Annals of Arid Zone 48(1): 41-44, 2009

# Effect of *Chaetomium globosum* Inoculation and Organic Matter on Phosphorus Mobilization in Soil and Yield of Clusterbean

B.K. Yadav[1], Ram Niwas[1], R.S. Yadav[2] and J.C. Tarafdar[1]

[1] *Central Arid Zone Research Institute, Jodhpur 342 003, India*

[2] *Main Wheat Research Station, SDAU, Vijapur 382 870, India*

**Abstract:** Greenhouse experiment was conducted to study the effect of organic matter (OM) and *Chaetomium globosum* on enzyme activities, nutrient uptake and yield of clusterbean. The OM gradient (1% and 3%) was created by application of vermicompost to a sandy soil. In general 1.7% more decline in pH and 18% more increase in EC was observed due to inoculation of *C. globosum* in presence of OM. As compared to control soil, the enhancement of acid phosphatase activity was observed up to 35% with OM alone and 50% when OM was combined with *C. globosum*. The increase in alkaline phosphatase activity was 12% more due to inoculation of *C. globosum* in OM compared to application of only OM. Increase in phytase activity was 71% more in OM treatment with *C. globosum*, which was 15% higher than application of OM alone. In general 6%, 23% and 10% more N, P and K accumulated in plant with *C. globosum* in presence of OM as compared to no inoculation. The seed yield of clusterbean increased by 7.4% with *C. globosum* in the presence of high level of OM.

**Key words:** Organic manure, *Chaetomium globosum*, acid and alkaline phosphatase, phytase, nutrient content, clusterbean.

Clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.) is mainly grown under rainfed conditions of Rajasthan. The grain yield of the crop in arid soils is low because of low and erratic rainfall distribution and poor soil fertility, besides low availability of P. A large proportion of P that is applied to soil as fertilizer rapidly becomes unavailable to plants, accumulating in inorganic P fractions that are fixed by chemical adsorption and precipitation, and organic P fractions that are immobilized in soil organic matter (Sanyal and De Datta, 1991). About 20-30% of total P in the arid soils of Western Rajasthan of India is organic in nature (Tarafdar and Gharu, 2005) and 68% of the organic P in the soil is present as phytin (Tarafdar and Gharu, 2005). These organic P compounds must be hydrolyzed by phosphatases before their availability to plants. The ability of soil fungi to solubilize various forms of P is well known (Tarafdar and Gharu, 2005; Yadav and Tarafdar, 2007). *Chaetomium globosum* was found to be an efficient phosphatase and phytase releasing organism to exploit native P from arid soils (Tarafdar and Gharu, 2005). The present paper describes the effect of *Chaetomium globosum* on activities of root released enzymes, nutrient content and yield of clusterbean in a sandy soil at different OM levels.

## Materials and Methods

The soil used under the study was loamy sand (hypothermic typic haplocambids) collected from Research Farm of Central Arid Zone Research Institute, Jodhpur (Latitude 26°18′N, Longitude 73°01′E), Rajasthan. The characteristics of the experimental soil were: sand-85.5%, silt-9.5%, clay-4.5%, pH-8.2, EC-0.18 dS $m^{-1}$, organic carbon 0.18%, total P-1261 mg $kg^{-1}$, organic P-367 mg $kg^{-1}$, available P-8.3 mg $kg^{-1}$. Pot experiment was carried out during kharif 2006 with five treatments: ($T_1$) – control (0.2% OM); ($T_2$) - 1% OM; ($T_3$) - 1% OM + *C. globosum*; ($T_4$) - 3% OM; ($T_5$) - 3% OM + *C. globosum*. The source of OM used was vermicompost (pH-7.1, EC-0.80 dS $m^{-1}$, OM-14%, total N-0.45%, total $P_2O_5$-1.28% and total $K_2O$-0.34%) @ 0.4 kg and 1.2 kg $pot^{-1}$ for 1% and 3% OM gradient. The OM build up in pots was checked once in 15 days and the clusterbean seed was sown after two months when reached to a constant value. Twelve pots with 4 kg soil were used for each treatment with three replications.

The clusterbean seeds were surface sterilized with acidified 0.05% $HgCl_2$ for 2 minutes thereafter 5 to 6 times washed with sterilized deionized water. The inoculation with *C. globosum* was carried out in the slurry of carrier-based culture in sterilized (20%) jaggery (gur) solution and seeds were treated with *C. globosum* (100 g $kg^{-1}$ seed), dried under shed (to avoid direct sun rays) and sown immediately. For uninoculated treatment seed was inoculated with sterilized culture of the same amount (100 g $kg^{-1}$ seed). Ten seeds were sown in each pot; four seedlings were maintained after germination. The pots were watered to 50% water holding capacity every second day. The pots were completely randomized and re-positioned weekly to minimize effect of environmental factors. The soil and plant sampling was done at 28, 42, 56 and 70 (crop harvest) days after germination.

After each harvest plants were thoroughly washed free of soil, dried at 60°C and weight of dry matter was recorded. Plant N, P and K contents were analyzed by standard procedures (Gupta, 2000). Before analysis of enzyme activities of rhizosphere soil, any discernible root pieces were removed and the samples were sieved through 2 mm sieve. Total and organic P was estimated as described by Seeling and Jungk (1996). Organic carbon, pH (1:2), EC (1:2), soil texture and available P (Olsen's) was estimated following standard methods described by Gupta (2000).

Acid and Alkaline phosphatases were assayed by adopting the method of Tabatabai and Bremnar (1969) using acetate buffer (pH 5.4) and sodium tetra borate-NaOH buffer (pH 9.4), respectively. Phytase activity was assayed by measuring the amount of inorganic phosphate (Pi) released by hydrolysis of sodium phytate (1 mM) in 100 M sodium acetate buffer (pH 4.5) and incubated at 37°C for 1 h (Ames, 1966). The data were subjected to analysis of variance as described by Panse and Sukhatme (2000).

## Results and Discussion

The pH of the soil decreased with increase in level of OM and crop age. The decrease in soil pH ranged between 2.6 to 4.9% with 1% OM and 5.4 to 6.7% with 3% OM (Table 1) and inoculation with *C. globosum* decreased the soil pH up to 7.5%, as compared to control soil. The initial decrease in pH in the presence of OM may be due to higher humic and fulvic acids in vermicompost (Zachariah and Chhonkar, 2004).The effect of *C. globosum* on lowering of soil pH was due to the release of organic acids, such as malate, citrate and oxalate by soil fungi (Tarafdar *et al.*, 2003)

Application of OM positively influenced soil EC (Table 1), which increased between 19% to 28% due to OM and 38% to 53% when *C. globosum* was inoculated in soils having higher OM. This may be due to the production of $CO_2$ during decomposition of OM, which lowers the soil pH and causes dissolution of minerals releasing ions such as $Ca^{++}$, $Mg^{++}$ and $Na^{+}$ in soil solution (Kumar *et al.*, 2006).

Significant ($P<0.05$, n = 60) increase in acid phosphatase was observed with increase in OM content in the soil, which progressively increased with crop age up to 42 days (Fig. 1). The net increase in activity was about 1.1 to 1.4 times with 1% OM and 1.2 to 1.7 times with 3% OM compared to unamended control. Inoculation with *C. globosum* further increased the activity by 1.3 to 1.7 times. In general 34% increase in acid phosphatase activity was observed with OM alone and additional 16% after the inoculation with *C. globosum* as compared to control soil. Alkaline phosphatase activity in the rhizosphere of clusterbean increased significantly ($P<0.05$, n = 60) between 28 to 70 days period due to increase in OM content during crop age as compared to control (Fig. 1). The increase in alkaline phosphatase

*Table 1. Effect of organic matter gradient and Chaetomium globosum on soil pH and electrical conductivity*

| Treatments | pH | | | | EC (dS $m^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | Days after germination | | | | Days after germination | | | |
| | 28 | 42 | 56 | 70 | 28 | 42 | 56 | 70 |
| Control (0.2% OM) | 8.09 | 8.06 | 8.04 | 8.04 | 0.14 | 0.15 | 0.16 | 0.15 |
| OM (1%) | 7.88 | 7.70 | 7.67 | 7.65 | 0.15 | 0.19 | 0.21 | 0.20 |
| OM (1%) + *C. globosum* | 7.60 | 7.55 | 7.50 | 7.48 | 0.17 | 0.23 | 0.25 | 0.22 |
| OM (3%) | 7.65 | 7.58 | 7.55 | 7.50 | 0.18 | 0.20 | 0.22 | 0.21 |
| OM (3%) + *C. globosum* | 7.58 | 7.50 | 7.47 | 7.47 | 0.22 | 0.24 | 0.27 | 0.24 |
| LSD (P = 0.05) | 0.19 | 0.32 | 0.34 | 0.30 | 0.01 | 0.02 | 0.03 | 0.03 |

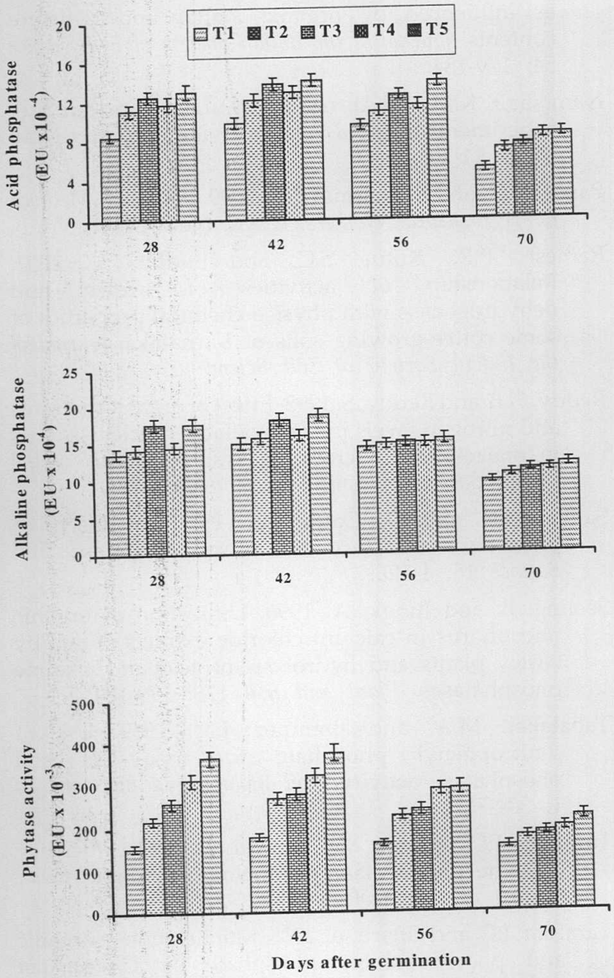


*Fig. 1. Enzyme activities of rhizosphere soil at different plant age. Vertical bar represent the LSD (P = 0.05).*

activity was more (12%) due to inoculation of *C. globosum* as compared to application of only OM. The phytase activity significantly ($P<0.05$, n = 60) increased with increase in level of OM and crop ageing up to 42 days (Fig. 1), which ranged between 1.1 to 1.5 times with 1% OM and 1.3 to 2.1 times with 3% OM. In general phytase activity increased by 71% in OM plus inoculation with *C. globosum*, whereas 56% higher activity was observed with OM alone as compared to control. Soil enzyme activities increased with increase in OM content (Zachariah and Chhonkar, 2004). Addition of OM stimulated the root growth and activity of microorganisms (Reddy and Reddy, 1998). Phosphatase and phytase may be released by both plant roots, as well as microorganisms (Tarafdar *et al.*, 2002; Yadav and Tarafdar, 2004). Inoculation of *C. globosum* significantly increased the enzyme activities because OM is known to increase the microbial population and their activity (Ramesh *et al.*, 2003).

Nitrogen content in clusterbean was increased by 13.8% with OM alone as compared to control, and it was further increased to 20.5% more with OM plus inoculation with *C. globosum* (Fig. 2). The plant P content was increased by 2.4 times and 3.0 times with OM alone and inoculation with *C. globosum* plus OM, respectively, compared to control (Fig. 2). On an average 23% more plant P uptake was recorded with *C. globosum* combined with OM as compared to OM alone. The K uptake was 1.2 times higher in OM and 1.3 times higher in OM plus inoculation with *C. globosum* than control (Fig. 2).

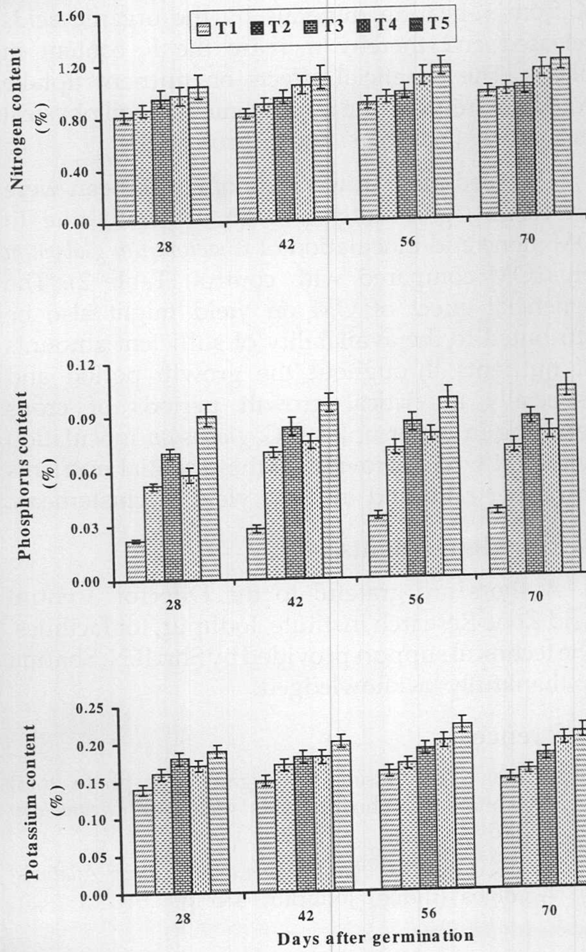


*Fig. 2. Nutrient content of clusterbean at different plant age. Vertical bar represent the LSD (P = 0.05).*

*Table 2 Grain and straw yield of clusterbean*

| Treatments | Yield (g $plot^{-1}$) | |
|---|---|---|
| | Grain | Straw |
| Control (0.2% OM) | 5.82 | 11.90 |
| OM (1%) | 6.33 | 13.02 |
| OM (1%) + *C. globosum* | 6.78 | 14.08 |
| OM (3%) | 6.68 | 13.78 |
| OM (3%) + *C. globosum* | 7.19 | 14.89 |
| LSD (P = 0.05) | 0.04 | 0.94 |

Increased plant N content with OM could be higher availability of N due to mineralization of organic N (Reddy and Reddy, 1998). The higher P content in clusterbean could be due to the solubilization effect of organic acids produced during decomposition of OM and improved aeration and better root proliferation (Reddy and Reddy, 1998). The increased availability of soil K by direct supply of its K and by solubilizing K from K-bearing minerals by the organic acids released and thereby increase the K content in plants. The beneficial effects on nutrient uptake could also relate to the improvement in soil physical properties (Nambiar and Abrol, 1989).

The seed and straw yields of clusterbean were increased significantly ($P<0.05$, $n = 15$) due to OM alone and inoculation of *Chaetomium globosum* plus OM compared with control (Table 2). The beneficial effect of OM on yield might also be attributed to the availability of sufficient amounts of nutrients throughout the growth period and especially at critical growth periods of crops resulting in better uptake. *C. globosum* inoculation with OM would provide all the essential nutrients in proper ratio and increase yield of clusterbean.

## Acknowledgements

Authors are grateful to the Director, Central Arid Zone Research Institute, Jodhpur, for facilities. The technical support provided by Shri B.N. Sharma is thankfully acknowledged.

## References

Ames, B.N. 1966. Assay of inorganic phosphate, total phosphate and phosphatases. *Method in Enzymology* 8: 115-118.

Gupta, P.K. 2000. *Soil, Plant, Water and Fertilizer Analysis*, Agrobios (India), Jodhpur, 438 p.

Kumar, C., Swarup, A. and Sharma, D.R. 2006. Release of ions from calcium carbonate treated alkaline soil as influenced by organic matter and moisture contents. *Journal of the Indian Society of Soil Science* 54: 179-184.

Nambiar, K.K.M. and Abrol, I.P. 1989. Long-term fertilizer experiments in India – An overview. *Fertilizer News* 34(1): 11-20.

Panse, V.G. and Sukhatme, P.V. 2000. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi, 359 p.

Ramesh, P.R., Kotur, S.C. and Sudhir, K. 2003. Relationship of activities of urease and dehydrogenase with physico-chemical properties of some coffee-growing soils of Karnataka. *Journal of the Indian Society of Soil Science* 51: 78-80.

Reddy, G.B. and Reddy, S. 1998. Effect of organic manures and nitrogen levels in soil available nutrients status in maize-soybean cropping system. *Journal of the Indian Society of Soil Science* 46: 474-476.

Sanyal, S.K. and De Datta, S.K. 1991. Chemistry of phosphorus transformation in soil. *Advances in Soil Science* 16: 1-120.

Seeling, B. and Jungk, A. 1996. Utilization of organic phosphorus in calcium chloride extracts of soil by barley plants and hydrolysis of acid and alkaline phosphatases. *Plant and Soil* 178: 179-184.

Tabatabai, M.A. and Bremner, J.M. 1969. Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biology and Biochemistry* 1: 301-307.

Tarafdar, J.C., Bareja, M., Panwar, J. 2003. Efficiency of some phosphatase producing soil-fungi. *Indian Journal of Microbiology* 43: 27-32.

Tarafdar, J.C. and Gharu, A. 2005. Mobilization of organic and poorly soluble phosphate by *Chaetomium globosum*. *Applied Soil Ecology* 32: 273-283.

Tarafdar, J.C., Yadav, R.S. and Niwas, R. 2002. Relative efficiency of fungal intra- and extra-cellular phosphatases and phytase. *Journal of Plant Nutrition and Soil Science* 165: 17-20.

Yadav, B.K. and Tarafdar, J.C. 2004. Phytase activity in the rhizosphere of crops, trees and grasses under arid environment. *Journal of Arid Environments* 56: 285-293.

Yadav, B.K. and Tarafdar, J.C. 2007. Ability of *Emericella rugulosa* to mobilize unavailable P compounds during pearl millet (*Pennisetum glaucum* L.) crop under arid condition. *Indian Journal of Microbiology* 41: 57-63.

Zachariah, A.S. and Chhonkar, P.K. 2004. Biological properties of compost as influenced by earthworm and feed materials. *Journal of the Indian Society of Soil Science* 52: 155-159.