

Effect of long term manure and fertilizer application on availability of phosphorus and its fraction in long term fertilizer experimental field under finger millet-maize cropping system in Karnataka

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ABSTRACT

AICRP on long-term fertilizer experiment ie finger millet-maize cropping system was initiated at the Zonal Agricultural Research Station, GKVK, UAS, Bengaluru during 1986-87. Incorporation of organic and inorganic fertilizers resulted in significant variation of available phosphorous and its fractions as compared to control. Growing of finger millet-maize cropping sequence continuously over the years with the use of inorganic fertilizers and farm yard manure markedly increased available P content of soil over the control. There was a considerable build up of available phosphorus (194.06 kg/ha), aluminium bound phosphorus (118.52 kg/ ha), iron bound phosphorus (167.55 kg/ha), occluded phosphorus (85.74 kg/ ha), calcium bound phosphorus (87.15 kg/ha) and total phosphorus (568.85 kg/ha) at application of higher dose of phosphorus.

Keywords: Long term; available P; fractions; finger millet-maize; cropping sequence

INTRODUCTION

In Indian agriculture improving and maintaining soil fertility are of paramount importance to meet the demands of food grain production for an ever increasing population in the country. Good soil fertility management ensures adequate nutrient availability to plants and increases yields. The long-term fertiliser experiments (LTFEs) are invaluable for the study of yield trends,

changes in nutrient dynamics and balances, predicting soil carrying capacity, assessing soil quality, system sustainability and risk management. In India the LTFEs were established in the early seventies of the last century. Since then these experiments are assessed periodically for the changes of soil fertility or biochemical parameters. In recent years trends of soil fertility changes in many of the long term studies in India or elsewhere have been reported from

samples obtained after the crop harvest or prior to growing next crop (Manna et al 2005).

Phosphorus is classified as a major nutrient and the total phosphorus concentration in agricultural crops generally varies from 0.1 to 0.5 per cent. Phosphorus plays very important role in plant growth and is found in every living plant cell. It is involved in several key plant functions such as energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant, transfer of genetic characteristics from one generation to the next, root initiation, cell elongation etc. Phosphorus in agricultural soils originates primarily from two sources the parent material from which the soil is developed and phosphorus containing materials applied by farmers. The weathering of phosphorus from minerals such as sedimentary phosphorite and apatite can take several years and rarely releases enough phosphorus into the soil for plant uptake (Walker and Syers 1976). Slow phosphorus release from minerals necessitated farmers to add phosphorus containing materials, manures or commercial fertilizers.

Variable effects of manure and fertilizer phosphorus on different pools of soil phosphorus have been reported and they mainly depend on the rates of phosphorus applied, phosphorus removal by crops, inherent soil properties and

climatic conditions. Many researchers reported that fertilizer phosphorus and manure applied annually for many years resulted in accumulation of inorganic phosphorus and organic phosphorus fractions in the soil. The effects of fertilizer and manuring on soil phosphorus transformations also depend on soil texture. Most of the research on dynamics of soil phosphorus pools is focused mainly on soils of temperate regions and not much on the soils of other climatic regions.

MATERIAL and METHODS

The All India Coordinated Research Project (AICRP) on long-term fertilizer experiment ie finger millet-maize cropping system was initiated at the Zonal Agricultural Research Station, GKVK, UAS, Bengaluru during 1986-87. The soil of the area is classified as fine, mixed Isothermic Kandic Paleustalfs of Vijayapura series. Initial properties of soil were sand: 69 per cent, silt: 16 per cent, clay: 14 per cent, pH: (1:2.5) 6.17, electrical conductivity (EC) (1:2.5): 0.45 dS/m, CEC: 12.2 cmol (p+)/kg, soil organic carbon (Walkley-Black): 0.46 g/kg, available N: 257 kg/ha, available P: 34.3 kg/ha and available K: 123.1 kg/ha.

The treatments were planned as per the technical programme of AICRP on LTFE and consisted of 11 fertiliser treatments (T_1 : 50% NPK, T_2 : 100% NPK, T_3 : 150% NPK, T_4 : 100% NPK +

hand weeding, T₅: 100% NPK + lime, T₆: 100% NP, T₇: 100% N, T₈: 100% NPK + FYM, T₉: 100% NPK (S free), T₁₀: 100% NPK + FYM + lime, T₁₁: control) and 4 replications.

Ongoing long term fertilizer experiment was selected at GKVK, Bengaluru on finger millet-maize to investigate the levels of different fractions of phosphorus and available nutrients in soil. In total 64 soil samples were collected after the harvest of crops at 0 to 15 cm depth. Following analytical methods were used:

Available phosphorus: The collected soil samples were found acidic. Hence Bray's # 1 extractant was used for extracting available P content (1:10). The phosphorus content in the soil extract was determined by developing blue colour using ascorbic acid-molybdate complex. The colour intensity was read at 660 nm using spectrophotometer (Jackson 1973).

Estimation of phosphorus fractions: Fractions of phosphorus were divided into three active fractions and two relatively inactive fractions. The active fractions were calcium phosphate, aluminium phosphate and iron phosphate while inactive fractions included reductant soluble and occluded P (Jackson et al 1973).

Aluminium bound phosphorus (Al-P): One gram of soil was shaken with 25 ml 0.5 M NH₄F (pH 8.2) for one hour. The

suspension was centrifuged to get a clear solution. Phosphorus in the solution was determined by chloromolybdic-boric acid method using stannous chloride as reductant. The intensity of blue color developed was read in a spectrophotometer at 660 nm.

Iron bound phosphorus (Fe-P): The soil sediment in the centrifugation tube obtained after Al-P estimation was washed twice with 25 ml portion of saturated NaCl by shaking and centrifuging. The soil was then treated with 0.1 M NaOH and shaken for 17 hours and centrifuged. The supernatant was treated with five drops of concentrated H₂SO₄. Phosphorus free activated carbon was used to remove color and filtered to remove suspended organic matter. Phosphorus in the solution was determined by chloromolybdic-boric acid method using stannous chloride as reductant. The intensity of blue colour developed was read in a spectrophotometer at 660 nm

Occluded phosphorus (occl P): The soil residue left after the estimation of reductant soluble-P was added with 25 ml of 0.1N NaOH and shaken for one hour. Supernatant solution after centrifugation was taken for estimation of occl-P. Phosphorus in the solution was determined by chloromolybdic-boric acid method using stannous chloride as reductant.

Calcium bound phosphorus (Ca-P): The soil sample after extraction of occl-P was

Table 1. Effect of long term manure and fertilizer application on fractions of phosphorus (avail P, Al-P and Fe-P) in soil under finger millet–maize cropping system

Treatment	Avail P (mg/kg)	Al-P (mg/kg)	Fe-P (mg/kg)
T ₁ : 50% NPK	21.73	65.25	76.56
T ₂ : 100% NPK	48.41	96.91	115.77
T ₃ : 150% NPK	74.23	118.52	167.55
T ₄ : 100% NPK + hand weeding	46.01	91.67	119.75
T ₅ : 100% NPK + lime	49.19	91.44	105.82
T ₆ : 100% NP	53.41	92.89	102.62
T ₇ : 100% N	5.37	22.11	30.32
T ₈ : 100% NPK + FYM	94.10	76.85	84.65
T ₉ : 100% NPK (S free)	46.05	94.39	115.11
T ₁₀ : 100% NPK + FYM + lime	96.54	64.85	81.95
T ₁₁ : control	6.56	24.00	33.92
SEm±	0.85	1.26	1.55
CD _{0.05}	2.46	3.66	4.49

Avail P = Available phosphorus, Al-P = Aluminium bound phosphorus, Fe-P = Iron bound phosphorus

washed twice with 25 ml saturated NaCl and washings were discarded after centrifuging. Ca-P was extracted by using 0.25 M H₂SO₄, shaking for one hour and centrifuging for five minutes. Supernatant solution after centrifugation was taken for estimation of the calcium bond phosphorus in the solution and determined by chloromolybdic-boric acid method using stannous chloride as reductant.

Total phosphorus (total P): One gram of 0.5 mm sieved soil was weighed and transferred to a 300 ml platinum crucible; 30 ml of 60 per cent HClO₄ was added and digestion was carried out on sand bath at 130°C till the dense fumes of HClO₄ evolved. When digestion was completed the flask was removed and cooled. 50 ml of

distilled water was added to the flask and solution was filtered into a 100 ml volumetric flask and volume was made with distilled water. An aliquot from this was used for estimation of total P by using vanodomolybdophosphoric acid reagent and the intensity of yellow colour was read at 470 nm in spectrophotometer (Jackson 1967).

RESULTS and DISCUSSION

The results of different fractions of phosphorus viz Al-P, Fe-P, occl P, Ca-P and total P are presented in Table 1 and 2.

Available phosphorus: The higher available phosphorus content of soil was recorded in treatment that was supplied with

100 per cent NPK + FYM + lime (T_{10}), followed by 100 per cent NPK + FYM (T_6). Increased available P status of soils could be attributed to application of NPK along with FYM that might prevent the precipitation of phosphorus. Similar observation was made by Sudhir et al (1998). Continuous liming reduced the acidity to a greater extent by neutralizing Fe and Al hydroxides thereby releasing P from such oxides. Removal of labile P by the crops in soil was not nourished by the addition of P from external sources that might be the reason for significant reduction in available P content of the soil in plots treated with only N and also in control plots (Srivastava 1990).

Aluminium bound phosphorus (mg/kg):

The higher Al-P content of soil was recorded in treatment that was supplied with 150 per cent NPK (T_3) followed by 100 per cent NPK, S free (T_9) it ranged from 22.11 to 118.52 mg/kg which indicated strong effect of fertilization on this form of phosphorus. The variation of Al-P in soil might be due to higher levels of fertilizer application, higher sesquioxides content and low pH. Relative increase of Al-P indicated the strong effect of fertilization on this form of phosphorus (Amaizah et al 2012).

Iron bound phosphorus (mg/kg): The iron phosphorus content of soil ranged from 30.32 to 167.55 mg/kg. Higher Fe-P content recorded in 150 per cent NPK (T_3) treated treatment might be due to higher

organic carbon content which helped in release of organic acids which solubilizes iron to ferrous form along with phosphates resulting in precipitation of ferrous phosphate. These results are similar to the findings of Sharma (1980) who concluded that Fe-P was significantly lower in control, 100 per cent N and 100 per cent NPK + lime treatments.

Occluded phosphorus (mg/kg):

The occluded phosphorus fraction content was found to be lower than Al-P and Fe-P. The higher occl P content of soil was recorded in treatment that was supplied with 150 per cent NPK (T_3) followed by 100 per cent NPK, S free (T_9). Long term application of fertilizer might have resulted in increase of occluded P content of soil probably due to irregularities in the fertilizer application and crop uptake. These results are in conformity with the findings of Krishnamoorthy and Kothandaraman (1978).

Calcium bound phosphorus (mg/kg):

The higher Ca-P content of soil was recorded in treatment that was supplied with 100 per cent NPK + FYM + lime (T_{10}) followed by 100 per cent NPK + lime (T_5) which was mainly because of application of lime along with FYM while the lower content of Ca-P was recorded in T_7 (100% N) and it might be due to lower pH. The content of Ca-P was lesser than Fe-P, Al-P and occl P. It can be inferred that the low content of Ca-P in the

Table 2. Effect of long term manure and fertilizer application on fractions of phosphorus (occl P, Ca-P and total P) in soil under finger millet-maize cropping system

Treatment	Occl P (mg/kg)	Ca-P (mg/kg)	Total P (mg/kg)
T ₁ : 50% NPK	35.92	30.96	347.48
T ₂ : 100% NPK	63.45	53.10	498.78
T ₃ : 150% NPK	85.74	76.04	568.85
T ₄ : 100% NPK + HW	65.01	58.12	504.30
T ₅ : 100% NPK + lime	66.27	81.20	501.50
T ₆ : 100% NP	66.54	61.22	498.72
T ₇ : 100% N	27.08	19.84	133.33
T ₈ : 100% NPK + FYM	65.55	63.72	551.57
T ₉ : 100% NPK (S free)	69.94	55.55	488.02
T ₁₀ : 100% NPK + FYM + lime	53.65	87.65	563.70
T ₁₁ : control	27.67	23.54	152.42
SEm±	0.92	0.91	7.14
CD _{0.05}	2.67	2.64	21.71

Occl P= Occluded phosphorus, Ca-P= Calcium bound phosphorus, Total P= Total phosphorus

surface soil may be due to low soil pH. Increase in fixation of added phosphorus as Ca-P by liming was also reported by Amarsiri and Olsen (1973).

Total phosphorus (mg/kg): The total P content of surface soils was higher in the treatments with phosphorus application than the treatment without phosphorus. The higher total P content might be due to higher application of fertilizer, higher amount of oxides of iron, aluminium and organic carbon content which are effective immobilizers of applied and native P in the soil. Similar results were also reported by Scherer and Sharma (2002) in a long term fertilizer field

experiment after 38 years of manuring and they concluded that continuous addition of inorganic fertilizers and amendments resulted in increased total P (P_t) content of soil in all the treatments compared with the original soil.

CONCLUSION

Among phosphorus fractions the treatment T₃ (150 per cent NPK) application had higher phosphorus fractions compared to all other treatments under finger millet-maize cropping systems. Higher total phosphorus content was observed in 150 per cent NPK and 100 per cent NPK + FYM + lime applied treatment.

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