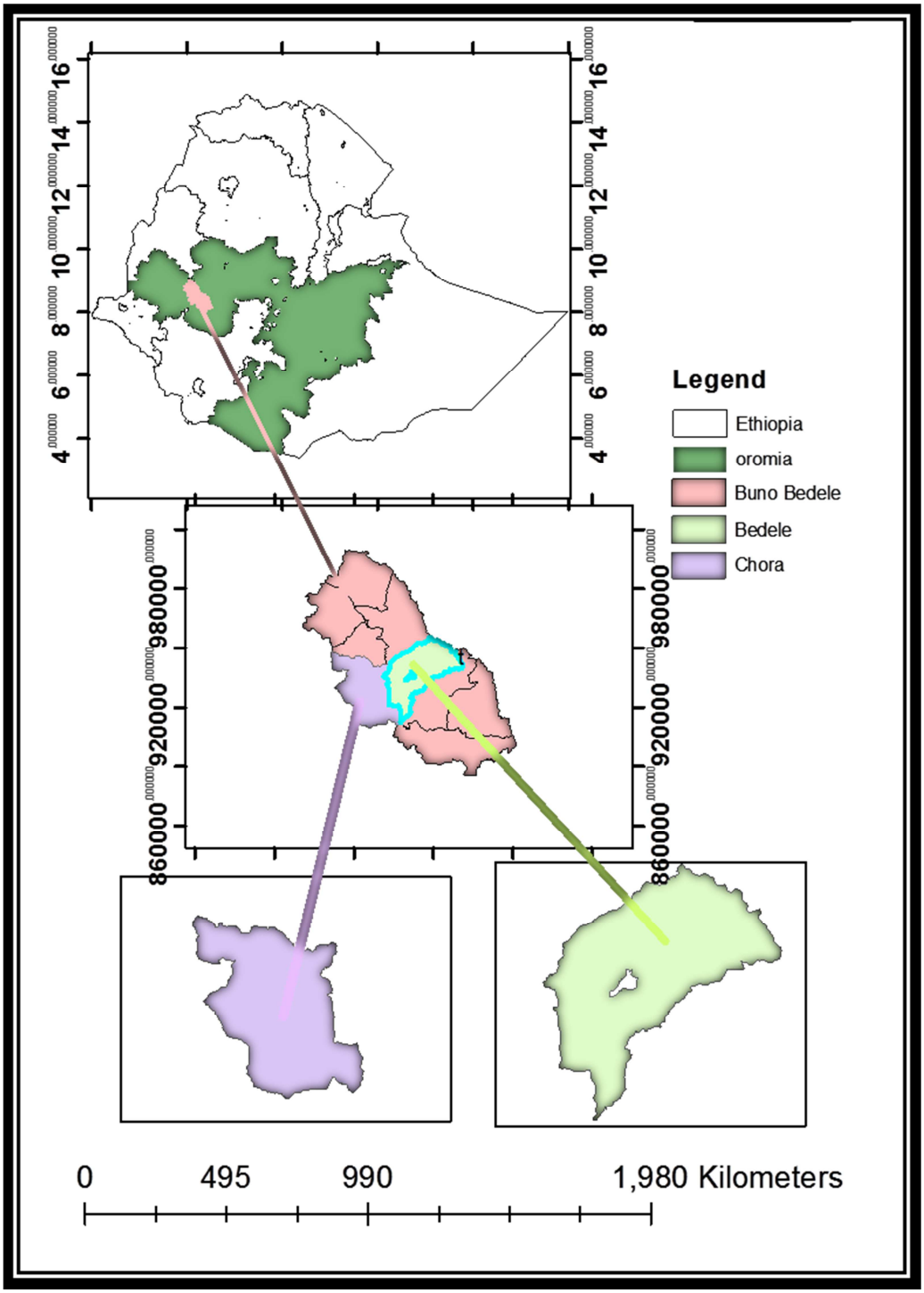


Figure 1. *Map of study areas.*

2.3. Materials and Field Design

Based on the interest of clustered farmers improved maize varieties Shone was scaled up on 8 hectares, whereas BH661 was on 7 hectares of land with soil test based p and N fertilizer recommendation rate in Bedele and Chora districts respectively. The land was prepared following the conventional farmers' practices that need to be changed and are ploughed three times; weeds are cleared and leveled by clustered farmers. Based on pH status of the field, 200qt of lime was applied manually in both districts. Using the recommended spacing of 80 and 50 cm between rows and seed respectively; both maize varieties were planted with the seed rate of 25 kg ha^{-1} in collaboration with clustered farmers, researchers and district agricultural offices.

2.4. Soil Sampling and Analysis

The six composite soil samples were collected at the depth of 0-20cm using auger instrument during fallow period. To ensure a representative sample of the field; zigzag method was used next to considering land slope and crop history of the fields. Composite soil sample was labeled, backed by a clean plastic bag and brought to the soil laboratory for analysis. Accordingly the required parameters like available phosphorus, nitrogen, organic matters, exchangeable acidity and pH of the soil sample were analyzed. Based on pH, initial phosphorus and nitrogen status of the field, the recommended rate of lime, (P and N fertilizer) were applied. The site-specific p-fertilizer was determined using P (kg ha^{-1}) = (P critical – P initial) x P_{rf} formula and applied during planting time. The recommended N-fertilizer (urea) 92 kg N ha^{-1} per the districts was applied with split application of 1/3 at planting time and 2/3 at tillering stage of the maize.

2.5. Technology Dissemination Method

Training was given to clustered farmers, development agents and the district agricultural experts on the concept of soil test based fertilizer application, cluster approach and activity implementation in respective districts. Mass field day that supported with media coverage was organized during the technology promotion with the intension of reaching huge numbers of maize producers and other interested farmers. To enhance the success of the field day, leaflets that summaries about the technologies were distributed to participants those who can read whereas poster that describe every step of the activities was used for farmers those cannot read.

2.6. The role and Responsibilities of Stakeholders in Activity Implementation

For the achievement of the activity, different stakeholders like Agricultural Growth Program (AGP-II), Bedele Agricultural Research Center (BeARC), Bedele and Chora district agricultural offices and farmers have been provide influential support in every step. Specifically, AGP II contributes through financing for input (seed and fertilizers) and promotion events (training and field day). BeARC provide training for experts and clustered farmers, technical know-how, supervision, evaluation and monitoring and field day for the sustainability of the activity. Bedele and Chora district agricultural offices provide the recommended amount of lime and facilitating clustered farmers in proper technology utilization. Particularly, development agents closely with researchers and farmers made indispensable support from site selection to threshing for final data collection as their major responsibility is forward and backward linking farmers and research.

Farmers are another primary stakeholder in allocating land, helping and motivating one another while performing required agronomic practices. It is obvious that 'farmers are furtherance' when development actors are show the path, motivate and organize them through considering their indigenous knowledge and so, they smoothen the cluster activity implementation by selecting clustered farmers coordinator among them by them, facilitate the spirit of group work using 'Dabo' or 'Jigi' that help the weaker section in cluster based scaling up activity.

2.7. Exit Strategy of the Technology

An exit strategy is a way of minimizing or leaving the intervention of currently implementing technologies or practice after a predetermined objective has been achieved. It is where the responsibility of expanding technology released or adapted by the research is transferred from research hand to public agricultural extension system with the intension of technology commercialization. So, the responsibility of further technology transfer has been given to Bedele and Chora district agricultural offices with minimal research center intervention in sustaining the technology.

3. Result and Discussions

3.1. Capacity Building of Clustered Farmers and Other Stakeholders

Participatory training was given to concerned agricultural stakeholders by the researchers from Soil Fertility Improvement and Agricultural Extension research team of Bedele Agricultural Research Center in the study areas. A total of 37 participants (33 male and 4 female) in Bedele and 33 participants (29 male and 4 female) in Chora districts were participated on the training. Training was given to the participants on the concept of soil test fertilizer application, cluster approach and activity implementation in respective districts.

3.2. Field Day

At physiological maturity stage of soil test fertilizer recommendation rate for maize, mass field day that supported with media coverage was organized to reach huge

number of maize producers and other interested farmers. Accordingly, a total of 213 (191 male and 22 female) relevant agricultural stakeholders were participated on the events.

Table 1. *Number of clustered farmers and other stakeholders take part in the training.*

participant Categories	Sex	Bedele	Chora	Total
Clustered Farmers	Male	23	22	45
	Female	4	3	7
Development Agents	Male	3	1	4
	Female	-	1	1
Other Stakeholders	Male	7	6	13
	Female	-	-	-
Total		37	33	70

Source: Own data, 2019.

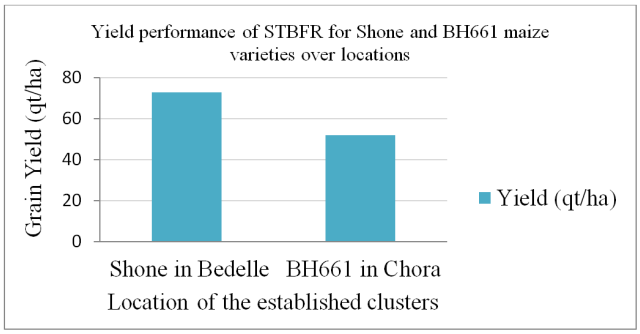
Table 2. *Relevant agricultural stakeholders' participated on field day in both districts.*

Participants from	Sex		Total
	Male	Female	
IQQO Directorates and Centers	73	1	74
District and Zonal agricultural offices, OBN media and other sector	36	2	38
Bedele Agricultural Research Center	35	12	47
Clustered Farmers	47	7	54
Total	191	22	213

Source: Own data, 2019.

3.3. Yield Performance

With the recommended N-fertilizer rate of 92 kg ha^{-1} in both Bedele and Chora districts and site specific soil test based crop response P-fertilizer recommendation rate; the average grain yield obtained in Bedele was 7.3 tons ha^{-1} whereas 5.2 tons ha^{-1} in Chora. The reason for low average grain yield in Chora cluster was due to rain interruption (frost) during physiological maturity stage of the crop. Even though, the obtained yield in both locations were high greater than that of National Average maize grain yield which is 3.7 tons ha^{-1} in 2019 cropping season. The yield gap between the study areas and national, suggests that there is potential for increasing production through improved soil and crop management practices, particularly optimum use of fertilizers through soil test-test based fertilizer recommendation.



Source: Own sketch, 2019

Figure 2. *Yield performance of cluster based pre-scaling up of soil test fertilizer recommendation rate for maize in the study areas.*

4. Conclusion and Recommendation

Cluster based pre-scaling up of soil test fertilizer recommendation rate for maize was conducted in Bedele and Chora districts with the objectives of enhancing farmers' knowledge and skill of applying soil test fertilizer recommendation rate for maize, popularizing soil test fertilizer recommendation rate for maize and strengthening stakeholders' linkage in promoting soil test fertilizer recommendation rate for maize in 2019 cropping season. The activity was financed by AGP II and addressed 52 clustered farmers owing 15 hectares of land. More than 280 stakeholders were participated during technology promotion events.

With the recommended N-fertilizer rate of 92 kg ha^{-1} in both Bedele and Chora districts and site specific soil test based crop response P-fertilizer recommendation rate; the average grain yield obtained in Bedele was 7.3 tons ha^{-1} whereas 5.2 tons ha^{-1} in Chora which was high greater than the National Average maize grain yield of 3.7 tons ha^{-1} in 2019 cropping season. Therefore, scaling-out of the soil test fertilizer recommendation rate for maize should be carried out in the study areas and similar maize potential agro-ecological zones with strong stakeholders' participation.

Conflict of Interest

The authors declare that they have no competing interests.

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