Science Research
2025, Vol. 13, No. 4, pp. 84-89
https://doi.org/10.11648/j.sr.20251304.14

Research Article

Pre Scalingup of NPS Fertilizer Rate Recommendation Based on Phosphorus Calibration Study for Bread Wheat (*TriticumAestivum L.*) Production at Horo District, Western Oromia Region, Ethiopia

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Abstract

A *pre-scaling up activity*on soil test crop response-based phosphorus calibration for *bread wheat* was conducted on farmers' fields in *Horo District*, HoroGuduruWollega Zone, Oromia Region. The objective of this study was to popularize and create wider demand for *site-specific crop response fertilizer recommendations* in the area. The trial was implemented on *11 farmer fields* across the district, each covering a *plot area of 50m x 50m (2,500m²)*. The intervention applied *phosphorus fertilizer rates* based on soil test crop response recommendations, along with an *optimum nitrogen fertilizer rate of 46kg/ha*. The bread wheat variety *"Danda'a"* was used, sown at a seed rate of *150kg/ha*. A total of *6 Farmer Research Extension Groups (FREGs)* were established, comprising *64 male and 20 female members*, ensuring *24% women participation*to promote gender equity. The highest *mean grain yield* of *4,152kg/ha* was recorded under the soil test crop response-based fertilizer treatment, indicating the effectiveness of this approach. Furthermore, *institutional linkages* were established between research centers and district and zonal agriculture offices, laying the groundwork for future collaboration. Based on the promising results and positive stakeholder engagement, it is recommended that *wider scaling up/out* of soil test crop response-based phosphorus fertilizer recommendations be undertaken. This effort should be *coordinated and managed by agricultural offices*in collaboration with relevant *research institutions, extension services, and development partners* to ensure sustainable and site-specific fertilizer use for increased wheat productivity.

Keywords

Pre Scaling up, Bread Wheat, Horo, FREG

1. Introduction

Bread wheat (*TriticumAestivum L.*) is one of the most staple food crops in the world and it is one of the most important cereals cultivated in Ethiopia. It stands fourth in both area coverage and total annual production, and second in yield per hectare next to maize [4]. Bread wheat grain is used for making bread, porridge, soup, and consumed as roasted and boiled forms. Moreover, the straw of bread wheat is an important feed for livestock, thatching roofs, and bedding [1-3].

In spite of its tremendous importance, its production in Ethiopia as well as in Oromia region has faced immense

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Received: 24 June 2025; **Accepted:** 9 July 2025; **Published:** 31 July 2025

production constraints affecting both its yield potential and industrial quality. Among these constraints mainly farmers are using low yielding local varieties and declining soil fertility [6]. Continuous cropping and applications of suboptimal rates of mineral fertilizers have aggravated the decline in soil fertility and crop yield [9].

An accurate soil test interpretation requires knowledge of relationship between the amount of a nutrient extracted by a given soil test and the number of plant nutrient that should be added to achieve optimum yield for each crop. Hence, calibration is a vital tool to attain the objective while calibrations are specific for each crop type and they may also different by soil type, climate, and the crop variety. That means, fertilizer recommendations on soil test basis for economic crop production should be both location and situation specific and can be modified with changes in soil test value as well as input output ratios. Soil test based fertilizer recommendation plays a crucial 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 [5]. As in all other regions of country, fertilizer recommendations in Horo district is also not based on soil test results.

A soil test-based phosphorus calibration study was conducted on bread wheat in Horo District, using different levels of phosphorus (P) and nitrogen (N) fertilizers. The study yielded promising results, indicating the effectiveness of site-specific fertilizer management. Following the calibration study, a pre-extension demonstration was carried out on farmers' fields, comparing the soil test-based phosphorus fertilizer recommendation with farmer practice. The results showed a yield advantage, with an average grain yield of 3,920kg/ha obtained from the soil test-based recommendation. A partial budget analysis confirmed that the soil test-based phosphorus recommendation is economically feasible and profitable for bread wheat production in the district. Based on these encouraging outcomes, the pre-scaling up of the technology was initiated to promote wider adoption among farmers.

2. Objective

1) To popularize soil test based p-fertilizer recommendation technology for bread wheat.
2) To create wider demand on the importance of site specific crop response fertilizer recommendation through Pre scaling up approach.
3) To strengthen the linkage among concerned stakeholders.

3. Materials and Methods

3.1. Description of Study Area

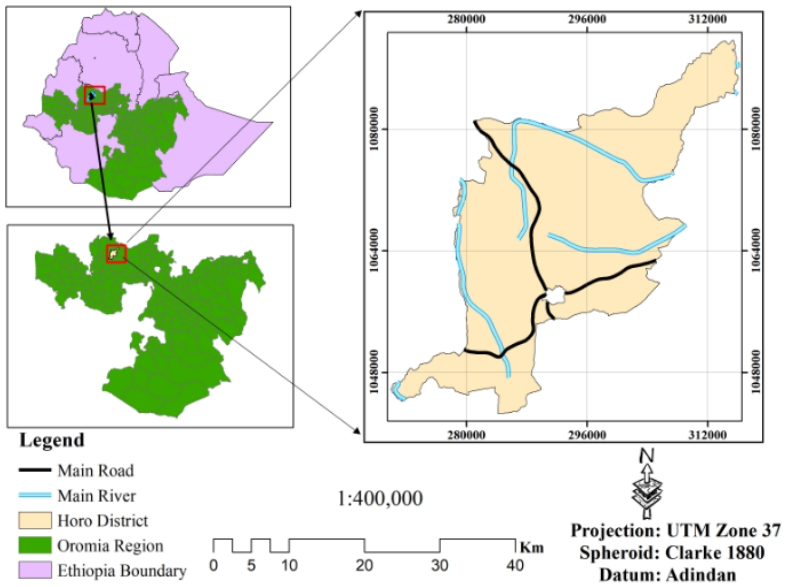

Figure 1. *Location map of Horro District.*

The study was conducted on 11 farmer's fields at Horo District. The District is located in western Oromia at about 310km from Finfinne. Geographically the study are is located 37°22' E longitude and 09°33' N latitude with an elevation ranges of 1600-2900 meter above sea level. The agro-ecology include lowland (51%), midland (37%) and highland (12%). the annual rainfall of the study area ranges of 1500-2700 mm and has an annual temperature ranges of 15-22 ℃.

3.2. Site and Farmers Selection

The study area was selected by considering willingness of farmers, road accessibility for supervision and management criteria. Pre scaling up approach was followed to scale up the technology as it strengthens stakeholders linkage, accelerate technology dissemination and increases production and productivity of the farmers. The phosphorus fertilizer requirement was calculated by using the formula given below.

Phosphorus fertilizer rate (kg/ha) = (Pc-Pi)*Pf;

where: Pc- Critical phosphorus concentration 10ppm
Pi- Initial available Phosphorus
Pf- Phosphorus requirement factor (11.03).

The experiment was conducted on farmer's field. Also, the number of farmers was selected based on the initial available phosphorus level of soil, suitable and sufficient land to accommodate the trials and their accessibility. The land area of 0.25 ha per farmer was used. Amount of applied phosphorus will calculated based soil test based phosphorus fertilizer recommended rate and economic N level (46kg/ha) was applied. The improved bread wheat variety "Danda'a" was used with the seed rate of 150kg/ha and use row method of planting.

3.3. Soil Sampling and Analysis

Soil samples were collected at the depth of 0-20cm from farm land of the study area and the results were pulled together and used to calculate the average soil available phosphorus. Composite soil sample was label and backed by a clean plastic bag and brought to the laboratory to analyze available phosphorus and pH of the soil with standard laboratory procedures. Depending on initial phosphorus and pH status of the soil, p-fertilizer and lime was applied. The previously recommended economic N-fertilizer was applied with split application of 1/3 at planting time 2/3 at tillering stage of the crop.

3.4. Data Collection

Appropriate data collection methods (direct field observation/measurements, focused group discussion, and knowledge test) were employed to collect both qualitative and quantitative data. The types of data collected include yield data, change in level of knowledge and skill of farmers, farmers' perception towards the performance of the technologies, farmers' preferences, total number of farmers participated on extension/promotional events such as training, field visits and field days, and stakeholder's participation's and role in technology demonstration and evaluation.

3.5. Technology Demonstration, Evaluation Techniques and FREGs Establishment

The FREGs member of farmers was selected based on their willingness accessibility for supervision of activities and considering age and gender issues. One FREGs having (10-15) members with the composition of men, and women, will established in each site. FREGs members and other follower farmers will encourage to participate on different extension/promotional events organized at each site. Training was given on the importance of soil test crop response based fertilizer recommendation as well as related agronomic practices to be followed in wheat production. These was mechanisms used to enhance farmer-to-farmer learning and information exchange such as trainings, field visits/tours, experience sharing, field days, etc.

3.6. Field Day

Field day and field visits are important extension methods for creating wider awareness and facilitating farmer-to-farmer information/experience sharing. Field day was organized towards the end of the trial (at crop maturity stage) to create wider awareness of farmers and other stakeholders. Discussion session and communication forum was also organized.

3.7. Data Management and Analysis

Grain yield, farmers' perception and soil data which were collected was properly managed using the EXCEL computer software. The collected data was analyzed using descriptive statistics and SPSS software.

4. Result and Discussion

4.1. Soil Reaction (pH) and Available Phosphorus of Experimental Field

The soil pH (H_2O) of the study area is strongly acidic with the value ranged from 4.81 to 5.37 according to the ratings suggested by [8]. Thus, the pH of the experimental soil was within the range for productive soils. The available phosphorus content of soils was low with the value ranged from 1.94 to 8.94 ppm according to the ratings suggested by [7] (Table 1). Therefore, the soil of the study areas needs application of phosphorus containing fertilizers for crop production.

Table 1. *Selected experimental soil properties before planting in Jima Arjo District.*

Farmers field (Sites)	PH (H_2O)	Av. P (ppm)
1	5.3	5.60
2	5.02	8.47
3	5.25	8.94
4	5.24	6.49

Farmers field (Sites)	PH (H_2O)	Av. P (ppm)
5	4.86	7.67
6	4.81	5.71
7	4.97	1.94
8	4.90	4.37
9	4.79	2.06
10	5.21	7.91
11	5.30	6.75

4.2. Establishment of Farmers Research Extension Group (FREGs)

During implementation of the activity, farmers were organized under farmers research extension group (FREGs). A total of 6 FREG units which are having 64 male and 20 female members were established. 24% of the participants were women and 76% were male. They were capacitated with different trainings, experience sharing and on working together to build their capacity to solve their problems by themselves.

Table 2. *Number of established farmer's research group and their members.*

District	Kebele	FREGestablished	Member of FREG		
			Men	Women	Total
Horo	D/Bariso	3	32	10	42
Horo	R/Chabir	2	23	5	28
Horo	G/Abuna	1	9	5	14
Total		6	64	20	84

4.3. Field Day

Field day which supported by mass media was organized at crop maturity stage to create wider awareness of farmers and other stakeholders. Discussion session and communication forum was also organized. A total of 28 farmers, 10 DAs, 7 SMS and 41 others were participated on field day organized (Table 3).

Table 3. *Number of stakeholders participated on field day organized at Horo district.*

Farmers			DAs			SMS			Others		
M	F	T	M	F	T	M	F	T	M	F	T
26	2	28	7	3	10	3	4	7	32	9	41

Figure 2. *Photos taken during mini-field day and crop maturity stages.*

4.4. Communication Methods Used

Appropriate extension approaches were used during the implementation of the activity such as telephone (fixed and/or mobile), field visit or experience sharing, supervision, monitoring and evaluation, group meeting and discussion session, field day (to bring mass mobilization).

4.5. Average Grain Yield

The result of the finding shows that bread wheat grain yield was increased with the application of 46kg/ha of N and soil test crop response based P-fertilizer recommendation which gives high mean grain yield (4152kg/ha). The maximum grain yield (5200kg/ha) and minimum grain yield (2740kg/ha) was recorded with the soil test crop response based fertilizer recommendation result.

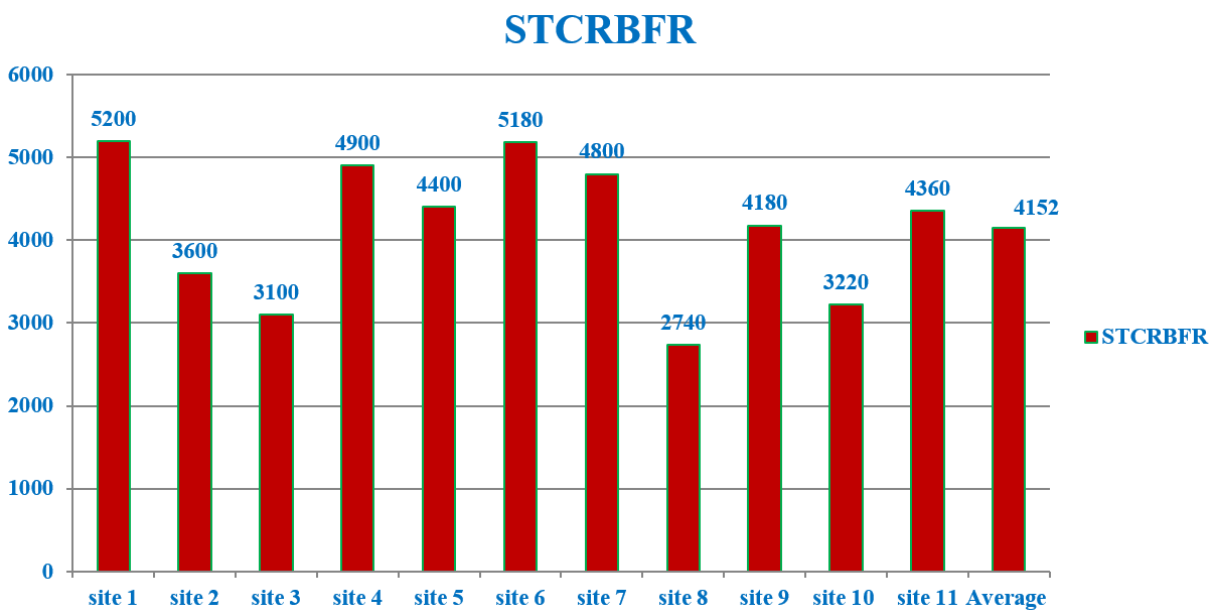

Figure 3. *Bread wheat grain yield obtained from pre-scaling sites.*

4.6. Farmers' Feedback

A field day was organized to showcase the pre-scaling up activity, with active participation from various stakeholders, including farmers, development agents, and agricultural experts. Participants observed the performance of the scaled-up soil test crop response-based phosphorus fertilizer recommendation and provided positive feedback based on their observations.

The technology was evaluated using farmer-preferred criteria, including: high grain yield, good tillering capacity, and high number of seeds per spike, spike length, uniform heading, and high biomass production suitable for animal feed. At the conclusion of the event, farmers expressed strong interest in accessing free soil analysis services to enable the continued and accurate use of soil test crop response-based phosphorus fertilizer recommendations on their own farms.

4.7. Exit Strategy

The mandate and scope of Nekemte Soil Research Center is demand creation through demonstration and pre-scaling up activities on limited farmers' fields. Therefore; the research center will promised to provide soil samples analysis and the wider scope dissemination or scaling up/out of the technology should be handled/over taken and implemented by district agricultural offices as well as other stakeholders'. To this effect, NSRC and the respective agriculture offices discussed, agreed and promised on how the technology is to be promoted sustainably and on wider scale.

5. Conclusion and Recommendations

A pre-scaling up activity on soil test crop response-based phosphorus (P) fertilizer recommendation was conducted at 11 sites inHoro District, Horo Guduru Wollega Zone. The primary objective was to raise awareness and promote the adoption of site-specific phosphorus fertilizer recommendations based on soil test results. The trials were implemented on plots of 2,500m², using the recommended fertilizer rates and the improved bread wheat variety 'Danda'a'. A total of six Farmer Research Extension Groups (FREGs) were established in purposefully selected kebeles, and training was delivered to farmers, development agents (DAs), agricultural experts, and other stakeholders on soil test-based crop response fertilizer application.

To enhance knowledge sharing and visibility, a field day was organized where farmers exchanged experiences and best practices. The intervention resulted in an average yield of 4,152kg/ha, demonstrating the feasibility and profitability of the approach. Additionally, strong linkages were established with the research center, as well as the district and zonal agriculture offices, to support ongoing and future collaboration.

Abbreviations

CSA	Central Statistical Agency
FREG	Farmers Research Extension Group
STCRBFR	Soil Test Crop Response Fertilizer Recommendation
DA	Development Agents
NSRC	Nekemte Soil Research Center

Conflicts of Interest

The authors declare no conflicts of interest.

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