

Effectiveness of Phosphorous Fertilizers in Wheat Crop Production in Pakistan

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Abstract. Phosphorus (P) is that element of the periodic table, which is extensively found in nature and along with nitrogen and potassium represents the overall composition of plants and animal life. Phosphorus performed different metabolic activities in plants and is one of the key elements for the maturation of plants and boosting up the larger quantities. As it has a vital role in the metabolism and energy production reaction and can survive the unfavorable environmental effects so cause increase in yield. A research review was carried out on the effectiveness of P fertilizers for wheat crop production in Pakistan. Almost all of the researchers in all areas indicated that P fertilizers significantly improved the growth as well as yield parameters of wheat crop. But the optimum rate of P fertilizer at which highest yield recorded was different for each area, soil and environmental condition. Although these findings on P fertilization representing many capable results regarding to yield and yield components of wheat but still further research is strongly recommended to evaluate the dynamics of P in soil as well as the interaction effect of P with other micro and macro nutrients.

1. Introduction

Phosphorus has a vital role in the metabolism and energy production reaction and can survive the unfavourable environmental effects so cause an increase in yield [1]. Phosphorous has a dominant role in the physiological processes of living organisms particularly in plants [2].

Most of Pakistan soils are calcareous in nature, which are not only low in the parent material containing the phosphorus mineral but its alkaline nature further reduces its availability in soil. Most of the soils in Pakistan contain less than 10 mg P₂O₅ kg⁻¹ soil [3]. Wheat occupied more than 36.3 of the total cropped area of Pakistan which is still below the average production of wheat as compared with developing countries [4]. The most important factor which increases wheat crop production is the supply of nutrients in an adequate amount [5]. J.M.T. Tariq et al. [6] also considered the adequate and proper supply of nutrients to wheat crop as key factor for optimum production.

Soils of Pakistan are alkaline in reaction and calcareous in nature that's why P fixation in these soils is a serious problem when P fertilizers are added to the soil, the soil rapidly and tightly adsorbed large amount of P and this adsorbed P is not available to plants [7]. According to [8] 93 % of Pakistani soils are deficient in available P; the phosphorus fertilizer use can help to reduce the adverse effect of drought under rainfed conditions. P got dominant importance for crop production and importance is being given on the efficient use of P fertilizers for sustainable crop production [9].

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, continued evaluation of fertilizer effectiveness should be exercised through short and long term experimentation [10], and different methods of fertilizer application need to be assessed in depth for a more meaningful correlation with yield and plant uptake [11].

2. Review of Literature

2.1 Availability of P and soil conditions

Even though the overall P content in soil is high (> 80%), yet certain factors like adsorption, conversion of P into organic forms and precipitation of P restricts its availability for the plants. Iron and aluminium dominate the acidic soils, upon reaction with P they form either Fe phosphate or aluminium phosphate, and adsorption of P occurs to Fe oxides or aluminium oxides or also to humic substances, whereas in alkaline calcareous soils P reacts with Ca to form Ca-P. In many soils more than 50 % of overall P is organic P (mostly Phytate) [12]. Plants take P from the soil solution in monovalent (H_2PO_4) and divalent (HPO_4) orthophosphate anions forms, at a neutral pH each of them show almost 50% of the total P. In acidic soil condition pH 4-6, H_2PO_4 is dominant, however in alkaline soil pH 8 HPO_4 is 80% of overall P [13].

M. Amrani et al. [14] worked on P adsorption of arid and semiarid regions soils. Langmuir, Cooke, and Freundlich models were applied to determine P sorption. The results concluded that various soil solutions P are required for different soil series to obtain optimum yield. Soil P availability is influenced by many factors such as soil reactions, amount and form of P as well as soil type [15]. More P fertilization was suggested in high clay-calcareous soils by L.S. Tisdale et al. [10] because large quantities of clay will fix more P than soils with low clay content. Similarly [16] suggested that as the soil solution P increased, the adsorption also increased simultaneously, while working on 11 different soil series of rice. Moreover, it was also summarized that adsorption has a close relation with clay and free lime content of soil. The response of plants towards phosphatic fertilizers and the availability of P in soil solution concentration are greatly affected by P sorption capacity [17], and also have an adverse effect on the movement of P in soil [18].

2.2 Impact of P fertilizers on wheat growth and yield

A tremendous amount of investigations were carried out on the effect of phosphorous fertilizers on different crops, however, the scope of this review is focused on the effect of phosphorous fertilizers on wheat crop production in Pakistan.

A. Rahim et al. [19] found that P and irrigation levels have a significant effect on wheat yield. P at the rate of 81 kg ha^{-1} could result the maximum grain yield if an application is done through band placement rather than broadcast method. Proper irrigation at various levels of crop growth could result optimum yield and also increased P use efficiency. Adsorption isotherms are useful to calculate various P doses for crop requirements. [20] summarized the effect of nitrogen and phosphorous on wheat yield and concluded that both N and P affect the agronomic parameters of wheat crop. N and P_2O_5 at the rate of 120 and 90 kg ha^{-1} could attribute the maximum yield under the agro-climatic conditions. Similarly, two experiments conducted during 2013 on Peshawar and Guliana soil series having diverse lime content 19 and 4% respectively, and revealed that in Peshawar soil wheat yield increased by 76.5% at $45\text{-}135 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ as compared to Guliana soil where the maximum yield of 54.8 % was obtained at $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$. The study of the two soils revealed, that wheat yield showed the significant increase in Guliana than Peshawar soil series, and concluded that high lime soil (Peshawar soil) required more P ($90\text{-}135 \text{ P}_2\text{O}_5 \text{ ha}^{-1}$) than low lime soil (Guliana) $45 \text{ to } 90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ [4].

Moreover, the result of two-year experiment revealed that agronomic parameters of wheat like plant height, number of grains spike⁻¹, grain weight spike⁻¹ and 1000-grain weight significantly increased by the application of 180 kg N and $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ [21]. In another experiment [22] reported that significant increase in wheat biomass yield can be obtained with the application of P at $75 \text{ to } 100 \text{ kg ha}^{-1}$. Similarly the result of another experiment conducted at Agricultural University Peshawar indicated that application of phosphorus at the rate of 100 kg ha^{-1} through double band placement significantly ($P < 0.05$) enhanced plant height, productive tillers m^{-2} , grains spike⁻¹, 1000 grain weight, biological yield, grain yield, harvest index and agronomic phosphorus efficiency of wheat crop and reduced non-productive tillers m^{-2} compared with other treatments [23]. The significant effect of P as foliar spray was also reported by [24] however in wheat the soil treatment yields good results as compared with foliar spray.

Moreover, an experiment conducted during 2005-2006 at Bahauddin Zakariya University, Multan, Pakistan revealed that application of 60 to 120 kg P ha⁻¹ maximally improved the growth parameters as well as yield of wheat crop [25]. Another study was conducted on P application methods, broadcast (0 and 100 kg P₂O₅ kg ha⁻¹) and fertigation (50, 75 and 100 kg P₂O₅ ha⁻¹) in calcareous soils varying in CaCO₃ concentrations (6, 9 and 13% CaCO₃). According to this study, Phosphorus fertigation at 100 kg ha⁻¹ significantly enhanced the grain (4.4 tons ha⁻¹) and biological yields (11.4 tons ha⁻¹) as compared to control and broadcast at each level of CaCO₃ % [26]. The experiment conducted on Rasulpur soil series (Typic Camborthid) revealed that 0.2 mg P L⁻¹ soil solution as per Freundlich equation is sufficient to produce the maximum grain as well as straw yield; however P concentration in grain and straw was maximum at 0.5 mg PL⁻¹ soil solution, and advocated that for obtaining 95% relative yield of wheat both the external and internal solution P requirement were found to be 0.172 mg P L⁻¹ and 0.276 % respectively [27]. In recent research on Swabi soil revealed that 90 kg ha⁻¹ P along with 6 t ha⁻¹ poultry manure is sufficient for obtaining the optimum yield of wheat crop [28]. The result of two consecutive years experiment during 2000-2001 and 2001-2002 indicated that maximum wheat yield can be achieved by broadcast application of P at 114 kg ha⁻¹ by intra row drilling techniques, according to this study increase in economic yield may be due to better availability and uptake of phosphate fertilizer by drilling method [29]. The result of another study revealed that application of phosphorus at a higher rate could compensate the drastic effect of water stress and increased wheat yield. On overall performance, application of phosphorus at the rate of 120 kg ha⁻¹ showed better yield under water stress conditions as compared to other phosphorus levels [30].

Furthermore the result of a pot experiment conducted during Rabi season 2007 at Rawalpindi indicated that phosphorus application at the rate of 80 kg P ha⁻¹ as single super phosphate (SSP) showed better results as compared to triple superphosphate (TSP), nitrophos (NP) and diammonium phosphate (DAP) on phosphorus deficient soil of Balkasr area of Tehsil Chakwal [31]. Similarly in another study conducted on growth and yield of wheat cultivar Bhakar-2002 at the Agronomic Research Area, University of Agriculture, Faisalabad, during Rabi 2006-2007 concluded that phosphorus source in the form of DAP at the rate of 90 kg ha⁻¹ should be applied to get maximum benefit from wheat crop [32]. Another experiment was conducted at D.I Khan Pakistan during 2004-2005 with the main aim to evaluate the response of wheat to P. According to this study Phosphorus application significantly increased the grain yield of wheat from 2920 kg ha⁻¹ in control to 3560 kg ha⁻¹ in the treatments receiving P at 90 kg P₂O₅ ha⁻¹ giving an increase of 22 % over control, moreover the growth parameters like number of tillers, spikes, spike length and plant height of wheat were also significantly increased by P application [33]. Similarly, the result of the study performed by [34] suggested that wheat grain yield increased with increasing level of P over control. The maximum increase in wheat grain yield over control was recorded with 36 mg kg⁻¹ soil. The result of a two years field study conducted at Vehari Pakistan during 2008-2009 and 2009-2010 concluded that application of P as single superphosphate (SSP) gave better results as compared to nitrophos (NP), diammonium phosphate (DAP), monoammonium phosphate (MAP) and triple superphosphate (TSP) on phosphorus deficient soil, according to this study the wheat growth parameters were significantly increased with P application however different P fertilizers have the same effect on wheat emergence [35].

Conclusions

From this review it was clearly concluded that P has great importance in wheat crop nutrition, however, the findings of different investigators at different areas were not clearly addressed the issue related to socioeconomic rather all of them were focused on the impact of P on wheat yield and yield components. Although these findings on P fertilization representing many capable results regarding to yield and yield components of wheat still further research is strongly recommended to evaluate the dynamics of P in the soil as well as the interaction effect of P with other micro and macronutrients.

Conflict of Interest

The authors declare that there is no conflict of interest.

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