Research & Development
2022; 3(3): 154-158
http://www.sciencepublishinggroup.com/j/rd
doi: 10.11648/j.rd.20220303.13

On Farm Verification of Soil Test Based Phosphorus Fertilizer Recommendations on Bread Wheat in Degem District of North Shewa Zone, Oromia

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To cite this article:
Dejene Getahun, Lello Dejene, Meron Tolesa, Dereje Girma. On Farm Verification of Soil Test Based Phosphorus Fertilizer Recommendations on Bread Wheat in Degem District of North Shewa Zone, Oromia. *Research & Development*. Vol. 3, No. 3, 2022, pp. 154-158. doi: 10.11648/j.rd.20220303.13

Received: July 18, 2022; **Accepted**: August 18, 2022; **Published**: August 31, 2022

Abstract: On farm verification trial of soil test based crop response phosphorus calibration study on bread Wheat was conducted at Degam district of North Shewa zone during 2019 cropping season using optimum amount of nitrogen (92kgN/ha), critical P-value (22ppm) and Phosphorus requirement factor (5.85) determined during soil test based crop response phosphorus calibration study. Using the determined value of P critical concentration and phosphorus requirement factor, this study was initiated to verify P critical value and P requirement factor for bread wheat. Three treatments were included in the experiments as: control (without fertilizer (T1), (blanket recommendation= (100:100kg/ha Urea and DAP) (T2) and soil test based crop response phosphorus recommendation (T3). The activity was conducted across seven farmers' and those farmers were used as replications with RCBD design. The plot size was 10m*10m for each treatment. Soil data were collected on Soil pH and available phosphorus which ranges 56 - 5.72 and 9.71- 20.66 respectively; agronomic data were collected on plant height and grain yield. The highest plant height and grain yield were obtained from STBCR 95.03 cm and 2996.43 kg/ha correspondingly. To estimate the economical significant of the different fertilizer rates, partial budget analysis (CIMMYT, 1988) was employed to calculate the Marginal rate of return (MRR) to investigate the economic feasibility of treatments. Based on this, the Marginal Rate of Return (MRR) were found to be 150.81% for soil test based fertilizer rate and 134.7% for farmer practice (blanket recommendation). The economic analysis revealed that the highest net income (56202 ETB) was gained from soil test based P-fertilizer recommended treatments with marginal rate of return (150.81%) which is superior than the minimum rate of return (MRR) 100%. Therefore, based on the result obtained from this trial soil test based fertilizer recommendation is recommended for the study area. furthermore, further studies should be needed since the soil is heterogeneous and changed in short period of time.

Keywords: Verification, Blanket Recommendation, Soil Test Based Fertilizer Rate, Marginal Rate of Return

1. Introduction

The majority of Ethiopia's grain production, at 87.97 percent, is made up of cereal crops, which are also the most extensively cultivated. One of the most significant grains in Ethiopia is wheat, and the country ranks among the major producers of the grain in sub-Saharan Africa. According to estimates, Ethiopia's crop covers 1.7 million hectares of land and produces 4.8 million tons of grain annually. This represents around 15.39% of the nation's total grain production (CSA) [3]. Ethiopia produces two different types of wheat: durum and bread wheat, which account for 40 and 60 percent of total production, respectively.

Wheat is the country's second-most significant food crop in terms of caloric intake, after maize [6]. However, smallholder farmers dominate Ethiopia's wheat output, which is characterized by subsistence farming (Minot et al., 2015).

Wheat productivity in the country was still below the global average (3.4 tone ha) in 2019 [2, 6]. The most significant causes of low wheat production are those related to declining soil fertility, disease prevalence, reliance on rain-fed traditional agriculture, and minimal input, especially fertilizer use [14].

The importance of mineral nutrition is rising as one of the key elements in boosting crop output. Unfortunately, many of the highland soils of Ethiopia are naturally deficient in organic matter and plant nutrients [7, 8]. Due to reports that the majority of the soils in Ethiopia's highland regions are lacking in phosphorus, this element is of particular importance when evaluating the country's soil resources [1]. proving that the application of fertilizer containing N and P is necessary for crop growth in that area.

But crops only utilize 10–30% of the P applied in the year of application, and less in succeeding years [12]. Along with the naturally low accessible P level, the high P fixation potential of some soils added to the complexity of the issue [5, 11]. It is clear that chemical fertilizers play a part in raising yield. The rise in output was largely attributed to fertilizers [22].

According to past experience, farmers use fertilizer to increase their production during excellent rainy seasons. The rates, however, vary depending on factors like soil types, agroecology, how farmers feel about fertilizer, the availability of resources, and loans. Contrary to this variation in fertilizer application, some general fertilizer recommendations have been created and added to the extension system. For instance, the previous national requirement of 20 kg P for Vertisols wheat production areas [21]. This suggestion was gradually improved and discovered to be 60; most recently, it is 45 P. [15] The available nutrient status on the experimental fields was lower, equal, or higher than that of the farmers' fields, hence this strategy to fertilizer advice has limitations in extrapolating the results to farmer fields. Therefore, suggestions for fertilizer should consider the nutrients that are already present in the soil and are readily available [9, 10, 13].

A site-specific soil test based crop response fertilizer calibration trial on bread wheat was carried out by Fitche Agricultural Research Center in the Degem area to address this problem. They then determined P-critical and P-requirement factors as well as the optimal nitrogen to apply in this specific location. The amount of phosphorus in the soil that must be present for there to be any prospect of a yield response when using phosphorus fertilizers is known as the critical phosphorus value [11, 16]. The "P-Requirement Factor" measures how much P is required per hectare to raise the soil test level by one mg/kg.

To boost confidence in our recommendations, these calculated values should be contrasted to a broad recommendation while accounting for grain output and economic viability. Because the two primary issues to be considered when making fertilizer recommendations based on the findings of soil tests are maximizing return on input and limiting environmental harm. Consequently, Fitche Agricultural Research Center began a verification trail with the following objectives based on the results of this calibration inquiry (Optimal nitrogen level, P-critical, and P-correction factor):

Objectives

1) To confirm the viability of the Pc and Pf calculated during site-specific soil test-based crop response fertilizer calibration;
2) To raise awareness of fertilizer recommendations for certain sites.

2. Materials and Methods

2.1. Description of the Study Area

The study was under taken at Degem districts of North Shewa Zone, Oromia. The District is found in the North Western direction at a distance of 123 km from Addis Ababa capital city of Ethiopia and 10 km from Fitche, capital city of North Shewa, Oromia. It has an astronomical location which extends from 38°25’0’’ E-38°45’00 E and 09°03’’0’0N10°30’0” N longitude and latitude respectively.

The climate of the District is divided into three agro-climatic zones: Dega (30%), Woynadega (38%) and Kola (32%). The altitude ranges from 1500-3541 masl. Mean annual rainfall is 1128.47 mm with a unimodal rainfall distribution. The annual maximum and minimum temperatures of the study area were 20.3°C and 8.17°C, respectively (DWARDO, 2010).

Mixed farming system (crop and livestock production) are the common agricultural practice in the study area. The major annual crops grown in the study area were (Triticum sativum), (Solanum tuberosum), (Avena sativa), (Hordeum vulgare L.) and (Guizotia abyssinica). The total area of the district is 67,070 ha.

2.2. Experimental Design, Treatment and Procedure

For verification purpose the experiment was laid out in randomized complete block design that was replicated over farmers. The treatment considered were Calculated P (Rate of P fertilizer to be applied = (Critical P conc - initial P values) × P requirement factor; whereas Pc= 22 ppm, and Pf= 5.85) with determined optimum N (92 kg), Farmer practice (100 kg DAP and 100 kg Urea) and control (without fertilizer), which had got 10*10-meter square plot area. The land for the experiment was prepared by the local ox plow.

Treatment descriptions

1. Blanket fertilizer recommendation. This is the P fertilizer previously recommended for the study areas which is 100: 100 kg/ha (DAP: Urea).
2. Soil test-based phosphorus fertilizer recommendation: This fertilizer recommendation is based on the soil P level and consider the inherent soil P levels of farmer’s field. For this recommendation, soil samples were collected from each farmer’s field. The samples were analyzed for available P using Olsen method which was vary from farmer to farmer field.
3. Control: Without Fertilizer Application.

Table 1. *Treatments with their composition.*

Treatment	Composition
Control	No Fertilizer Application
Blanket Recommendation	100 Kg/ha Urea and 100kg/ha Dap
Soil Test Based Fertilizer Recommendation	Optimum Fertilizer Application based on soil test

2.3. Laboratory Soil Analysis

Soil parameters such as available P and pH of the experimental soil was taken and analyzed before the trial has been conducted. The pH of the soil was measured by using a pH meter in a 1:2.5 soil: water ratio and available phosphorous (P) was determined using Olsen method [17].

2.4. Statistical Analysis

Data were analyzed through using descriptive statistics as well as analysis of variance. One-way analysis of variance (ANOVA) was performed to assess the significance differences in the yield and yield components of wheat among the treatments. R statistical software was used for the analysis of the data for its ease of applicability. Mean separation was done using least significant difference (LSD) after the treatments were found significant at $P<0.05$.

3. Results and Discussions

3.1. Chemical Properties of the Farmer's Experimental Field

Soil pH influences the solubility of nutrients. It also affects the activity of micro-organisms responsible for breaking down organic matter and most chemical transformations in the soil. Soil pH thus affects the availability of several plant nutrients. A pH range of 6 to 7 is generally most favorable for plant growth because most plant nutrients are readily available. The soil pH of the study area ranges from 5.56 - 5.72 according to USDA Natural Resources Conservation Service classification system (1998) the pH of the study area falls under strongly acidic to moderately acidic. However, the pH range between 5.5 and 7.0 is appropriate for the wheat crop, according to [18]. Continuous farming and long-term use of inorganic fertilizers decreased soil pH and made it more difficult for basic cations to be lost from severely weathered soils. According to Tisdale *et al.* [20] rating of Avail. P levels, the Avail. P of the soils of the study area ranges from medium and very low.

Table 2. *Soil Chemical Properties Before Planting.*

Site	Available P	Soil pH
1	10.93	5.72
2	20.54	5.64
3	9.71	5.56
4	18.01	5.8
5	20.66	5.63
6	12	5.64
7	16.44	5.59
Average	15.47	5.65

3.2. Grain Yield and Plant Height of Bread Wheat

As shown in the table below, various fertilizer rates had an impact on wheat grain production (kg/ha). The experiment's findings in the Degam district showed a significant difference ($p<0.05$) between various fertilizer rates according to the analysis of variance. The study's findings demonstrate that using 92N kg/ha of fertilizer and following site-specific fertilizer recommendations significantly boosted wheat grain production, giving them a 1075 kg/ha yield advantage over general fertilizer recommendations. The soil test-based calibration result treatment had the highest mean grain yield (2996 kg/ha), which was significantly higher than the farmer practice (1921 kg/ha). The result was in agreement with Dejene *et al*. [4]. Who states that optimum N which is 92 Kg/ha N and site specific fertilizer recommendation gave higher grain yield. This result also consistent with the finding of Temesgen and Chalsissa [19] reported that the highest main grain yield was obtained from application of P calibration.

Table 3. *Effects of P-Fertilizer and supplemented nitrogen on some parameters of Bread wheat.*

Treatment	PH (cm)	GY (kg/ha)
Control (No NP fertilizer)	69.20 a	778.57a
Farmer practice	88.89 b	1921.43b
Soil test based P-recommended (STBFR)	95.03 c	2996.43c
LSD	5.55	288.96
CV (%)	5.86	13.55

PH=plant height, GY=Grain Yield, LSD= Least Significant Difference, CV (%) = Coefficient of Variation

3.3. Partial Budget Analysis

To estimate the economical significant of the different fertilizer rates, partial budget analysis (CIMMYT, 1988) was employed to calculate the Marginal rate of return (MRR) to investigate the economic feasibility of treatments. Based on actual unit prices during the year 2019/20 harvesting season (personal observation) farm gate price of 20 ETB (Ethiopian Birr) per kg of wheat, 12.78&10.4 Birr per kg of DAP & Urea, respectively (Table 2) were used to calculate variable cost. The Marginal Rate of Return (MRR) were found to be 150.81% for soil test based fertilizer rate and 134.7% for farmer practice as indicated in Table 2. The economic analysis showed that the highest net income (56202 ETB) was obtained from soil test based P-fertilizer recommended treatments with marginal rate of return (150.81%) which is greater than the minimum rate of return (MRR) 100% (CIMMT, 1998). Therefore, farmers use this soil test crop response-based fertilizer application over other treatments because it is more cost-effective and practically viable, and because those treatments that receive the suggested fertilizer have the highest MRR acceptance range.

***Table 4.** Partial Budget Analyses of Grain yield.*

Trt	Fertilizer rate	Variable Input (Kg/ha)		Unit price (ETB)		TVC	Output (Kg/ha)	Unit price (ETB)	Gross Income	Net Income	MRR (%)
		DAP	Urea	DAP	Urea						
1	Control	0	0	12.73	10.4	0	778.6	20	0	0	-
2	Farmer practice	100	100	12.73	10.4	2313	1921.43	20	38428.6	36115.6	134.7
3	Soil test based	190.13	125.6	12.73	10.4	3726.59	2996.43	20	59928.6	56202.01	150.81

4. Conclusion and Recommendation

Soil testing is a farm management tool that could benefit the farmer by increasing yields, lowering operational costs, and providing enhanced environmental risk management. A soil testing-based fertility control scheme has many advantages for the farmer. Increased homogeneity in nutrient availability across a field due to increased crop yields and profitability improves reactivity to other management inputs. Crop characteristics in this study, such as the yield of grain and the response to plant height, demonstrate a substantial difference between the treatments. These things occurred as a result of the fertilizer being applied to the soil based on the results of a soil test having the ideal level of phosphorus for feeding the crop that was planted there.

A partial budget analysis was used in additional computations, and the recommendation for soil test-based P-fertilizer produced the highest net income. As a result, it is advised to use the fertilizer recommendation rate calibrated on soil test results and developed at Degem districts in similar agro-ecology and soil types of wheat-growing areas. Additionally, before introducing the technology to the user, a larger scale up or demonstration of the results on farmers' fields may be necessary.

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