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Effect of Phosphatic Fertilizers on Chemical Composition and Total Phosphorus Uptake by Wheat (Triticum aestivum L.)

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Abstract

Wheat (Triticum aestivum L.) was grown in earthen pots containing soil of Balkasar Soil Series (Sandy Loam) in green house at the Department of Soil Science and SWC, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi during Rabi season, 2007. The Crop was treated with two levels of Phosphorus (40 and 80 kg P ha^{-1}) in the form of SSP, TSP, NP and DAP. A basal doze of 100 kg N and 60 kg K ha^{-1} was applied as urea and murate of potash (MOP) respectively. Chemical composition of wheat plants showed that all the parameters were significantly improved by addition of P except the Phosphorus concentration (%) in wheat straw and potassium conc. (%) in wheat grain. Similarly Phosphorus uptake was increased with the increased level of phosphorus application. It was concluded from the study that different sources and levels of phosphorus has significant effect on the NPK contents of wheat and total P uptake by wheat plants. Among all the sources and levels of phosphorus, 80kg P ha^{-1} as single superphosphate (SSP) showed superiority over triple superphosphate (TSP), nitrophos (NP) and diammonium phosphate (DAP) on phosphorus deficient soil of Balkasr area of Tehsil Chakwal. **[Bilal Khan et al. Effect of phosphatic fertilizers on chemical composition and Total Phosphorus Uptake by wheat (Triticum aestivum L.). International Journal of Agricultural Science, Research and Technology, 2012; 2(1):37-42].**

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1. Introduction

Wheat is the main staple food for most of the population and largest grain source of the country. It occupies the central position in formulating agricultural policies. It contributes 12.5 percent to the value added in agriculture and 2.6 percent to GDP (Anonymous, 2011-12). The average yield of wheat (*Triticum aestivum* L.) in Pakistan (2451 kg ha^{-1}) is low as compared to world average(3086 kg ha^{-1}) or even to its neighboring countries like India (2802 kg ha^{-1}), and china (4762 kg ha^{-1}) (MINFA, 2010). Wheat is cultivated on an area of 1.43 million hectares in rain-fed area and the average yield is static at around 1.0 t ha^{-1} for almost 20 years (MINFAL, 2001), which is quite low. Drought, nutritional stress including widespread nutrient deficiencies (Rashid, 1994) and low and unbalanced use of fertilizer (NFDC, 1997) are the major limiting factors causing less wheat production under rain-fed conditions. Among different factors, the role of nutrients is well recognized in crop production. The inadequate supply of the essential plant nutrients in soil is growth limiting factor towards its production. Among all the elements required by a plant, phosphorus (P) is one of the most important nutrient for crop production and emphasis is being given on the sufficient use of P fertilizer for sustainable crop production (Ryan, 2002). Phosphorus plays a vital role in several key physiological processes viz; photosynthesis, respiration, energy storage, cell division, cell enlargement etc. phosphorus is essential for seed formation and root development (Memon et al, 2001). The consumption of major nutrients (N, P and K) in Pakistan though increased substantially but did not show a balance growth. Since introduction in early 1950, nitrogen consumption showed a consistent growth rate, which peaked at 2 million nutrient tones in 1998-99, whereas phosphorus and potassium showed a slow growth rate and thereby only 435 thousand tones phosphate and 26 thousand tones of potash was consumed in 1998-99 (Ahmad, 2000). The nutrient balance sheet shows a negative balance for P indicating more removal and less addition to the soil. Low P use was mainly due to increased price hike of phosphate compared to nitrogen fertilizers during the last two decades that deter the small or low income farmers to apply fertilizers proportionally (Ahmad, 2000). But during the last year (2009-2010) Nitrogen off-take increased by 15.4 percent while that of phosphate by 66.2 percent. Main reasons for increased off-take of fertilizers were affordable price of DAP and higher support price of wheat. (MINFA, 2010). There are several kinds of inorganic phosphatic fertilizers manufactured by industries in different grades of elements essential for plant growth. These inorganic fertilizers include single super phosphate (SSP), TSP, MAP, DAP and nitrophos (NP). In Pakistan the major inorganic phosphatic fertilizers are: TSP, DAP, SSP, MAP and NP. Single superphosphate and NP are manufactured locally. However DAP is imported from other countries such as Jordan, USA, Morocco etc. Soils of Pakistan are alkaline and mostly calcareous in nature and P fixation is a serious problem in these soils (Sharif *et al,* 2000). According to NFDC (2003), 93 percent of Pakistani soils are P deficient. Phosphatic fertilizers are applied to soil to enhance the production of crops. The application of P fertilizers to calcareous soils, with pH levels greater than 7.5 has been problematic mainly due to P fixation. When P is applied to the soil, the plant takes up only small percentage; the remainder is either permanently or temporarily fixed in forms varying in plant availability. The temporarily fixed P, also called residual P, becomes available with time, but at slow rates (Sharif *et al,* 2000). The phosphorus fertilizer use can help to reduce the adverse effect of drought under rainfed conditions. The Potash and Phosphate Institute (PPI, 1999) reported that phosphorus, in balanced soil fertility program, increase water use efficiency and helps crop to achieve optimal performance under limited moisture conditions. As wheat is staple food of Pakistan and Phosphatic fertilizers are very expensive therefore it is essential to know the effects of the P sources and levels on NPK Contents of wheat plants and total P-uptake by wheat plantson phosphorus deficient soil.

2. Methods and Materials

A pot experiment was conducted to compare the effect of different phosphatic fertilizers on wheat crop in Balkasr soil series of Tehsil Chakwal. The study was conducted in green house at the Department of Soil Science and SWC, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi during Rabi season, 2007. For this, bulk soil sample from 0-30 cm depth was brought from farmer's field of Balkasr area of Tehsil Chakwal. Soil sample was air dried, ground, passed through a 2 mm sieve and mixed thoroughly. Ten kg of the prepared soil was packed in each earthen pot having height and diameter of 18 and 12, inches respectively. The pots were lined with polythene bags. Eight seeds of wheat (cv. GA 2002) were sown on 20th November, 2006. Phosphorus was applied at the rate of 40 and 80 kg P ha^{-1} in the form of SSP, TSP, NP and DAP. A basal doze of 100 kg N and 60 kg K ha^{-1} was applied as urea and murate of potash (MOP) respectively. Thinning was conducted on 22nd December, 2006 and four plants per pot were grown. Distilled water was used to bring the soil to 50 percent of maximum water holding capacity by weighing the pots as and when required. One plant per pot was harvested at 80 days growth while three plants were harvested at maturity on Saturday, May 5, 2007 at 137 days growth. Experiment was laid out in completely randomized design (CRD) with three replications.

Soil sample collected from the farmer's field of Balkasr soil series was air dried, ground, passed through a 2 mm stainless steel sieve and mixed thoroughly. This soil sample was used for physio-chemical analysis like soil texture, macronutrients (P, K), electrical conductivity (EC_e), soil pH_s, and organic matter (OM) at the beginning of experiment (Table 1). The soil used for the experiment was sandy loam in texture, alkaline in reaction (pH=7.92), poor in organic matter (0.40%), adequate in potassium (92 mg kg^{-1}) and low in available phosphorus (4.6 mg kg^{-1}).

Particle Size Analysis was done by Bouyoucus Hydrometer Technique (Bouyoucus, 1962). Soil paste was prepared and saturation extract was obtained. Then the pH was determined with a pH meter (Page et al*.,* 1982) and Electrical conductivity was measured by using electrical conductivity meter (Page et al*.,* 1982). Organic matter was determined by using Walky and Blake method (Page et al*.,* 1982). Available Phosphorus was measured by spectrophotometer (Olsen, 1982). Extractable potassium was determined by using flame photometer (Knudsen et al*.,* 1982). The Total nitrogen and total phosphorus were determined colorimetrically (Anderson and Ingram, 1993). For determination of potassium, plant material was dry ashed and K was determined by Flame Emission spectroscopy (Winkleman *et al.,* 1990).

The data collected for various parameters were subjected to Analysis of Variance (ANOVA) and the means obtained were compared by LSD at 5 percent level of significance (Steel and Torrie, 1980).

3. Results and discussion

The data obtained were subjected to statistical analysis using MSTAT software. The conclusion drawn from the investigations are summarized as under.

3.1 Basic Soil Analysis

Soil sample collected from the farmer's field of Balkasr soil series was air dried, ground, passed through a 2 mm stainless steel sieve and mixed thoroughly. This soil sample was used for physio-chemical analysis like soil texture, macronutrients (P, K), electrical conductivity (ECe), soil pHs, and organic matter (OM) at the beginning of experiment

(Table 3.1). The soil used for the experiment was sandy loam in texture, alkaline in reaction (pH=7.92), poor in organic matter (0.40%), adequate in potassium (92 mg kg-1) and low in available phosphorus (4.6 mg kg-1).

3.2 Effect on Chemical Composition of Wheat Plants

Chemical composition of wheat plant showed that nitrogen conc. (%) in wheat grain and straw was significantly affected by different P sources. It was also noticed that nitrogen conc. (%) in wheat grain and straw was increased with the increased level of phosphorus application. At low level, NP and DAP showed superiority over SSP and TSP. At high level, SSP, NP and DAP showed the similar results which may be due to equal supply of phosphorus. While nitrogen conc. (%) in wheat straw showed that at low level of P fertilizer application, SSP and NP showed superiority over TSP and DAP. At high level, NP and DAP showed high nitrogen conc. (%) in wheat straw.The results are in line with findings of Raghbir *et al.* (2004) who observed that nitrogen conc. (%) of wheat grain and straw increased significantly and subsequently with increasing doses up to 40 mg P kg^{-1} soil application.

Phosphorus concentration in plant is a good criterion to observe the efficiency of optimum phosphorus level in soil. Analysis of variance showed that phosphorus conc. (%) in wheat grain increased significantly with the use of phosphorus fertilizer. Different P sources significantly affected the phosphorus conc. (%) in wheat grain and it was increased with the increased level of phosphorus application. At both levels DAP showed maximum P conc. (%) in wheat grain. Phosphorus concentration in plant can be related to phosphorus extraction power of roots from soil. Normally plant roots having wider contact with soil are better extractor of phosphorus from soil and feed well to above ground plant parts. This is true for extensive root system (Tisdale *et al.* 1993). Adequate phosphorus concentration in wheat grain is 0.42 percent (PPI, 1995). The similar type of results was also observed by Singh *et al.* (2005) who observed that grain yield and seasonal accumulation of P by wheat were higher for higher P rates. All the treatment for phosphrus concentration in wheat straw did not differ significantly from each other. Phosphorus concentration (%) in wheat straw was not significantly affected by different P sources and levels but at both levels DAP showed maximum P conc. (%) in wheat straw. The increased concentration at higher rates of phosphorus might be due to better supply of phosphorus in the growing medium. The behavior of all the P sources was quite similar and none of the phosphorus material used in the study could prove superiority. Alam and Shah (2002) observed that phosphorus rates increased both dry matter and phosphorus accumulation by plant.

Potassium conc. (%) in wheat grain showed that at low level of P fertilizer applications, DAP showed superiority over SSP, TSP and NP. At high level, SSP showed high K conc. (%) in wheat grain. Potassium conc. (%) in wheat straw was significantly affected by different P sources. Potassium conc. (%) in wheat straw increased with the increased level of phosphorus application. At low level, DAP showed superiority over SSP, TSP and NP but at high level, SSP showed greater K conc. (%) in wheat straw. Sharma and Namedo (1999) observed that seed and straw P and K contents, straw N contents increased with increasing phosphorus level.

3.3 Effect on Phosphorus Uptake (mg pot^{-1}) by Wheat Plants

Data on the effect of different P sources and levels on P uptake (mg pot $^{-1}$) by wheat grain is depicted in Table 3. It was found that each additional level of P had profound effect on its uptake. Phosphorus uptake by wheat grain was significantly affected by different P sources. Phosphorus uptake was increased with the increased level of phosphorus application. At low level, DAP showed maximum P uptake by wheat grain but at high level, SSP showed better P uptake. Uptake of P is most rapid in wheat from jointing stage to anthesis, complete growth stages and 75 percent of the P uptake is translocated to the grain at maturity (Fageria *et al.,* 1997). He also pointed out that phosphorus uptake by grain is the product of grain yield and the concentration of P in grain. It is stated that the amount of P removed on an average yield of harvested grain varies from 7–15 kg P ha $^{-1}$ and out of this, 2–8 kg P ha $^{-1}$ is returned back to the soil in the form of crop residues which are left in the field (Hanway and Olsen, 1980). The present results are supported with the findings of Rehman *et al.* (2004) and Goudidng *et al.* (1994) who reported an increase in P uptake with increase in phosphorus supply.

Phosphorus uptake by wheat straw is the product of straw yield and P concentration in straw, which is depicted in the Table 3. Phosphorus uptake by wheat straw was increased with increasing levels of P fertilizers. Different P sources and levels significantly affected phosphorus uptake by wheat straw. At low level, DAP showed maximum P uptake by wheat straw but at high level, SSP showed better P uptake. The results are in line with findings of Alam and Shah (2002) who observed that P uptake by plants at pre booting stage was higher from SSP and DAP than all other treatments.

Phosphorus uptake by grain and straw of wheat is collectively known as total phosphorus uptake by wheat plants. The amount of total P uptake by wheat depends upon the production level, amount of applied P and soil type (Fageria *et al.,* 1997). Phosphorus uptake by wheat plants was significantly affected by different P sources and phosphorus uptake was increased with the increased level of phosphorus application. At low level, DAP showed maximum P uptake by wheat grain but at high level, SSP showed better P uptake. Phosphorus removal by wheat with an average yield of 3 Mg ha^{-1} was 27 kg P ha^{-1} and 5 Mg ha^{-1} removed 60 kg P ha^{-1} (FAO, 1984). Alam (1995) also showed that the application of 25mg P kg^{-1} soil significantly increased the dry matter, straw and grain yields as well as total P uptake by wheat crop. Similar findings were also reported by Siddique (1998) who observed that increasing P has significant effect on P efficiency, P uptake, P stress factor and P harvest index.

Table 1. Basic Soil Analyses of the Selected Soil

Parameters	Units	Values
Sand	%	90.14
Silt	%	7.92
Clay	%	1.94
Textural Class		Sandy Loam
PH_s		7.90
EC_e	dS m^{-1}	1.48
Organic Matter	%	0.40
Available Phosphorus	mg kg^{-1}	4.6
Extractable Potassium	mg kg^{-1}	92

Table 2: Effect of different phosphatic fertilizers on chemical composition of wheat plants

Treatments	Sources and Levels of phosphorus	N conc. (%) in wheat grain	N conc. (%) in wheat straw	P conc. (%) in wheat grain	P conc. (%) in wheat straw	K conc. (%) in wheat grain	K conc. (%) in wheat straw
T_1	Control	3.11 c	0.39 b	0.25 c	0.027 a	0.33 c	1.84 e
T_2	40 kg P ha^{-1} as SSP	3.34 b	0.46 a	0.31 bc	0.030 a	0.37 b	2.16 c
T_3	40 kg P ha^{-1} as TSP	3.36 b	0.45 a	0.32 abc	0.033 a	0.38 ab	2.11 d
T_4	40 kg P ha^{-1} as NP	3.37 b	0.46 a	0.31 bc	0.031 a	0.38 ab	2.13 cd
T_5	40 kg P ha^{-1} as DAP	3.37 b	0.44 a	0.32 abc	0.035 a	0.39 ab	2.22 b
T_6	80 kg P ha^{-1} as SSP	3.44 a	0.44 a	0.37 ab	0.036 a	0.40 a	2.43 a
T_7	80 kg P ha^{-1} as TSP	3.42 a	0.44 a	0.36 ab	0.036 a	0.37 ab	2.41 a
T_8	80 kg P ha^{-1} as NP	3.43 a	0.46 a	0.38 ab	0.036 a	0.37 ab	2.42 a
T_9	80 kg P ha^{-1} as DAP	3.43 a	0.47 a	0.39 a	0.037 a	0.38 ab	2.42 a
LSD Value		0.031	0.097	0.07671	0.05404	0.031	0.031

- The means having different letter are significantly different from each other at 5% level of probability.

Table 3. Effect of different phosphatic fertilizers on phosphorus uptake (mg pot $^{-1}$) by wheat plants

Treatments	Sources and Levels of phosphorus	P-uptake (mg pot $^{-1}$) by wheat grain	P-uptake (mg pot $^{-1}$) by wheat straw	Total P-uptake (mg pot $^{-1}$) by wheat plants
T_1	Control	30.62 e	6.71 c	37.33 e
T_2	40 kg P ha^{-1} as SSP	63.77 d	12.43 b	76.20 d
T_3	40 kg P ha^{-1} as TSP	64.76 d	13.35 b	78.11 d
T_4	40 kg P ha^{-1} as NP	63.10 d	12.63 b	75.72 d
T_5	40 kg P ha^{-1} as DAP	70.62 d	13.94 b	84.55 d
T_6	80 kg P ha^{-1} as SSP	120.8 a	22.22 a	143.1 a
T_7	80 kg P ha^{-1} as TSP	92.81 c	20.54 a	113.3 c
T_8	80 kg P ha^{-1} as NP	98.67 bc	20.86 a	121.5 bc
T_9	80 kg P ha^{-1} as DAP	115.2 ab	21.87 a	137.1 ab
LSD Value		18.58	3.492	21.07

- The means having different letter are significantly different from each other at 5% level of probability.

4. Conclusion and Recommendation

It was concluded from the study that phosphorus application at the rate of 80kg P ha^{-1} as single superphosphate (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. This superiority of SSP over the other three sources could be due to presence of more Ca content and better water solubility of phosphate compound. Single superphosphate can be used on all crops and soils as a basal dressing. Its use for ailing saline/sodic soils is, however, preferred because of the ameliorative effect ascribable to its 46% gypsum content and highly acidic nature (pH 2.0). This product is also manufactured locally and easily available to farmers. However as it contains less percentage of phosphorus therefore its storage and transportation cost is high as compared to other sources. However, further investigations are required to verify this fact.

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