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A Review on: Effect of Phosphorus Fertilizer on Crop Production in Ethiopia

Hagos Brhane Gebreslassie[1] Hailemariam Abrha Demoz[2]
1.Tigray Agricultural Research Institute, Mekelle Soil Research Center. P.O.Box, 1070; Mekelle Ethiopia
2.Tigray Agricultural Research Institute, Humera Agricultural Research Center

ABSTRACT
Phosphorus is an essential plant nutrient which involves in all physiological activities of the crop production. A researches review was made on the effect of phosphorus fertilizer on wheat, maize, barley and teff production in Ethiopia. In all of these areas the research findings indicated that application of phosphorus fertilizer increases growth and yield of the crops. But the optimum rate of P fertilizer at which highest yield recorded was different for each crop types and research area's environmental conditions. In many parts of northwestern and northern Ethiopia applying P fertilizer at the highest rate has significantly enhanced yield and yield components of wheat, maize, barley and teff. Generally these various findings on P fertilization indicated us many promising results on yield and yield components of wheat and maize, barley and teff but there is still a research gaps on phosphorus that may need more attention for increasing crop production. So detail investigation of phorus fertilizer rate as it interacts with Macro and micro nutrients like potassium and others for specific crop type, soil type, soil moisture content and agro ecology are important .
Keywords: Phosphorus, wheat, maize, Barley,Teff, Ethipia.

1. INTRODUCTION

Adequate phosphorus nutrition enhances many aspects of plant physiology, including the fundamental processes of photosynthesis, root growth particularly development of lateral roots and fibrous rootlets (Brady and Weil, 2002).

As a result of continued land degradation and rapid population growth, addressing poor soil fertility in the farming land in the tropics including Ethiopia has become a major issue to achieve food security at household level (FAO, 1984). In the semiarid areas of Ethiopia such as in Tigray, poor soil nutrient availability in the farming land is one of the major crop production constraints next to low soil moisture stress (Kidane Giorgis and Getachew Alemu, 1994). The root causes of the current low soil fertility problem in this part of the country are soils of inherent low fertility; continual nutrient mining due to continues cropping without replacement of nutrients taken together with the harvest and top soil removal through water erosion (Asnakew Woldeab, 1994; Kidane Giorgis and Getachew Alemu, 1994). Even though tremendous amount of research have been conducted on phosphorus for the last many years, its behavior in the soil and availability to crops are still not fully understood. Therefore, a continued evaluation of fertilizer effectiveness should be exercised through short and long term experimentation (Tisdale *et al*., 2002), and different methods of fertilizer application need to be assessed in-depth for a more meaningful correlation with yield and plant uptake (Mesfin, 1998).

2. LITERATURE REVIEW

2.1. SOIL CONDITIONS AND P AVAILABILITY

The relative abundance forms of phosphorus are largely dependent on the soil pH (Halvin, 1999). The "free" phosphoric acid (H3PO4) predominates in strongly acid solutions and PO4 $^{3-}$ in strongly alkaline solutions. However, the proportions of these two forms are negligible within the pH range of 5 to 9. At intermediates pH level (pH 7.2), H2PO4- and HPO4^{2}- may be present simultaneously in equal amounts whereas below and above this pH, H2PO4 - and HPO4 $^{2-}$ are the predominant forms of available P, respectively. As the pH of the solution goes up, phosphate ions tend to dissociate proton (H+) and get converted to the HPO4^{2-} ions. Primary orthophosphate (H2PO4) is somewhat more available to plants than HPO4^{2-} (Tisdale *et al*., 2002).

Eylachew (1987) reviewed different reports and stated that the availability of soil P is influenced by soil reaction, soil type, amount and forms of P as well as many other factors. Oxisols high in iron oxides and aluminum oxides, and many sandy soils low in humus content, for instance, have low available P (Miller and Danahaue, 1995). Addition of organic matter indirectly reduces P adsorption by inhibiting aluminum oxide and to certain extent Fe-oxide crystallization while addition of manure and fertilizer P reduces P fixation by increasing saturation of adsorption sites

(Boeggaad *et al*.,1990). In acid soils with high Al and Fe contents, phosphoric acid and soluble P fertilizer transformed into insoluble forms of P so quickly that plants can derive very little from P fertilized treatments (Sinha,1999). Brady and Weil (2002) indicated that at pH lower than 5.5, the retention results largely from the reactions with Fe, Al and their hydrous oxides resulting into low forms of available P. At pH higher than 7.0, high concentration of Ca, Mg and their carbonates cause precipitation of the added phosphorus and reduce the availability of P (Mengel and Kirkby, 1996). Optimum P availability in mineral soils as generalized by these authors is believed to be near pH 6.5.

Large addition of P is required to reach a given level of solution P in fine textured compared to coarse-textured soils. Consequently, high clay calcareous soils will often require more fertilizer P to optimize yields compared to loam soils. Soils containing large quantities of clay will fix more P than soils with low clay content. In other words, the more surface area exposed with a given type of clay, the greater is the tendency to absorb P (Tisdale *et al*., 2002).

2.2. EFFECT OF PHOSPHORUS FERTILIZER AND RATE ON GROWTH AND YIELD OF CROPS.

There are many investigations with respect to the effect of phosphorus fertilization on different crops productivity. However; the scope of this review is focused on effect of phosphorus fertilizer on wheat, maize, barley and teff productivity in Ethiopia. In this regard a review of various researches conducted on phosphorus in the country was made.

Wheat experiment had been conducted in Ethiopia in major wheat growing areas of north western Ethiopia; such as Gozamen, Awabel, Machakel, Gonchasiso-Enebssie, Enarge-Enawga and Debay-Tilatgin, Burie, Banja and Wogera for three consecutive years (2000-2003). The results revealed that increased yield and yield component of wheat was observed with application of P fertilizer and the highest biological and grain yield was obtained at the application of the highest P fertilizer rate (92 kg P2O5/ha) with 184kg/ha of N interaction in all locations (Minale *et al*., 2006). Besides study conducted on Kulumsa Agricultural Research Center, Ethiopia showed that out of the measured traits; days to seedling emergence, days to heading and maturity were highly significantly ($p \leq 0.01$) affected by methods of P placement and P rates while total above ground biomass and grain yield were significantly ($p \leq 0.01$) influenced by the P rates. Moreover, days to emergence, days to heading and maturity were highly significantly affected by interaction of main plot (methods of P placement) and subplot (P rates). Application of 30 kg P/ha increased the grain yield and biomass yield of wheat by 6.5 qt/ha (23.73%) and 11.27 qt/ ha (15.17%) respectively when compared with the no P application. The response to the increased application of P was associated with improvement in the concentration and uptakes of P and N that could account for the increase in yield. On the other hand, N and P uptakes by wheat ranged from 42.01 kg N/ha with no P to 52.28 kg N/ha at the rate of 30 kg P/ha, and 20.08 kg P/ha with no P to 29.06 kg P/ha at rate of 30 kg P/ha, respectively (Endalkachew, 2006).

Moreover, an experiment carried out from 2007 to 2008 in Enderta,North Ethiopia indicated that application of different rates of phosphorus fertilizers had significantly increased both grain and straw yield of wheat (Abreha *et al.,* 2008). According to this report increased application rates of 10 and 20 kg P/ha, increased the grain yields of wheat by 4 and 11 percent respectively over the control. Further more research conducted on Samre, North Ethiopia indicated that grain yield, plant height, above ground dry matter yield and panicle length of wheat HAR250 variety increased significantly with increasing P rates and the highest grain yield, plant height, above ground dry matter yield, panicle length and 1000 seed weight were found at 20 Kg/ha of P(Fiseha,2008). He also indicated that the highest grain yield of wheat (34.35Q), and above ground dry matter yield (92.00Q) were found at 46Kg/ha P with interaction of 75kg/ha of urea.

Recently another research conducted in northern Ethiopia Hawzen district to investigate effect of phosphorus fertilizer level on the growth and yield of wheat also indicated Phosphorus application at a rate of 46 kg P2O5/ha increased significantly grain and straw yields by 38 % and 46 %, respectively than control (Bereket *et al*., 2014).

Like that of wheat maize and other cereals production is affected by phosphorus fertilizer application. In line to this reviewing of phosphorus fertilizer application on maize,barley and teff production has been made. Many researchers had investigated the effect of phosphorus fertilization on maize in different parts of Ethiopia. Application of P fertilizer has positive relationship with yield and yield component of maize. According to Tilahun *et al*.(2006) research conducted on various sites of maize growing areas in north west Ethiopia revealed that application of phosphorous fertilizer significantly increases grain yield, plant height and thousand seeds weight and the highest grain yield (5242.8 kg/ ha) was obtained at the 138 kg/ ha P2O5 rate. Besides the interaction of P with N did also significantly affected grain yield, plant height and thousand seeds weight. The highest mean grain yield, 6202.5 kg ha^{-1} was obtained with the application of 128-92 N-P2O5kg/ ha, representing an increase of 4546.8 kg ha^{-1} that is 274.6% over the control (unfertilized) treatment. More over the statistical analysis indicated that the optimum rates of nitrogen and phosphorous fertilizers were 128-92, 128-138 and 192-138 N-P2O5 kg/ ha rates all resulting in grain yields that are statistically equivalent. However, the further economic analysis indicated that it was the 128-92 N-P2O5 kg/ ha level that was the most optimum profitable rate followed by the 64-46 N-P2O5 kg/ ha level (Tilahun *et al*., 2006).

Phosphorus fertilizer on yield and yield components of barley indicated promising effect in various parts Ethiopia. Research conducted on barley at Ellala Vertisols of Northern Ethiopia depicted that yield and yield components of barley was increased with increasing P fertilizers and increment of grain yield from

740.75Kg/ha at the control plot to 1119.60Kg/ha at the rate of 20kg/ha P with 50kg/ha of Urea was observed (Fisseha ,2008). Besides study conducted on barley in northern Ethiopia, Tigray region in three sites characterized by different climatic conditions during the cropping season of 2009/10 indicated that Grain yield has shown varied significantly (*p<0.001*) in response of phosphorus fertilization across different sites. The crop respond positively as P rate increased from 0 to 30kg/ha in the two sites. However, at one site yield showed declining trend as rate of P increase from 20 to 30kg/ha. The maximum yield (1706kg/ha) was obtained at P rate of 20kg/ha (Dejen and Fetien,2014). Similarly an experiment conducted on the effects of different phosphorus fertilizer levels on yield and yield components of barley at south eastern Oromia, Bore, in 2009 cropping indicated that P application significantly influenced all the parameters of growth and development of barley and the highest total biomass of 8.91 Kg ha-1 was obtained from the highest P level of 69 Kg ha-1 (Wakene *et al,* 2014).

Phosphorus fertilizer trial on teff was conducted from the year 2000 to 2003 on the major teff growing areas of northwestern Ethiopia on vertisol and Nitosols of farmers' field on a total of thirteen major teff growing localities. The results indicated that the highest grain yield was obtained with the highest P fertilizer rate (80 kgP2O5 ha-1) in most localities of Vertisols and the highest grain yield in most localities of Nitosols were obtained at 60 kg P2O5 /ha with interaction of 100 and 60 Kg N/ha respectively (Alemayehu *et al,* 2006). Similarly a field experiment conducted in 2008 at Laelay Maichew, Central Tigray, Northern Ethiopia to determine the effect of seed and phosphate fertilizer rates on yield and yield components of Teff indicated that phosphate fertilizer brought a significant (P≤0.05) effect on most of the agronomic parameters (Mehreteab H.,2008). According to this report the days to heading and maturity were significantly (P≤0.05) reduced as the level of phosphate fertilizer increased. However, panicle length, plant height, number of nodes, number of effective tillers, lodging index, biomass yield, grain yield and harvest index increased with an increased level of phosphate fertilizer and the optimum grain yield was obtained by applying phosphate fertilizer rate of 46 kg P_2O_5/ha.

3. CONCLUSSION

Phosphorus has great importance in plant nutrition. It involves in the processes of energy transformations, genetic inheritance, protein synthesis and cell division. Moreover phosphorus enhances root development and strengthening of straw, affects flowering, fruiting, seed formation and crop maturation. Inline to this availability of phosphorus in soil is affected by different factors like soil reaction and climate. Phosphorus application as fertilizer is important in increasing crop production of wheat,maize barley and Teff in Ethiopia. Based on the various findings of P fertilization results the yield and yield components of wheat, maize, barley and Teff were increasing with increasing P fertilizer application rates. The critical level (optimum level) of P fertilizer rate after which crop response declines or not significant in economic point of view is different for each crop type, soil type and agro ecology.

The findings by different researchers in various regions was not addressed issues related to socioeconomic and residual effect of the applied P fertilizer on the next cropping season rather they were focused on the effect of P fertilization only on yield and yield components of wheat, maize, barley and Teff. Even though the various findings on P fertilization indicated us many promising results on yield and yield components of wheat, maize, barley and teff there is still a research gaps on phosphorus that may need more attention for increasing crop production like:

- Investigating on optimum phosphorus fertilizer rate as it interacts with Macro and micro nutrients like potassium and others for specific crop type, soil type, soil moisture content and agroecology.
- The relationship between Total and available soil P as the total P can be converted to available form as a result of moisture.
- Investigating in more detail about the interaction effect of P not only with nitrogen but also with other macro and micro nutrients at various environmental conditions with specific crop type and variety (synergetic or antagonistic).
- Developing models for better P fertilizer recommendations based on soil, plant and environmental factors

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