
Pre-extension Demonstration of Soil Test Based NPS Fertilizer Recommendation under Lime Application for Bread Wheat (*Triticum aestivum*) in Horo District at Horo Guduru Wollega Zone, Oromia Region, Ethiopia

ABSTRACT

Wheat is a major crop produced in Ethiopian high lands and in particularly in study area, which is a staple food crop. Soil nutrient depletion restrains agricultural crop production and economic growth. A major challenge on recommendations on the amount and type of fertilizers to applied in the country level and in the study area. Soil test based phosphorous calibration study was conducted on bread wheat for three consecutive years for determination of the values of critical level phosphorus (10 ppm) and phosphorus requirement factor (11.03 kg/ha) in Horo District. This District was selected purposively based on potential Bread wheat production. Due to Ethiopia begun to use NPS fertilizer recently, Optimum NPS fertilizer rate for bread wheat production was determined in Horo District. In order to gain confidence in the diffusion of technology to end users, a pre-extension demonstration of the NPS fertilizer recommended rate for bread wheat based on soil tests was completed in the Horo district. The goal of this demonstration was to allow farmers to participate and test the technology during the 2020–21 cropping season. There were two treatments presented: a blanket recommendation and 100% phosphorous critical NPS at optimum nitrogen (46 kg/ha). The research findings were that the soil test crop-based NPS fertilizer rate application from 100% phosphorous critical NPS at optimum nitrogen (46 kg/ha) was recommended for the production of bread wheat in the Horo district. The analysis of variance indicated that, the highest grain yield (4110 kg/ha) was obtained from the application of Soil Test based NPS fertilizer recommendation (STBFR) whereas the lowest grain yield 3322.67 kg/ha from the blanket fertilizer recommendation. The economic analysis also revealed that the maximum net benefit 87089.40 Ethiopia Birr was obtained from STBFR. Soil test based NPS fertilizer recommendation was economically feasible and the highest Marginal rate of return and net income were obtained from soil test based fertilizer recommendation. Therefore, 100% Pc from NPS and Nitrogen 46 kg/ ha fertilizer rate recommended for bread wheat production and productive in the study area. Further scaling up/out the technology to reach more produced in the same soil type and agro ecology in particularly Eastern Wollega Zone and Horo district.

Keywords: Pre-extension; demonstration; soil test based; fertilizer rate; bread wheat.

1. INTRODUCTION

“Soil fertility is one of the biggest challenges in Ethiopia. Soil nutrient depletion restrains

agricultural crop production and economic growth. In Ethiopia fertilizer use has focused mainly on only nitrogen and phosphorous almost all cultivated crops. Such unbalanced application of plant nutrients may aggravate the depletion of

other important nutrient in soils. Continuous cropping, high proportions of cereals in the cropping system, and the application of suboptimal levels of mineral fertilizers aggravate the decline in soil fertility" [1,2,3]. "Fertilizer consumption in Ethiopia was still below 20 kg ha⁻¹" [4]. "Only 30 to 40% of Ethiopian smallholder farmers use fertilizer, and those that do only apply 37 to 40 kg on average per hectare, which is significantly below the recommended rates" [5]. It is essential that environmentally sound and economically profitable fertilizer application rates are paramount importance for sustainable crop production. Thus it is vital to search for alternative nutrient sources. Soil test based phosphorus calibration study was conducted in Horo district on bread wheat for three consecutive years. The study's findings were modified or converted to NPS rate determination using two years of consecutive experimental trials because Ethiopia recently decided to use NPS fertilizer as a compound. From the experiment, optimum NPS rate for bread wheat production in the district was determined.

Pre extension demonstration activity was conducted before further popularization in order to evaluate and create awareness in the community. NPS fertilizer recommendation to the study area cannot be achieved without farmers' participatory. To have confidential on technology dissemination to end users, the economic visibility and acceptance of the technology, decided to demonstrate it at the same area to achieve. The objective of this research activity was: to pre-extension demonstration of soil test based NPS fertilizer rate recommendation for bread wheat under participatory farmers on site specific crop response fertilizer recommendation in the Horo District.

2.METHODS AND MATERIALS

2.1 Description of the Study Areas

"Horo is situated at latitude: 1,042,726N to 1,091,814N; Longitude 270,000 E to 316,199 E and an altitude ranging from 1449-3147 m above sea level; in Horo Guduru Wollega Zone of the

Oromia regional state, Ethiopia (Fig. 1.). The terrain is generally undulating to rolling plains. The area is characterized by a mono-modal rainfall pattern. The mean monthly rainfall ranges from 12.8 to 343.8 mm, and mean monthly temperature is 17.23 to 22.9°C. The major soil types are generally described as Nitisols" (FAO. 1990).

The study was conducted on farmers' areas over the Horo District. Soil samples collected from the fields of selected farmers. To begin with composite soil samples was made in zigzag method from 20 farmers arrive and analyzed for, soil pH and available P, in assemble to be familiar with the level of the desired parameters within the soil to choose cultivate land for actual experiment. Based on the initial soil phosphorous values, five "5" cultivate lands were chosen. Three farmers research group (15 members each) established purposively based on will of actors. The groups trained on the concept of FRG and the activities they are going to perform. DAs, Stakeholders and a multidisciplinary team of researchers were join the FRG (Agronomist, Soil scientist, Socio economist and extensions) all actors will come up with ground rules and regulations.

Phosphorus addition based on initial phosphorous content of the soil and phosphorous critical level determined in the study area for bread wheat. Available phosphorus in the soil was tested in Nekemte SOil Research Center Soil Test laboratory. Optimum NPS rates determined during the study was compared with blanket recommendation/farmers practice and control/without fertilizer. All agronomic/crop management practices and variety was secured with previous experiment/study. Improved Bread wheat variety Dendea used with a rate of 150 kg/ha seed with 20 cm inter row spacing were sown in the study area.

The collected soil samples were analyzed for the parameters of pH (H₂O) within the suspension of a 1:2.5 soil to water proportion using a pH meter and Available P was determined by the Olsen's strategy using a spectrophotometer [6,7].

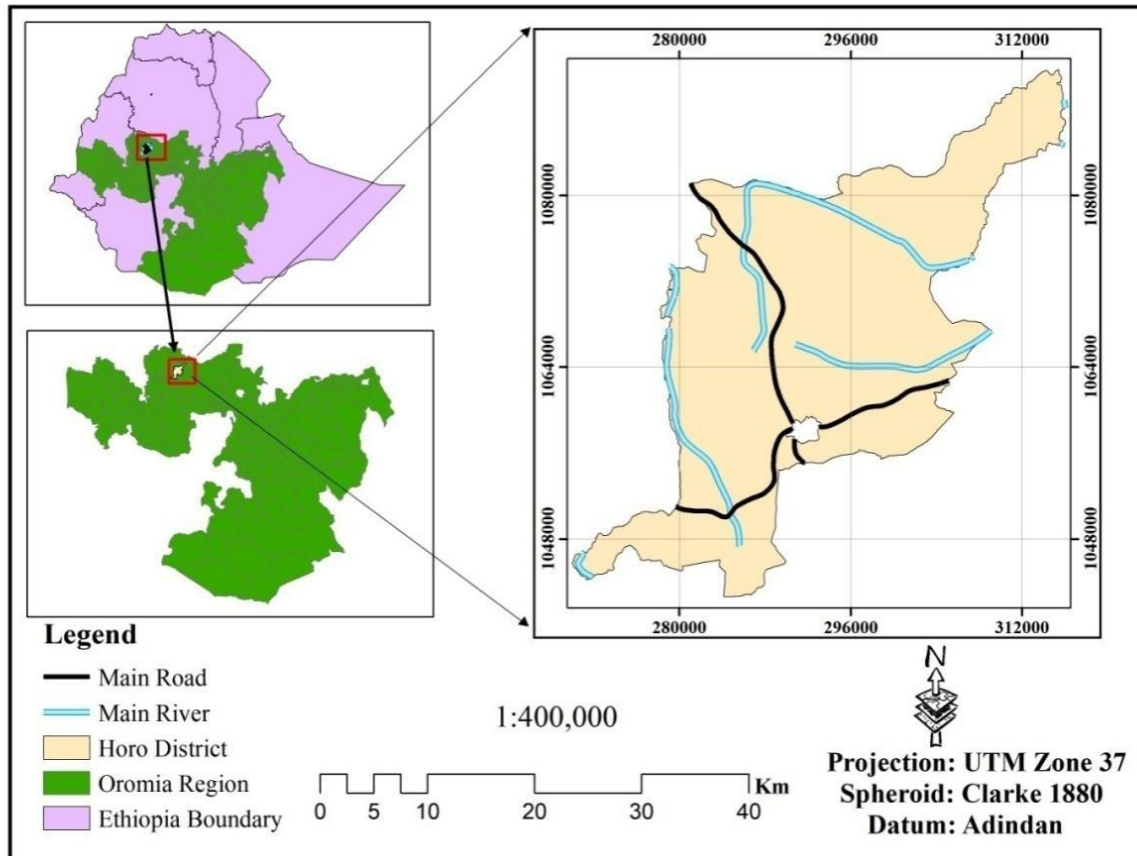


Fig. 1. Location map of Horo District, Oromia, Ethiopia

2.2 Field Design and Materials

The experimental was conducted on five farmers' fields across the district in three representative productive Peasant associations. The demonstration treatments were established adjacent plots of 10 m x 10 m (100 m²) each replicated over five farmers. Amount of Phosphorus applied based on initial Phosphorus content of the soil. Available Phosphorus in the soil was tested and P recommendation rate was given according to the formula. Application of Phosphorus in kg/ha = (P critical – P initial)*P requirement factor. Financially ideal N (46 kg/ha), critical level phosphorus (10 ppm) and phosphorus requirement factor (11.03 kg/ha) for bread wheat production within the district were picked up and recommended during the calibration study phosphorous as stated by Temesgen and Chalchisa [8], whereas 100% Pc from NPS and Nitrogen 46 kg/ ha recommended by Nekemte soil research center to the study area for bread wheat production as recommended by Chalsisa et.al. [9] in the district. Phosphorus applied at planting while, urea by spilt during planting and after planting 20 days

top dressed with the rate of 46N Kg/ha as recommended [8,9]. The treatment arrangements;

- I. Blanket fertilizer recommendation RR
- II. Soil Test based fertilizer recommendation "100% Pc from NPS and Nitrogen 46 kg/ ha"= STBFR

2.3 Data Management and Analysis

All agronomic and soil data was collected and properly managed using the Excel computer software. The collected data were subjected to an analysis of variance using SAS.

3. RESULTS AND DISCUSSION

Soil reaction (pH) and available phosphorus; whereas soil pH (H₂O) of the soil samples collected before planting were ranged from (4.78 -6.01) with mean values 5.49 (Table1). Accordingly, the soils were strongly to moderately acidic range in reaction [10]. This could occur as a result of long-term inorganic fertilizer application and persistent cultivation, which are caused by the low pH of the soil in the study area. This result agreed with the finding of

Temesgen and Chalchisa [8]. The most extreme and least values of available P were 8.53 and 2.7 ppm, respectively (Table 1). Available phosphorus of most tests drop under low category according to the basic level set by Karlton et al. [11]. In generally, the available P status of the soils within the consider area are low, even below the basic level representative that soil P inadequacy. This appears it does require for external application of phosphorus fertilizer sources for great crop development and yield obtained.

The yield obtained from the demonstration sites revealed that the maximum grain yield wheat (4110kg/ha) obtained from the application of soil test based Phosphorus fertilizer recommendation (STBFR) and optimum Nitrogen recommended, While grain yield of 3322.67 kg/ha obtained from blanket recommendation. The results of this believe are reliable with discoveries of who detailed that the highest grain yield was recorded under application of soil testing based fertilizer applied [12]. Average biomass and grain yield (kg/ha) as affected by the treatment (Fig. 2).

3.1 Yield Performance of the Demonstrated Technology

Table 1. Descriptive statistics for experimental site selective soil chemical properties result in Horo District

Descriptive statistics of Experiment sites	pH (H2O)	Exch.A (cmol(+)/Kg)	Av.P (ppm)
1	5.34	1.34	8.53
2	5.42	2.09	5.83
3	4.78	0.37	2.70
4	6.01	2.18	7.98
5	5.92	0.85	6.68
Mean	5.49	1.37	6.34
Min	4.78	0.37	2.7
Max	6.01	2.18	8.53
Std Dev	0.50	0.78	2.30

Min= Minimum Value, Max= Maximum Value, Std Dev= Standard deviation Value, Exch.A= Exchangeable acidity, Av.P= Available phosphorous

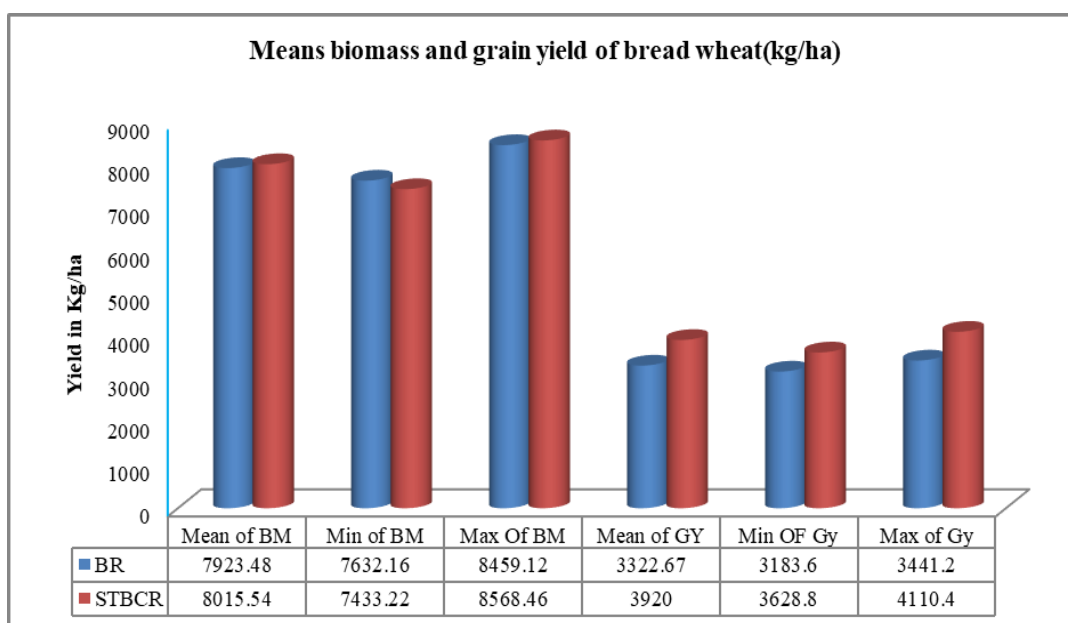


Fig. 2. Mean biomass and bread wheat grain yield kg/ha at Horo District

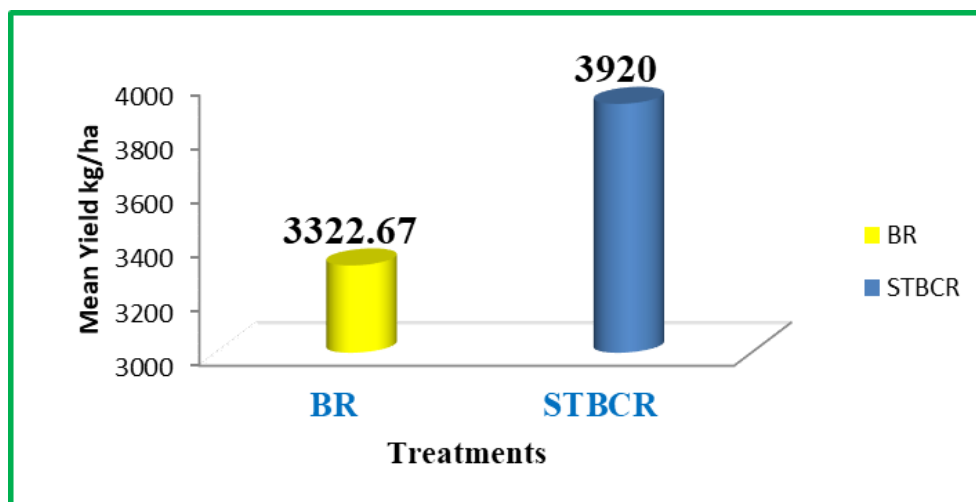


Fig. 3. Mean grain yield of bread wheat (kg/ha) of the experimental site of study area
BR= Blanket Fertilizer Recommendation; STBCR= Soil Test Based Crop Response NPS fertilizer Recommendation

The data available on Fig. 3 showed high of mean grain yield at study area due to availability of plant nutrients differences under treatments. This finding indicating the effect essentiality of balanced fertilizer applied.

3.2 Yield Advantage

$$\text{Yield advantage \%} = \left(\text{Mean Yield of STBFR} \left(\frac{\text{Kg}}{\text{ha}} \right) - \text{Mean Yield of BR} \left(\frac{\text{Kg}}{\text{ha}} \right) \right) * 100 / \text{Mean Yield of BR Kg/ha}$$

Yield advantage of STBFR over with blanket recommendation fertilizer rate %= $(3920 - 3322.67) * 100 / 3322.67 = 17.98\%$. It's revealed that the yield advantage of the soil test based phosphorus fertilizer recommendation with that of blanket recommendation is 17.98 %.

Table 2. Partial budget Economic analysis of blanket recommendation and Soil test based fertilizer recommendation on bread wheat in Horo District

Trt	GY (qt/ha)	AGY (qt/ha)	GFB (ETB/ha)	TVC (birr/ha)	NB (birr/ha)	MRR (%)
BR	33.23	29.91	89721.00	14539.30	75181.70	
STBFR	39.20	35.28	105840.00	18750.60	87089.40	282.76

Trt= Treatments, GY= Grain Yield, AGY= Adjusted Grain Yield, GFB=Gross field benefit, TVC =total cost that vary, NB=Net benefit, MRR=marginal rate of return, BR= Blanket recommendation, STBFR= Soil test based fertilizer recommendation

3.1 Partial Budget Analysis

According to the partial budget analysis the highest net income (87089.40 EB) obtained from (100% Pc from NPS + optimum N recommended.) with greater than the acceptable minimum rate of return (>100%); whereas alone blanket fertilizer recommendation treatment gave the lowest net benefit (75181.70 Birr/ha) (Table 1). Soil test based NPS fertilizer rate recommendation based on P critical level was chosen as economically feasible and led to the maximum yields of bread wheat in Horo District.

In any case, the marginal rate of return Soil test based fertilizer recommendation is 282.76 % (Table 1). This suggests that for one birr investment in wheat production with application of soil test based NPS fertilizer applied the producer can get additional net advantage of birr 2.83 compared to the application of blanket recommendation fertilizer rate. Since the least satisfactory rate of return considered in this test was 100%, the treatment with application of Soil test based NPS fertilizer applied deliver an acceptable marginal rate of return is higher than

the least satisfactory rate of return (100%) showing it is economical to use this treatment.

4 CONCLUSION AND RECOMMENDATION

A pre-extension demonstration activity was conducted at Horo District; Oromia for demonstrating soil test based wheat response phosphorus fertilizer recommendation through FRGs. Thus, popularization of the demonstrated soil test based wheat response NPS fertilizer rate should be made on different extension/promotional events in order to create high demand. This finding confirmed that (100% Pc from NPS + 46 kg/ha N fertilizer rate recommended) was economically feasible and led to the maximum yields of bread wheat in Horo District. The performance of wheat bread yield grain based on soil test-based NPS fertilizer recommendations still has potential in comparison to blanket NPS fertilizer recommendations. This study revealed that the yield advantage of the soil test based phosphorus fertilizer recommendation with that of blanket recommendation is 17.98 %. Despite this detail, the average yield obtain from soil test based NPS fertilizer recommendation was higher than that of blanket NPS fertilizer recommendation. Soil test based NPS fertilizer recommendation was chosen as economically feasible and led to the maximum yields of bread wheat in Horo District. Therefore, soil test based NPS fertilizer rate recommended (100% Pc from NPS + 46 kg/ha N fertilizer rate recommended) was selected and recommended for further pre-scaling up activity on wider plot (at least 0.25ha per farmer) in the participant district and to similar soil type and agro-ecologies of the zonal.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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