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Verification of Soil Test Based Phosphorus Fertilizer Recommendation for Yield and Yield Components of Wheat in Hintalo-wajirat District, Ethiopia

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Abstract
The popularization of urea and DAP (Diammonium Phosphate) fertilizers are increasing from time to time. However, small holder farmers are facing challenges on the price, amount and type of fertilizers to be applied on their land. These farmers were using blanket type of fertilizer application which is not recommended based on soil fertility status and crop nutrient requirements. Due to this, Mekelle Agricultural Research Centre has developed soil test based phosphorus critical value and phosphorus requirement factor for wheat in Enderta district. So, this trial was conducted in Tigray region Hintalo- wajirate district with the objective of verifying soil test phosphorus calibration findings established at Enderta district using wheat as an indicator crop. This was evaluated using three rates of fertilizer application treatments with no fertilizer applied, blanket type of fertilizer application and soil test based fertilizer recommendation laid out in Randomized Complete Block Design with eighteen replications at nine farmer's field. Data on yield and yield components of wheat was collected and the result reveals that the straw and grain yield observed in soil test based fertilizer recommendation were 21% and 14% higher than the blanket type of application (50 Urea:100 DAP), respectively. Hence, in this trial there was a significant ($p<0.05$) grain as well as straw yield difference among the treatments. This shows that it is recommended to use the soil test based phosphorus fertilizer recommendation rate calibrated in Enderta district at similar agro ecological and soil types of wheat growing areas of Hintalo-wajirate district.
Keywords: Soil Test, fertilizer, wheat, Hintalo- wajirate

1. INTRODUCTION

Declining soil fertility is a major constraint on crop production in the semi-arid highlands of Tigray, Northern Ethiopia. Farmers are either entirely abandoning the traditional practice of using natural fallow to restore soil fertility, or are unable to leave land fallow for long enough for it to be effective (Corbeels *et al.*, 2000). Due to this, farmers are intending to find other options for mitigating continuous decline of soil fertility status for crop production.

The popularization of urea and DAP (Diammonium Phosphate) fertilizers are increasing from time to time through the extension programs. However, there is a major challenge facing the small holder farmers not only to find ways of making fertilizer available at affordable price but also recommendations on the amount and type of fertilizers to be applied for most crops and soil types. Farmers are using blanket type fertilizer recommendations which is not recommended based on soil fertility status and crop nutrient requirements.

In this line, unless there is an option for fertilizer recommendation based on soil fertility status and crop nutrient requirements, farmers will be forced either to use excess or low amount of these inputs. Excessive nutrient applications are economically wasteful and can also damage the environment (Conway and Pretty, 1991; Bumb and Baanate, 1996). On the other hand, insufficient nutrient application can retard crop growth and results in lower yield.

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 P fertilizer (Vitosh, 1998).Thus, Soil test-based, site-specific nutrient management has become a major tool for increasing productivity of agricultural soils. Soil tests are designed to help farmers predict their soil's available nutrient status. Once 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 while managing for impacts such as erosion, nutrient runoff, and water quality. Critical P value is the phosphorus level in the soil in which the probability of getting yield response due to the application of P fertilizers above this value is very low (Nelson and Anderson, 1977; Kelling, 1991). P- Requirement factors, is the amount of P required per hectare to raise the soil test level by one mg/kg.

In the past, most research consisted of trials to determine the appropriate amount and type of fertiliser needed to obtain the best yields for particular soil types and specific agro-ecological locations. In addition, Soil Testing is well recognized as a sound scientific tool to assess inherent power of soil to supply plant nutrients and have been established through scientific research, extensive field demonstrations, and on the basis of actual fertilizer use by the farmers on soil test based fertilizer use recommendations (Corbeels *et al.*, 2000; India Soil Testing manual, 2011).

Accordingly, Mekelle Agricultural Research Centre has developed soil test based phosphorus critical value and p requirement factor for wheat in Enderta district (Abrha *et al*., 2008). So this achievement should be verified for the other wheat growing district s to be scaled out and develop phosphorus fertilizer recommendation guide line for all wheat growing areas in the region.

2. MATERIALS AND METHODS

2.1 Area description

This verification experiment was conducted in Hintalo-wajirate district, 24km far from Mekelle city in the way to Addis Ababa, in the year 2013.

The district is located at 39°27'-39°87'E and 12°88'-13°44'N. The altitude ranges from 1825-2625 meters above sea level. The mean annual maximum and minimum temperatures are 26.55°C and 11.06°C respectively. Meanwhile, annual rainfall of the study area ranges from 336-933mm. The district is placed in an area of 1933.09 km^2 of which 63% are weina dega, 13.75% is dega and 22.5% is kola. The total population of the district is estimated to be 164804 (budget and planning programme, 2008) and 92% of the people are dependent on agriculture. Wheat is the dominant crop cultivated in the district.

2.2 Experimental design and procedure

Nine farmer's field were selected for the experiment. The treatments were replicated two times at each farmer's field (a total of eighteen replications). The experiment was laid out in Randomized Complete Block Design (RCBD) of 5m*5m (25m^2) plot sizes. Data were collected from the net plot size of 2m*2m (4m^2) for each treatment. The treatments of the experiments are listed in Table 1.

Table 1: Treatments with their composition

Treatment	Composition
Control	No fertilizer application
Blanket recommendation	50 kg/ha Urea and 100kg/ha DAP
STBR(Soil test based fertilizer recommendation)	Optimum fertilizer application

The Blanket type fertilizer recommendation containg DAP (46% of P_2O_5 and 18% N) and Urea (46% N) is commonly used fertilizer application type. The soil test based fertilizer recomendationis taken as a treatment in this experiment is the one which is recommended at Enderta district .

Regarding application of the fertilizers on the experimental plot, one third of the Nitrogen (Urea fertilizer) was split and applied at planting time and the remaining two third was applied after weeding. The phosphorus fertilizer was applied at sowing stage by broadcasting.

The indicator crop used in this study was wheat (*Triticum aestivum*) with a seed rate of 150 kg/ha. All crop management practices including planting, harvesting, protection against damage by disease and pests, weeding etc. were done according to farmer's practice in the area.

2.3 Laboratory soil analysis

Soil parameters such as organic carbon, available P of the soil, pH and EC of the experimental soil was taken and analysed 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 electrical conductivity (EC) was also measured in water at a soil to water ratio of 1:2.5. The soil organic carbon was determined by the Walkley-Black method since this method is common and gives consistent results (Marx *et al*., 1999). The organic carbon is then converted to organic matter by multiplying a constant conversion (1.72) factor assuming that 50% of the organic matter is organic carbon (Pluske, 2013). Moreover, available phosphorous (P) was determined using Olsen method.

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. JMP 5 statistical software was used for the analysis of the collected data for its ease of applicability for this kind of data. Means separation was done using least significant difference (LSD) after the treatments were found significant at $P<0.05$.

3. RESULT AND DISCUSSION

3.1 Physicochemical properties of the farmers experimental soil

Fertilizer experiments always takes under consideration the amount of macro and micro nutrients available in the soil. So, it is preliminary work to take soil samples as per the interest of the experimental work. The farmer's experimental soil samples were taken for analysis and was analysed at Mekelle Soil Laboratory Centre. The analysed result revealed that the soil is neutral with an average pH value of 7.07 (Table 2). It is also supported by Marx *et al* (1999) who indicated that most crops grow best if the soil pH is in between 6.5-7.5. In addition, the experimental soil is registered with an EC value of 0.1dS/m. Hence, the soil is suitable for crop production but with deficit in available phosphorus with a mean value of 1.83ppm. On the other hand, organic matter content of the soil was 1.4% which was below the recommendations.

Table 2: Physicochemical properties of experimental soil

Farmers Name	pH_{water} (1:2.5)	EC_{water}(1:2.5) (dS/m)	Organic matter (%)	Available Phosphorus (ppm)
Farmer 1	7.02	0.13	1.26	1.86
Farmer 2	6.91	0.18	1.96	1.00
Farmer 3	6.93	0.05	1.88	2.64
Farmer 4	7.00	0.14	2.17	5.44
Farmer 5	6.88	0.09	1.09	1.26
Farmer 6	7.07	0.07	0.90	0.76
Farmer 7	7.25	0.07	1.01	0.32
Farmer 8	7.28	0.08	1.49	1.42
Farmer 9	7.35	0.10	1.15	1.78
Mean	**7.07**	**0.10**	**1.4**	**1.83**

3.2 Phosphorus values as bases for phosphorus fertilizer recommendation

According to Abrha *et al*., (2008) soil test based phosphorus fertilizer recommendations were established for critical phosphorus concentration and P- requirement factor for wheat at Enderta district . This was done by first deriving formula from successive field trials over years. The formula is expressed as,

Rate of fertilizer to be applied (kg P/ha) = (Pc-Po)*Pf

Where: - Pc = Critical P concentration (6.5 mg/kg)
Po = Initial P values for site (mg/kg)
Pf = P-requirement factor (4.76 (kg P/ha)/ (mg/kg))

The critical value of available phosphorus for crop wheat in Enderta district is 6.5 ppm. As shown in Table 2, from the soil laboratory result the farmer's entire field was found to be with deficits of phosphorus for the specified crop wheat. As a result, phosphorus fertilizer (DAP) was added by calculating with the help of the formula derived at Enderta district for wheat. Urea was applied based on the previously recommended fertilizer use for Urea.

After having calculated the rate of P fertilizer in kg per hectare (Table 3), it was converted in to the experimental plot size. This helps to determine the amount of P fertilizer to be applied to each experimental farmer's field.

Table 3: P fertilizer values at each farmer's entire field of experiment

Farmers Name	Po(initial p values) mg/kg	Pc(critical p concentration) mg/kg	Pf (P requirement factor)((kg P/ha)/ (mg/kg)	Rate of fertilizer applied Kg P/ha
Farmer 1	1.86	6.5	4.76	22.08
Farmer 2	1.00	6.5	4.76	26.18
Farmer 3	2.64	6.5	4.76	18.37
Farmer 4	5.44	6.5	4.76	5.05
Farmer 5	1.26	6.5	4.76	24.94
Farmer 6	0.76	6.5	4.76	27.32
Farmer 7	0.32	6.5	4.76	29.42
Farmer 8	1.42	6.5	4.76	24.18
Farmer 9	1.78	6.5	4.76	22.47
Mean	**1.83**	**6.5**	**4.76**	**22.22**

3.3 The responses of the treatments on yield and yield components of wheat

In this experiment, the responses obtained from the plant height, panicle length, grain yield, straw yield and harvest index of wheat were analysed. From the analysed data the plant height as well as panicle length shows highly significant ($p<0.05$) among the treatments. The maximum plant height and panicle length was obtained in STBR (soil test based fertilizer recomendation) and the minimum is gained in control (Table 4). (Slaton *et al*., 2004; Kastens *et al*., 2000) reported that, soil-test based P fertilization guidelines for wheat predicts accurately the need for P fertilizers. In addition, a model of wheat response to STP (soil test phosphorus) was developed and observed. Hence, STP had the most influence on wheat yield, even more than fertilizer phosphorus.

Similarly, in this experiment, significant wheat grain yield responses to P fertilization rate were occurred. The maximum straw yield and grain yield were gained from STBR (soil test based fertilizer recomendation). On the contrary, the lowest straw and grain yield were obtained from control in all experimental farmers. Hence this result showed that there was a highly significant difference ($p<0.05$) among the treatments in straw yield. For grain yield the STBR shows significant difference with control in all treatments.

Moreover, the result of this data revealed that the straw and grain yield observed in soil test based fertilizer recommendation were 21% and 14% higher than the blanket type of application (50 Urea:100 DAP), respectively. Moreover, the STBR were 39% and 34% more than the control one in straw and grain yields, respectively. That is due to the soil test based fertilizer application is suitable in such a way that it receives an optimal fertilizer needed to feed the crop planted on the soil.

Table 4: The responses of different crop parameters against treatments

Treatment	**Plant height(cm)**	**Panicle length (cm)**	**Straw yield (kg/ha)**	**Grain yield (kg/ha)**	**Harvest index (HI)**
STBR(soil test based fertilizer recomendation)	74.31^{a}	8.49^{a}	3716.04^{a}	1925.93^{a}	0.53^{a}
Blanket (50:100)	68.74^{b}	7.76^{b}	2947.53^{b}	1657.41^{a}	0.57^{a}
Control (0:0)	62.35^{c}	7.1^{c}	2277.78^{c}	1262.35^{b}	0.56^{a}
Mean	68.47	7.78	2980.45	1615.23	0.55
CV (%)	10.6	12.29	26.19	26.34	20
α (0.05)	**	**	**	*	ns

Note: Treatments not connected by same letter are significantly different

3.4 Partial budget analysis

The first step in doing an economic analysis of on-farm experiments is to calculate the costs that vary for each treatment per hectare bases such as purchased inputs and labour. Farmers want to evaluate all the changes that are involved in adopting a new practice (CIMMYT, 1988).

During the course of this study, we were registering the costs payable for different purposes and the benefits produced due to the straw and grain yields. Net return were calculated from the total revenue and total costs incurred from each treatments so as to observe if there is a variation among the treatments. These costs and benefits calculated were based on the prices valued for each item in the 2012 cropping season. As a result, the soil test based fertilizer recommendation returns higher profit margin (39831.20 ETB/ha) than the other treatments. The blanket type fertilizer application net return were calculated to be 30197.10 ETB/ha and the non-fertilized plot (control) returns less (22966.70 ETB/ha) than the other treatments.

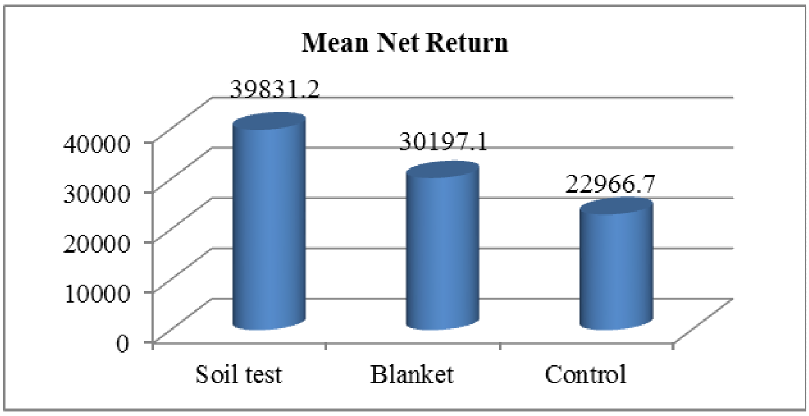

Figure 5: Mean net return of wheat due to different fertilizer treatments

4 CONCLUSION AND RECOMMENDATION

This study was conducted in Tigray Regional State, Hintalo-wajirat district with the objective of verifying soil test based phosphorus fertilizer calibrated at Enderta district. The soil test based fertilizer recommendation was implemented through using wheat crop as an indicator crop. Besides, Farmer's farm field were employed to verify the soil test based fertilizer recommendation for phosphorus. Data on pH, EC, organic carbon and available P of the experimental soil before planting were taken and analyzed. As a result, the soil was suitable for crop production but with deficit in available phosphorus.

Similarly, data on yield and yield components of wheat were collected and undergone an analysis.

Hence, the result has shown that the straw and grain yield makes a variation among the treatments. As a result, the soil test based fertilizer recommendation were 21% and 14% higher in straw and grain yield than the blanket type of fertilizer application respectively. Even is also higher than this as compared to the control by 39% and 34% respectively.

Generally, in this study almost all the dominant crop parameters such as response to plant height, response to panicle length, response to straw yield and response to grain yield in all the experimental farmers have shown significant difference among the treatments. These were happened, due to the soil test based fertilizer applied on the soil was received an optimal phosphorus fertilizer needed to feed the crop planted on the soil.

In addition, partial budget analysis was considered in this experiment and has also shown a variation among the treatments. As a result, the soil test based phosphorus fertilizer application returned higher marginal profit than the blanket type fertilizer application and the non fertilized plots. In all circumstances, the soil test based fertilizer application revealed that higher (straw and grain as well as economic advantage) than the other treatments considered in this experiment.

Therefore, from this study, it is recommended that soil test based fertilizer calibration and guideline formation is not needed in Hintalo-wajirat district as to the critical phosphorus concentration and P- requirement factor established at Enderta district were optimal for the phosphorus fertilizer requirement of the soil. Moreover, it is also recommended to use the soil test based fertilizer recommendation rate calibrated at Enderta district at similar agro ecological and soil types of wheat growing areas in Hintalo-wajirat district.

REFERENCES

Abreha Kidanemariam, Kasha Beyene and Semere Hailu, 2008. Determination of critical level and equirement factor of soil phosphorus: a base for a soil test based phosphorus fertilizer ecommendation; (unpublished report).

Budget and planning programme, 2008. Hintalo-wajirat district, (Unpublished document)

Bumb, B. and C. Baanate, 1999. The role of fertilizer in sustaining food security and protecting the environment to 2020. 2020, Vision paper 17. IFPRI, Washington, DC,1996.

CIMMYT. 1988. From Agronomic Data to Farmer Recommendations: An Economics training manual. Completely revised edition. Mexico. D.F.

Corbeels Marc, Abebe Shiferaw and Mitiku Haile, 2000. Farmers' knowledge of soil fertility and local management strategies in Tigray, Ethiopia; Managing Africa's Soils No. 10.

India Soil Testing Manual, 2011., Department of Agriculture & Cooperation Ministry of Agriculture, Government of India New Delhi;

Kastens, T.L., Dhuyvetter, K.C., Schmidt, J.P., and Stewart, W.M. 2000. Wheat yield

Kelling, K.A., Schulte, E.E., Bundy, L.G., Coombs, S.M., and Peters, J.B. 1991. Soil test

Marx E.S., J. Hart and R.G. Stevens. Soil test interpretation guide.modeling: how important is soil test phosphorus? Better Crops. 84: 8-10.

Nelson L.A. and R.L. Anderson, 1997. Partitioning soil test –crop probability.pp.19-39. In:T.R.Peck (ed.) soil Testing: Correlating and Interpreting the Analytical Results. American Socity of of Agronomy, Madison, W.I.

Pluske Wayne, Daniel Murphy and Jessica Sheppard; 2013. organic carbon, Nutrient Management Systems, the University of Western Australia and Avon Catchment Council.recommendations for field, vegetable, and fruit crops. University of Wisconsin Cooperative, Extension Service Bulletin A2809.

Slaton N.a., r.e. delong, m. Mozaffari, s. Clark, c. Allen, and r. Thompson , 2004.Wheat grain yield response to phosphorus fertilizer rate,

Vitosh M.L.. 1998. Wheat fertility & fertilization, Department of crop and soil sciences, Michigan University state university.

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