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Source and rate of inorganic P fertilizer affecting soil phosphatase enzymes, yield and P-uptake of Chillies

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Abstract

A pot experiment was conducted to investigate the impact and implication of source and rate of phosphatic fertilizer i.e. Diammonium phosphate (DAP) and single superphosphate (SSP) at different levels on the enzymes activity, P - uptake and yield of chillies during year 2012 at Department of Soil and Environmental Sciences, Faculty of Agriculture, Gomal University, Dera Ismail Khan (Pakistan). The results of the experiment revealed that the activity of acid phosphatase enzymes was significantly influenced by the application of treatments, whereas effect on alkaline phosphatase activity was non-significant. Effect of treatments showed significant effect on the yield attributes and yield of chilli. Plant height, number of branches per plant, number of fruits per plant and fruit yield was significantly increased by the application of fertilizers at different rate, while the sources of fertilizers showed non – significant effect on the yield component and fruit yield of chilli. The treatments also showed a significant ($p < 0.05$) effect on soil pH, extractable phosphorus content and P - uptake. The correlation studies showed non – significant association (0.424) between P – uptake and acid phosphatase activity with pots having DAP as a source. Likewise, alkaline phosphatase and P – uptake interdependence was non-significant with pots receiving SSP. Hence, it may be concluded that chilli fruit yield and its related attributes were not the only factors influenced by the rate and source of fertilizer but enzymes activity may also be considered and further studied.

Keywords: Phosphatic fertilizers, phosphatase enzymes, p uptake, chillies

Introduction

Phosphorus (P) is an essential plant nutrient required by the plant to perform various vital functions including energy transfer, seed formation and transformation of starch to sugar in flowering and fruiting stages. Use of P fertilizer in Pakistan has increased during the last few decades (Khan *et al*., 2010). Soils of Pakistan are moderate to severely deficient in Phosphorus (Memon *et al*., 1992; Alam *et al*., 1994). This has ultimately raised demand for P and resulted in increased prices of the fertilizer. Phosphorus fertilization is essential for utilizing maximum yield potentials of various crops (Rashid *et al.*, 1994). Supplying vegetable crops with organic and inorganic fertilizers has proved to be very effective for production of higher yields and for improving its quality (Mengal and Kirkby, 2001). Diammonium phosphate (DAP) and single super phosphate (SSP) are the most common phosphatic fertilizers used in Pakistan.

Phosphorus availability is considered as one of the major growth limiting factors for plants in many natural ecosystems. Plants have developed several adaptive mechanisms to overcome P stress (Marschner, 1995). The solubility of both the organic and inorganic phosphate compounds is very low and only small amounts of soil phosphorus are in solution at any one time, which is available to plants. Through adequate use of P fertilizers and better management of soil, the soil solution content of P can be made enough for the optimum crop production. Holford (1989) considered soil solution as an instant source of P for plant uptake. The available P in the soil solution, either from fertilizer or any other source reacts with iron, aluminium, calcium and clay to form less available compounds by the process of phosphorus adsorption or fixation.

Besides phosphorus fertilizers, enzymatic activity too is important in numerous reactions available for life processes of soil microbes, cycling of nutrients and formation of organic matter and soil structure (Dicks *et al*., 1994). There is a significant association between nature, amount of fertilizers upon the enzymatic activity (Saha *et al*., 2008). Similar coincidence is noted between phosphatic enzymes and phosphatic fertilizers. Soil enzymes play major role in transformation of organically bound nutrients into inorganic plant available nutrients. Enzymes accumulated in soils are present as free enzymes, such as exoenzymes released from living cells, endoenzymes

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released from disintegrating cell constituents (Kiss *et al*., 1975). Saha *et al*. (2008) reported that the nature and amount of applied organic fertilizers to the soil significantly influence the activity of phosphatase enzymes and available phosphorus. Among the soil phosphatases, phosphomonoesterases and to lesser extent phosphodiesterases, have been the most widely studied. The phosphomonoesterases are further classified as acid and alkaline phosphatases (Dodor and Tabatabai, 2003). The current study was carried out to investigate the effect of inorganic P fertilizer i.e. DAP and SSP on soil properties, growth and yield of chilli and establish a correlation between the inorganic P fertilizers, enzyme activity and P–uptake.

Materials and Methods

To investigate the impact of different phosphatic fertilizer on phosphatase enzyme activities, yield and P uptake of Chillies (*Capsicum annum*), an experiment was carried out in pots at Department of Soil and Environmental Sciences, Faculty of Agriculture, Gomal University, Dera Ismail Khan (Pakistan).

The experiment was laid out in complete randomized design with two factors. The chemical fertilizers diammonium phosphate (DAP) and single super phosphate (SSP) were applied at different rates (P_2O_5: 30, 90 and 120 kg ha^{-1}). Each pot was filled with 20 kg of sandy loam soil. Local chilli variety was grown and the nursery was transferred to the pots. Initially three plants per pot were grown, but after the establishment of the plant it was thinned to a single plant. A basal dose of nitrogen and potassium were applied to all the treatments at 120-60 kg ha^{-1}, respectively. The plants were irrigated with tap water on weekly basis.

Soil analysis

Soil samples were analysed for physico–chemical characteristics of soil before sowing (Table 1). Soil texture (Ryan *et al*., 2001); pH (Richard, 1954); ECe (Richard, 1954); SAR (Richard, 1954); bulk density (Blake and Hartage, 1986); organic matter (%) (Nelson and Sommer, 1982); nitrogen (Bremner, 1996); phosphorus (Olsen *et al*., 1954); exchangeable potassium (Richard, 1954) and soil acid and alkaline phosphatases (Tabatabai, 1994) were determined in the soil samples.

Growth attributes

Growth and yield parameters as plant height (cm); number of branches per plant, number of fruits per plant and fruit yield (kg ha^{-1}) were determined. Phosphorus uptake by the plant was measured by acid digestion followed by P analysis on spectrophotometer (Cottenie, 1980).

Table 1: Physico – chemical characteristics of the soil

Particular	Value
Soil texture	Sandy Clay loam
Bulk density	1.29 (g cm^{-3})
Total N	0.027 (%)
Olsen P	6.09 (mg kg^{-1})
Available K	152.6 (mg kg^{-1})
pH	8.09
ECe	281 (µS cm^{-1})
Organic matter	0.78 (%)

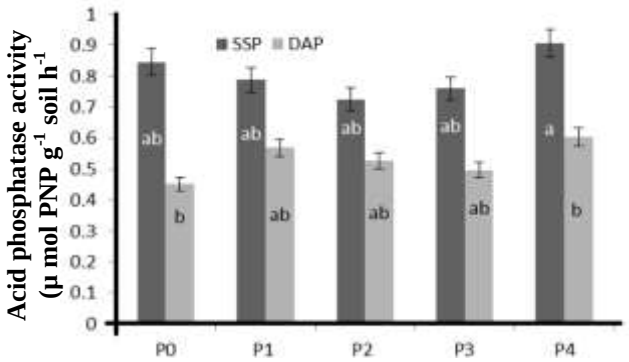
Statistical analysis

After obtaining the primary data it was subjected to analysis of variance by software Statistix 9.1. and correlation coefficient was determined by using the procedure described by Fisher and Yates (1953).

Results and Discussion

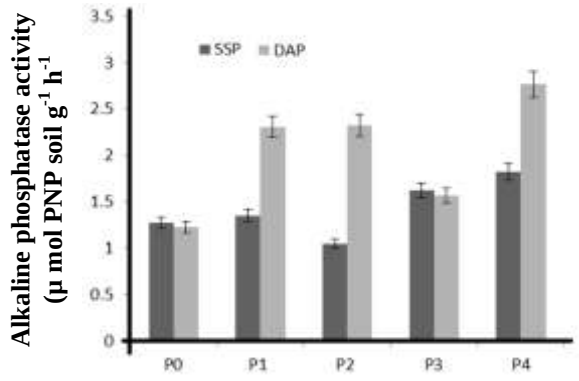
Phosphatase activity

The results of phosphatase activities showed that by the application of inorganic fertilizers the activity of acid phosphatase was significantly changed. The highest activity was recorded in the pots receiving SSP fertilizers as compared with the DAP fertilizers (Figure 1). Alkaline phosphatase activity was greater in the treatments receiving DAP fertilizers. The various rates of P fertilizers have shown influence on the activity of alkaline phosphatase than acid phosphatase (Figure 2).



P0: Control; P1: P_2O_5 at 30 kg ha^{-1}; P2: P_2O_5 at 60 kg ha^{-1}; P3: P_2O_5 at 90 kg ha^{-1}; P4: P_2O_5 at 120 kg ha^{-1}

Figure 1: Effect of fertilizer sources and rates on soil acid phosphatase activity (µ mole PNP g^{-1} soil h^{-1})



Phosphorus level of two fertilizer sources

P0: Control; P1: P_2O_5 at 30 kg ha^{-1}; P2: P_2O_5 at 60 kg ha^{-1}; P3: P_2O_5 at 90 kg ha^{-1}; P4: P_2O_5 at 120 kg ha^{-1}

Figure 2: Effect of fertilizer sources and rates on soil alkaline phosphatase activity (µ mole PNP g^{-1} soil hour^{-1})

Different researchers have considerable data suggesting that enzymic activity of soil can be used as an important indicator of soil nutrition and microbial biomass activity (Badiane *et al*., 2001) and also help in determining its effect on land use and soil characteristics (Saggar *et al*., 1999). In the present study it has been found that soil acid Phosphatase enzymes activity was higher in the soil deficient in extractable P. Muhammadi *et al.* (2011) reported significantly higher activity of acid phosphatase over control by the application of inorganic fertilizers, they have also reported non – significant influence of the inorganic fertilizer over control for the Alkaline phosphates activity. Abou-Aly (2006) reported that phosphatase activity decreases when soluble P-fertilizers are used. This may be due to the P cycle that enzyme activities are inversely related to P-availability and when P is a limiting nutrient its demand increases, resulting in an increase in phosphatase activity in the presence of P - solubilizers (Vazquez *et al*., 2000).

Growth and yield attributes

A non-significant effect of fertilizer sources was observed on the growth and yield of chillies (Table 2). Different rates of phosphorus applied to the pots showed significant influence on plant height, number of branches per plants, number of fruits per plants and yield of chillies. Plant height was found significantly higher (18.40 cm) in the pots receiving SSP at 120 kg P ha^{-1}, which was at par with the treatments receiving DAP at 120 kg P ha^{-1}. Number of branches per plants showed a similar pattern for the type and rates of fertilizers. Maximum numbers of branches were observed as the rate of P increased to 90 kg ha^{-1}, over the control. It was found maximum where DAP

Table 2: Effect of different fertilizers at various rates on the growth parameters of Chillies

Treatment	Plant Height (cm)		No. of branches plant^{-1}		No. of fruits per plant		Fruit Yield (t ha^{-1})	
	SSP	DAP	SSP	DAP	SSP	DAP	SSP	DAP
T1 Control (No P)	12.95 ± 0.915d	13.35±0.787cd	5.0±0.707 d	6.2±0.750 cd	27.5±0.645 cd	25.5 ± 0.645 d	4.57±0.149c	4.80±0.227c
T2 (P_2O_5 at 30 kg ha-1)	15.50±0.546bcd	13.62±0.804 cd	8.0± 0.816abc	7.5±0.645 bcd	29.2± 0.912bcd	33.0 ± 0.816abc	5.55±0.413 b	5.25±0.259bc
T3 (P_2O_5 at 60 kg ha-1)	15.85±0.885 abc	16.22±0.485ab	9.0±0.707 ab	9.2±0.853 ab	35.0±0.816ab	36.5 ± 0.645 a	5.85±0.638 b	5.57±0.275 b
T4 (P_2O_5 at 90 kg ha-1)	17.20±0.802 ab	16.32±0.672 ab	9.0± 0.707ab	10.5±0.500 a	34.5±0.957 ab	36.7 ± 0.478 a	6.45±0.578ab	6.65±0.352 ab
T5 (P_2O_5 at 120 kg ha-1)	18.40±0.535 a	17.70±0.958ab	9.2±0.853 ab	10.2±0.478 a	34.0±0.912ab	31.7 ± 0.853 abcd	6.97± 0.268 a	6.77±0.404a
Mean	15.98±0.915	15.44±0.841NS	8.2±0.887	8.5±0.607 NS	32.0±0.348	32.7±0.457 NS	5.88±0.408	5.81±0.388 NS
LSD treatment		2.5730		2.2273		6.4795		0.6537

Means followed by different letter(s) are statistically significant at 5% probability level

was applied at 90, 120 and 60 kg ha^{-1}, respectively, over the control. The number of fruits per plants were recorded non significantly different however, the highest number of fruit (36.7) in the treatments with DAP at 90 kg P ha^{-1}. All the growth and yield relating factors have supplemented towards the yield of chillies. The yield was recorded significantly higher in the treatments receiving maximum dosage of phosphorus SSP at 120 kg P ha^{-1} (T_5), which was at par with T_4 (P at 90 kg ha^{-1}). Naeem *et al*. (2002) have reported significantly higher plant height by the application of nitrogen and phosphorus over control. They have concluded that the maximum height might be due to increase in vegetative growth by the application of N and P. Rehman *et al*. (2012) reported that NPK fertilizers alone and in combination with organic compost significantly increased the number of branches per plant than the control with none of the fertilizers and manures.

Soil pH and phosphorus in relation to plant P - uptake

The phosphatic fertilizers applied to the soil have also showed profound effect on the properties of soil, i.e. soil pH, extractable phosphorus and P - uptake (Table 3). Application of fertilizers at different rates significantly reduced the pH of the soil. While the phosphorus uptake by plants ($p < 0.05$) was significantly increased. The highest uptake was observed (7.26 mg kg^{-1}) in the treatment receiving P_2O_5 at 120 kg ha^{-1}. The extractable P content of the soil was significantly enhanced by the application of P fertilizers. The highest P was observed in the soil receiving maximum dosage of P. Effect of different fertilizers viz. SSP and DAP was non - significant for all the soil properties studied. Increase in the soil P content by the application of P fertilizers at different levels has also been observed by various researchers (Vadhana, 2003; Kattimani, 2004; Naik, 2006). Rahim *et al*. (2010) investigated P – uptake of wheat and reported significant increase in the P – uptake by the increment in the rate of P fertilizer.

Correlation between Phosphatase enzymes and plant P – uptake

The correlation between acid phosphatase enzymes and P uptake in the pots receiving single super phosphate (SSP) fertilizer showed negative correlation (r = -0.1028). This might be due to the fact that as the concentration of phosphorus in the soil increased the acid phosphate activities decreased. While in case of diammonium phosphate (DAP) positive correlation was found (r = 0.424). The correlation between alkaline phosphatase activity and P – uptake as affected by the SSP and DAP fertilizers was non - significant with r =0.478 and r = 0.0031, respectively (Figure 3, 4, 5 and 6).

Table 3: Effect of different fertilizers at various rates on soil pH, P – uptake and soil P content

Treatment	pH		P – uptake (mg kg^{-1})		Phosphorus (mg kg^{-1})	
	SSP	DAP	SSP	DAP	SSP	DAP
T1 Control (No P)	8.21±0.054	8.21±0.057	5.06±0.448 c	5.57± 0.523 bc	6.11± 0.050cd	5.80±0.238 d
T2 (P_2O_5 at 30 kg ha^{-1})	8.10±0.007	8.17±0.036	6.08 ±0.623b	5.80±0.439	6.40±0.080 c	6.43±0.117 c
T3 (P_2O_5 at 60 kg ha^{-1})	8.05±0.023	8.14±0.019	6.73±0.449 ab	6.42 ±0.378 b	6.67±0.278 bc	6.52±0.124 bc
T4 (P_2O_5 at 90 kg ha^{-1})	8.01±0.035	8.10±0.033	6.35 ±0.464 b	7.19 ±0.423 a	6.69 ±0.190bc	7.04±0.3570 ab
T5 (P_2O_5 at 120 kg ha^{-1})	7.97±0.023	8.10±0.022	6.92 ±0.310 a	7.26±0.239a	7.27±0.172 a	7.10±0.290 ab
Mean	8.07±0.041	8.14±0.022	6.23±0.326	6.45±0.346^{NS}	6.62±0.195	6.58±0.235^{NS}
LSD treatment	NS		0.6799		0.582	

Means followed by different letter(s) are statistically significant at 5% probability level

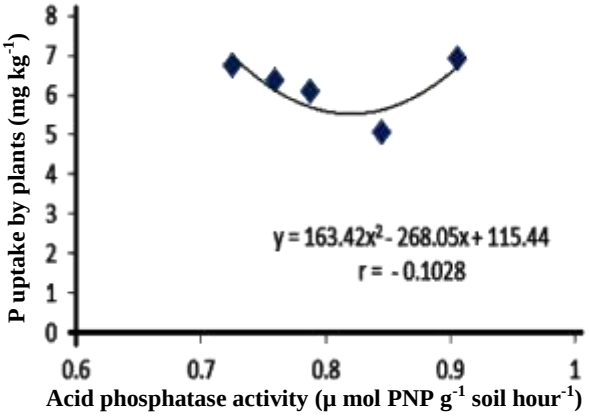


Figure 3: Correlation between acid phosphatase and P uptake as affected by SSP fertilizer

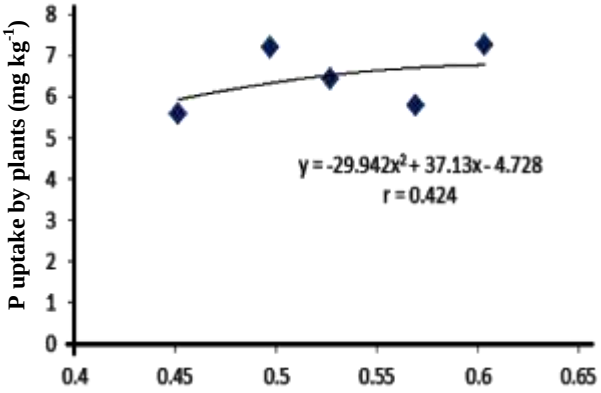


Figure 4: Correlation between acid phosphatase and P uptake as affected by DAP fertilizers

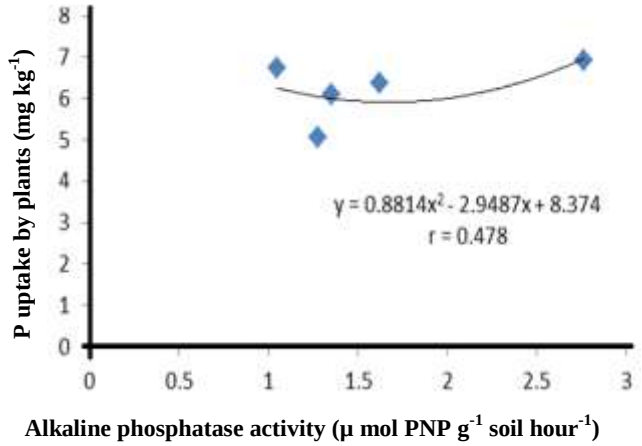


Figure 5: Correlation between alkaline phosphatase and P uptake as affected by SSP

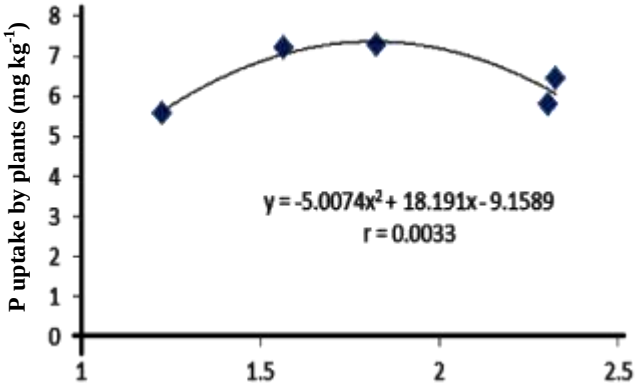


Figure 6: Correlation between alkaline phosphatase and P uptake as affected by DAP

Conclusion

It may be concluded from the study that alkaline phosphatase was non significantly influenced by the application of sources and rates of phosphatic fertilizers, however, the acid phosphatase was significantly higher in the treatments receiving SSP fertilizers as compared with the DAP. Effect of different rates of fertilizers on the soil properties showed significant effect on soil phosphorus, soil pH and P – uptake. The highest soil P content and P – uptake was found in the treatment receiving P_2O_5 at 120 kg ha^{-1}. Negative correlation between acid phosphatase activity and P – uptake showed that acid phosphatase activity is higher in the soil deficient in soil P.

References

Abou-Aly, H.E., M.A. Mady amd S.A.M. Moussa. 2006. Interaction effect between phosphate dissolving micro-organisms and boron on squash (*Cucurbita pepo* L.) growth, endogenous phytohormones and fruit yield. The First Scientific Conference of the Agriculture Chemistry and Environment Society "Clean Environment and Safe Food". December 5-7, 2006, Cairo, Egypt.

Alam, S.M., A. Latif and Z. Iqbal. 1994. Phosphorus-zinc interaction in wheat and maize crops. p. 239-243. Proc. 4th National Congress of Soil Science. May 24-26, 1992, National Agricultural Research Centre, Islamabad.

Badiane, N.N.Y., J.L. Chotte, E. Pate, D. Masse and C. Rouland. 2001. Use of soil enzyme activities to monitor soil quality in natural and improved fallows in semi-arid tropical regions. *Applied Soil Ecology* 18: 229-238.

Bremner, J.M. 1996. Nitrogen total. p. 1085-1022. *In:* Methods of Soil Analysis Part 3. D.L. Sparks (ed).

American Society of Agronomy. Soil Science Society of America, Madison, Wisconsin, USA.

Blake, G.R. and K.H. Hartge. 1986. Bulk density by core method. p. 364–367. *In:* Methods of Soil Analysis. Part 1. A. Klute (ed.). American Society of Agronomy, Madison, Wisconsin, USA.

Cottenie, A. 1980. Soil and plant testing as a basis of fertilizer recommendations. FAO Soil Bulletin 38/2, FAO Rome, Italy.

Dick, R.P, J.A. Sandor and N.S. Eash. 1994. Soil enzyme activities after 1500 years of terrace agriculture in the Colca Valley, Peru. *Agriculture Ecosystems and Environment* 50: 123-131.

Dodor, D.E. and M.A. Tabatabai. 2003. Effect of cropping systems on phosphatases in soils. *Journal of Plant Nutrition and Soil Science* 166: 7-13.

Fisher, R.A. and F. Yates. 1953. Statistical Tables for Biological, Agricultural and Medical Research. 4th Ed. Oliver and Boyd, Edinburgh. 126 p.

Holford, I. 1989. Phosphorous behavior in soils. *Agricultural Sciences* 12: 15-20.

Kattimani, S. 2004. Response of Chilli (*Capsicum annuum* L.) to Integrated Nutrient Management. M.Sc. (Agri.) Thesis, University of Agriculture Science, Dharwad, India.

Khan, H.G.A., A. Ahmad and Awais-e-Siraj. 2010. Impact of rising prices of fertilizers on crops production in Pakistan. *Global Journal of Management and Business Research* 10(9): 55-61.

Kiss, S., M. Dracan-Bularda and D. Radulescu. 1975. Biological significance of enzymes accumulated in soil. *Advances in Agronomy* 27: 25-87.

Marschner, H. 1995. Mineral Nutrition of Higher Plants. Academic Press International, San Diego, CA, USA. 889p.

Memon, K.S., A. Rashid and H.K. Puno. 1992. Phosphorus deficiency diagnosis and P soil test calibration in Pakistan. Proceedings Seminar on Phosphorus Decision Support System, Texas, USA.

Mengel, K. and E.A. Kirkby. 2001. *Principles of Plant Nutrition*. 5th Ed. Kluwer Academic Publishers, Dordrecht. 849p.

Muhammadi, K., M. Eskandari, A. Rokhzadi and G. Heidari. 2011. Canola traits and some soil biological indices in response to fertilizer and tillage management. *American-Eurasian Journal of Agriculture and Environmental Sciences* 12: 377-383.

Nelson, D.W. and L.E. Sommer. 1982. Total carbon, organic carbon and organic matter. p. 477-539. *In:* Method of Soil Analysis, Part II, 2nd Ed. A.L. Page, R.H. Miller and D.R. Keenay (ed.). American Society of Agronomy, Madison, Wisconsin, USA.

Naik, T. 2006. Studies on Organic Chilli Production. M.Sc. (Agri.) Thesis. University of Agricultural Science, Dharwad, India.

Naeem, N., I. Muhammad, J. Khan, G. Nabi, N. Muhammad and N. Badshah. 2002. Influence of various levels of nitrogen and phosphorus on the growth and yield of chilli (*Capsicum annum* L.). *Asian Journal of Plant Science* 1: 599-601.

Olsen, S.R., C.V. Cole, F.S. Watanabe and L.A. Dean. 1954. Estimation of available phosphorous in soil by extraction with sodium bicarbonate, USDA Circular. 939.

Rahim, A., A.M. Ranjha, Rehmatullah and E.A. Warraich. 2010. Effect of phosphorus application and irrigation scheduling on wheat yield and phosphorus use efficiency. *Soil & Environment* 29: 15-22.

Rahman, M.A., M.M. Rahman, M.F. Begum and M.F. Alam. 2012. Effect of bio compost, cow dung compost and NPK fertilizers on growth, yield and yield components of chilli. *International Journal of Biosciences* 2: 51-55.

Rashid, M.T., M. Yaseen and M.S. Zia. 1994. Phosphorus availability to wheat in three calcareous soils of rice tract. p. 265-270. Proc. 4th National Congress of Soil Science. May 24-26, 1992, National Agricultural Research Centre, Islamabad.

Richard, L.A. 1954. *Diagnosis and Improvement of Saline and Alkaline Soils*. USDA Agric. Handbook 60. Washington, D.C., USA.

Ryan, J., G. Estefan and A. Rashid. 2001. *Soil and Plant Analysis*. Laboratory Manual. International Centre for Agricultural Research in the Dry Areas. Aleppo, Syria.

Saggar, S., M.J. Hedley, R.E. White, K.W. Perrott, P.E.H. Gregg, I.S. Cornforth and A.G. Sinclair. 1999. Development and evaluation of an improved soil test for phosphorus, 3: field comparison of Olsen, Colwell and Resin soil P tests for New Zealand pasture soils. *Nutrient Cycling in Agroecosystems* 55: 35-50.

Saha, S., B.L. Mina, K.A. Gopinath, S. Kundu and H.S. Gupta. 2008. Relative changes in phosphatase activities as influenced by source and application rate of organic compost in field crop. *Bioresource Technology* 99: 1750-1757.

Tabatabai, M.A. 1994. Soil enzymes. p. 775-833. *In:* Methods of Soil Analysis. Part 2. Microbiological and Biochemical Properties. R.W. Weaver, S. Angle, P. Bottomley, D. Bezdieck, S. Smith, A. Tabatabai and A. Wollum (eds.). Soil Science Society of America, Madison, Wisconsin, USA.

Vadhana, P. 2003. Response of Green Chilli (*Capsicum annuum* L.) to Irrigation Schedule and Fertility Levels in Vertisols. M.Sc. (Agri.) Thesis. University of Agricultural Science, Dharwad, India.

Vazquez, M.M., S. Cesar, R. Azcon and J.M. Barea. 2000. Interactions between arbuscular mycorrhizal fungi and other microbial inoculants (*Azospirillum, Pseudomonas, Trichoderma*) and their effects on microbial population and enzyme activities in the rhizosphere of maize plants. *Applied Soil Ecology* 15: 261-372.