

Full Length Research Paper

Effect of fertilizers amendment on yield and yield components of wheat (*Triticum aestivum* L.) on acidic soil of Tsegede Highland, Northern Ethiopia

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A field experiment was carried out during 2012/2013 on acidic soil of Tsegede highlands, Northern Ethiopia to evaluate wheat crop response to different Fertilizers and Liming with four treatments: (1) (No fertilizer), (2) 64 kg/ha Nitrogen+ 150 kg/ha Minjingu organic hyper phosphate fertilizer, (3) 64 kg/ha Nitrogen and 20 kg/ha Phosphorus, and (4) 64 kg/ha Nitrogen and 20 kg/ha Phosphorus + 4.17 t/ha lime were arranged in Randomized Complete Block Design (RCBD) design with three replications. Soil samples were collected before planting and analyzed for selected physicochemical properties, which revealed that textural class was sandy loam and the pH, Exchangeable aluminum and Exchangeable Acid as very strong acid and toxic for plant growth. The total percentage of organic matter, Nitrogen and Cation Exchange capacity (CEC) were as high; while very low in available phosphorus. Results indicated soil that received 64 kg/ha Nitrogen from urea+150 kg/ha Minjingu organic hyper phosphate, 64 kg/ha Nitrogen and 20 Phosphorus and 64 kg/ha Nitrogen and 20 kg/ha Phosphorus + 4.17 t/ha lime gave additional grain yield increment by about 191, 211 and 413% over the control, respectively. While the straw yield improved by 226, 248 and 422% respectively. The highest yield was recorded on soils with 64 kg/ha Nitrogen and 20 kg/ha Phosphorus along with lime followed by the 64 kg/ha Nitrogen and 20 kg/ha Phosphorus, and soil with application of 64 kg/ha Nitrogen from urea+150 kg/ha Minjingu organic hyper phosphate. The recorded plant height was significantly affected only at 64 kg/ha Nitrogen and 20 kg/ha Phosphorus + 4.17 t/ha lime (21.2%) over the control. Hence uncontrolled land encroachment in the low land areas can minimize to make these farmlands productive. The rate of these fertilizers and marginal rate of return was not studied.

Key words: HAR-604, lime, Minjingu organic hyper phosphate, nitrogen, phosphorus.

INTRODUCTION

Wheat is an important crop that is grown on more acres globally than any other and provides a major share of the nutritional requirements for the growing world population

(Shapiro, 2009). It is cultivated in Ethiopia on about 1.51 million hectares and delivers about 3.3 million tons of grain, which makes Ethiopia the largest wheat producer

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in sub Saharan Africa (CSA, 2013). However, Soil chemical degradation such as (soil acidity, salinity and sodicity, low levels of fertilizers), pesticides and improved seeds, moisture stress, are some of the major crop production constraints in Ethiopia (Taffesse et al., 2011). Acid soil infertility is a major limitation to crop production on highly weathered and leached soils in the tropical and temperate regions of the world (Uexküll and Mutert, 1995), particularly in tsegede highlands (Kidānemariam et al., 2013). In addition to this, the fertilizer use focus was only on N and P fertilizers in the form of diammonium phosphate (DAP) and urea for all cultivated crops in all agro ecologies and on all soil types for the last several years. Such unbalanced application of plant nutrients has aggravated depletion of other important nutrient elements in soils. Among the key strategies that were identified to help increase agricultural production and productivity in the Growth and Transformation Program one (GTP1) period was the soil fertility mapping of the country's agricultural lands. In Tsegede highlands four soil nutrients {Nitrogen (N), phosphorus (P), Sulfur (S) and Boron (B)} are found to be deficient in the soils (MOA and ATA, 2014), and characterized by low pH level and high Exchangeable Aluminum (Kidānemariam et al., 2013) and (MOA and ATA, 2014). About 30% of the highly weathered soils of Ethiopia have been reported to be acidic (Mamo et al., 1988) and more than 81% of the Tsegede highlands are under strong acid (Kidānemariam et al., 2013). The need to transform agricultural sector with respect to soil fertility requires application of proper amounts of blended fertilizers and soil amendments for different crops. Besides, the importance of these nutrients in yield enhancement and quality improvement is utmost a great concern. This recalls that evaluation of different fertilizers and their amendment for optimum crop production. Fertilizers amendment has this all primary, secondary, micronutrients, and soil reclamation. There have been few or no studies on newly introduced fertilizers formulated like Minjingu organic hyper phosphate (28-30%P₂O₅) with liming in the country particularly in the acid soil of Tsegede. Thus, it is essential to evaluate these fertilizers and liming effect on the acidic soil of tsegede district.

Objective

To evaluate different fertilizers amendment effect on yield and yield components bread wheat grown on the acid soils of the area.

MATERIALS AND METHODS

Area description

The experiment was conducted on very strong acid soil of the high lands of Tsegede District which is located in the western Zone of Tigray Region, northern Ethiopia, located at 13° 14' 21" and 13° 44'

46" north and 36° 27' 44" and 37° 45' 05" longitudes with an altitude of 1053 to 2889 m above sea level. The mean annual rainfall of the area is about 2316 mm that usually starts at about the end of March and ends in early November with the peak in August. The mean annual temperature of the area is 13.2°C and ranges from 7.8 to 18.6°C. The study site was at Endasslassie kebele, with area coverage of 84.7 km². It consists of high and rugged mountains, flat topped plateau, deep gorges and rolling plains. The dominant soil types in the Tsegede highlands are mainly Humic Cambisols (Kidānemariam et al., 2013). Wheat (*Triticum* spp.), Barley (*Hordeum vulgare*), Teff (*Eragrostis tef*), finger millet (*Eleusine coracana*), Faba bean (*Vicia faba*), Field pea (*Pisum sativum*), Noog (*Guizotia abyssinica*), and Linseed (*Linum usitatissimum*) are Crops which are grown mostly in the highlands of the District.

Site selection, soil sampling and laboratory analysis

This was conducted across two acid affected locations each has three replication. A composite soil sample was taken by inserting the auger up to a depth of 20 cm. All the subsample of a single composite sample were collected and taken using quartering method with the necessary label on it. It was air-dried and sieves to pass through 2mm diameter mesh sieve except for soil organic carbon (OC) and total N analysis that passed through 0.5 mm sieve.

Laboratory analysis was made for Texture, pH, Organic carbon, Total Nitrogen, Available Phosphorus, Exchangeable acid, Exchangeable Aluminum (Al) and Cation Exchange Capacity (CEC) following their respective standard procedures. Particle size was determined following Bouyoucos hydrometer (Day, 1965) and Soil pH (1: 2.5 soils to water ratio) was measured using a glass electrode pH meter as described by Peech (1965). Soil organic carbon (OC) was also determined by the chromate acid oxidation method (Walkley and Black, 1934) and soil OM was calculated by multiplying percent OC by a factor of 1.724. Total nitrogen was analyzed using the macro-Kjeldahl digestion followed by ammonium distillation and titration method (Bremner, 1965). Available Phosphorus was extracted following the Bray I method (Bray and Kurtz, 1945) and determined spectrophotometrically. Exchangeable acidity and Exchangeable aluminum (Al) were analyzed as per the method described by Sumner (1992) and Pansu et al. (2001), respectively. Cation exchange capacity (CEC) was determined following the method described by Chapman (1965).

Experimental design and procedures

The Design was Randomized Complete Block Design (RCBD) with three replications and Plot size of 5 m × 5 m. Four treatments (1) Control (No fertilizer) (2) Recommended Nitrogen from urea+150kg/ha Minjingu organic hyper phosphate (3) Recommended NP and (4) Recommended NP + recommended lime were used in this study. 64 kg ha⁻¹ Nitrogen from urea and 20 kg ha⁻¹ Phosphorus from triple super phosphate were used as the recommended Nitrogen (N) and recommended phosphorus (P) rate, 4.17 t/ha lime (CaO) was used as recommended lime at the study area. Urea fertilizer was applied in split application. Improved bread wheat variety, Galama (HAR-604), was used as a test crop. All management practices such as Land preparation, plowing, weeding, pesticide application and other agronomic management were carried out.

Data collection, plant sampling

Plant height was determined by measuring the length of the plants

from the ground level to the top of the spike just before physiological maturity. At physiological maturity, the plants were harvested from 3 by 3 m plot sizes close to the ground level by hand; air dried in an open dry environment. The straw and grain was determined by weighing, using sensitive balance. Grain yield per plot was determined after carefully separating the grain from the straw.

Data analysis

Analysis of variance was subjected to the statistical software program JMP, version 7.0 to carry out for yield and yield parameters of the crop to determine its response to the applied fertilizers and lime.

RESULTS AND DISCUSSION

The soil reaction (pH) is classified as strong acid (pH of 4.79) according to Yuste and Gostincar (1999). The Exchangeable aluminum and Exchangeable Acid also revealed as toxic for plant growth. The total percentage of organic matter (6.83%) and total Nitrogen (0.34%) was high (Tadesse et al., 1991), while very low in available phosphorus (3.15 mg kg^{-1}) (Beegle and Oravec, 1990). According to Roy et al. (2006), the soil result indicated that the study area had high Cation Exchange capacity (Table 1).

Wheat yield response to Minjingu organic hyper phosphate

The analysis of variance result showed that except days to 50% maturity and harvest index all yield and yield components (plant height, grain yield and Straw yield) of bread wheat were significantly ($P < 0.05$) affected by the treatments (Table 2).

Wheat grain and straw yield

Application of the different fertilizer amendments resulted significant difference in grain and straw yield of wheat (Table 2). The soils that received Rec.N from urea+150 kg/ha Minjingu organic hyper phosphate, Recommended NP, and Recommended NP + recommended lime gave additional grain yield increment by about 191, 211 and 413% over the control respectively; while the straw yield improved by about 226, 248 and 422% respectively. The highest yield was recorded on soils with Recommended NP (64 Nitrogen and 20 Phosphorus kg/ha) along with lime (4.17 t/ha) followed by the Recommended NP (64 Nitrogen and 20 Phosphorus kg/ha), and soil with application of recommended N (64N) from urea+150 kg/ha Minjingu organic hyper phosphate. This indicates that liming is important in reclaiming of this acid problem to make other nutrients available to the plants in the area. Labetowicz et al. (2004) and Fageria and Baligar (2001)

reported that liming is the most common soil management practice and effective for reducing soil acidity related problems and it may be beneficial as plant nutrients. This result also shows as in addition to phosphorus fertilizer, Minjingu organic hyper phosphate can use as an option in maximizing the wheat production in the area.

Wheat plant height

The analysis of variance showed that recorded plant height was significantly affected only by the Recommended NP (64 Nitrogen and 20 Phosphorus kg/ha) + recommended lime. In soils that received Recommended NP + recommended lime considerably ($P \leq 0.05$) increased their Plant height 21.2% over the control (Table 2). This might be due to the liming effect in which plants can easily get available nutrients from the soil. A study conducted by Kidanemariam et al. (2013) also revealed that liming soils with calcium carbonate and other liming materials is important to increase production and productivity wheat of acidic soils at Tsegede highlands, Ethiopia.

CONCLUSION AND RECOMMENDATION

In the study area where the soil is strongly acidic and toxic for plant growth results showed that except days to 50% maturity and harvest index the other yield and yield components (plant height, grain yield and straw yield) of bread wheat were significantly ($P < 0.05$) affected by the treatments. The soil that received Recommended Nitrogen (64 kg/ha) from urea+150 kg/ha Minjingu organic hyper phosphate, Recommended NP (64 kg/ha Nitrogen and 20 kg/ha phosphorus), and Recommended NP (64 kg/ha Nitrogen and 20 kg/ha phosphorus) with recommended lime (4.17 t/ha) gave additional grain yield increment by about 191, 211 and 413% over the control, respectively. However, the straw yield improved by 226, 248 and 422% respectively. The highest yield was recorded on soils with Recommended N and P (64kg/ha Nitrogen and 20kg/ha phosphorus) along with lime followed by the Recommended NP, and soil with application of recommended N from urea+150 kg/ha Minjingu organic hyper phosphate. However the recorded plant height was significantly affected by the Recommended NP + recommended lime only (increased by about 21.2%) This might be due to the liming effect in which this helps that the soil to be suitable pH for plants easily to get available nutrients from the soil. In addition to this, the Minjingu organic hyper phosphate could also be source option for phosphorus fertilizer in the acidic soils of the Tsegede highlands as well as areas with similar climate and soil conditions. Hence, uncontrolled land encroachment in the low land areas can be minimized because of making these farmlands productive.

Table 1. Initial Surface (0-20 cm) physical and chemical property of the experimental field.

Texture	pH	OM (%)	TN (%)	Av. P (mg kg ⁻¹)	Exchangeable (cmol+ kg ⁻¹)		
					Acid	Al	CEC
Sandy loam	4.79	6.83	0.34	3.15	4.17	3.09	25.38

Note: OM= Organic Matter; CEC= Cation Exchange Capacity; TN= Total Nitrogen and Av. P= Available Phosphorus, Al-Aluminum.

Table 2. One ways analysis of variance for some considered wheat yield parameters response to the application of Minjingu organic hyper phosphate.

S/N	Treatments	Pht (cm)	G.Y(kg/ha)	S.Y(kg/ha)	H.I (%)	DFM
1	Control (No fertilizer)	73.0 ^b	548.2 ^c	799.4 ^c	40.68	121.3
2	Rec.N from urea+150 kg/ha Minjingu organic hyper phosphate	82.7 ^{ab}	1596.3 ^b	2610.0 ^b	37.95	122.3
3	Recommended NP(64 kg/haNand20 kg/haP)	85.5 ^{ab}	1707.4 ^b	2784.6 ^b	38.01	123.0
4	Recommended NP + recommended lime	88.5 ^a	2811.1 ^a	4174.7 ^a	40.24	123.0
	SEM(±)	2	65	83	Ns	Ns
	CV	11	28	29	5	4.5

Mean values across columns followed by the same letter(s) are not significantly different at P > 0.05.

NB-DFM-Days to 50% maturity, Pht (cm)-Plant height in centimeter, HI-Harvest index, G.Y (kg/ha)-Grain yield in kilogram per hectare and S.Y (kg/ha)-Straw yield in kilogram per hectare, Recommended NP=64kg/ha Nitrogen and 20kg/ha Phosphorus, Recommended lime=4.17 tone/ha.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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