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Effect of Added Phosphorous and Organic Matter on the Availability of Phosphorous Fractions in Normal Soil under Field Capacity Moisture Tension

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An Incubation study was conducted from January 2020 – May 2020 under "Laboratory conditions" at the Department of Soil Science and Agricultural Chemistry, Chandra Shekhar Azad Kanpur University of Agriculture and Technology, (U.P.) to study the "Effect of added phosphorous and organic matter on the availability of phosphorous fractions in normal soil under field capacity moisture tension". To obtain a different fraction of phosphorus under the field capacity regime all three experiments were conducted under kankar soil conditions to determine Ca-P, Al-P and Fe-P as influenced by six different treatments. The results showed that with advancement in time of incubation, the availability of Ca-P (308.2 ppm and 235.3 ppm at 0 days and 90 days of incubation

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period, respectively), Al-P (89.5 ppm and 44.9 ppm at 0 days and 90 days of incubation period, respectively), while Fe-P (13.8 ppm and 13.1 ppm at 0 days and 90 days of incubation period, respectively) increased marginally at field capacity in kankar soil condition. Sunhemp (T_2) proved more beneficial than FYM (T_3) in increasing Fe-P, Al-P, and Ca-P as also Olsen's P content in the soil. Therefore, the application of organic matter either in the form of sun hemp with phosphorus proved very useful in improving the avoidable content of the soil.

Keywords: Field capacity; incubation period; organic matter; phosphorous.

1. INTRODUCTION

Phosphorus (P) is essential for plants and animals because of its role in vital life processes, such as in photosynthesis in plants and energy transformations in all forms available to crops. Thus, unless the soil contains an adequate amount of plant-available P or is supplied with readily available-(inorganic)-P fertilizers, crop growth will suffer [1]. Although P is one of the most important Factors to limit soil ecosystem productivity [2]. Phosphorus has been called the bottleneck of the world's hunger. This is true for large parts of the world, particularly Australia and South Africa where the crop production is. Limited over the enormous area by phosphate supply, Colling has stated as follows, "Low crops yield are more often due to lack of phosphoric acid than due to lack of any other nutrients". Phosphoric acid has often been called the 'Master Key' to agriculture. Phosphorus has been attributed to a role in the further plant growth processes: Carbohydrate breakdown for energy release, Cell division, Transfer of inherited characteristics, Stimulation of early root growth and development Hastening maturity of plant Fruiting and seed production, and Energy transformation.

In a statistical study by IARI, with data on more than 8 million soil tests, it was found that the available phosphorus status of the soil of 363 districts of India, comprising about 46.3% of districts, that are low in the category, 51.5% constitute the medium category and only 2.2% shows the high category of P level in the soil. Thus, 98% of cultivated soils in India need P fertilizers for an efficient production level. The lower halves of the Ganga -Yamuna and Ganga-Gomti doabs right up to Azamgarh districts are the worst affected districts. The salts, found, cause physical deterioration by destroying soil structure and reducing permeability, besides increasing soil pH, and making nutrients unavailable. Saline-Alkali soils are characterized by high pH and appreciable $CaCO_3$ content, but poor in organic carbon. An excess of Na^+ has an antagonistic effect on the absorption of Ca and Mg^+ and thereby may have a depressing effect on the availability of phosphorus.

The word transformation refers to the conversion and inter-conversion of one form of phosphorus into another form. This inter-conversion in phosphorus was found mostly in inorganic forms. The transformation of phosphorus is greatly related to the fixation and availability of phosphorus in soil and therefore, serves as a guide for suggesting a successful P fertilization programmed for a given area. This fact emphasizes the study of inorganic phosphorus in soil. The transformation of inorganic P is observed mostly in solid-P, Al-P, Fe-P and Ca-P forms, respectively.

The availability of phosphorus is influenced by various factors viz. physicochemical properties of soil, moisture, temperature, organic matter, pH, lime, incubation period etc. Phosphorus availability would be of paramount importance in working out successful phosphorus fertilization in particular soil types in the region. Phosphorus uptake is enhanced by the Addition of organics due to the production of organic acids which in turn, transform P from Non-utilizable form to plant utilizable form [3]. Thus, the incorporation of FYM improves soil health and crop yield [4].

2. MATERIALS AND METHODS

The experiment was conducted from January 2020 – May 2020 at the experimental field, Department of Entomology, C.S.A. University of Agriculture and Technology, Kanpur Nagar (U.P.). An Incubation study was conducted from January 2020 – May 2020 under the "Laboratory conditions" Department of Soil Science and Agricultural Chemistry.

The soil collected directly from the field from a depth of 0-20cm with the help of Kudali were dried, crushed and passed through a 2 mm sieve after homogenizing the whole material for evaluating inorganic P fraction at different

interval (0, 15, 30, 60 and 90 days). It was mixed thoroughly to make it homogeneous before use. The mechanical composition of the soil is sand 58.3% in normal soil silt 25.4% clay 12.2% and silty loam of textural class. The physical and chemical properties of the used soil as p^h 7.7 EC 0.7 dsm $^{-1}$ exchangeable ca++,k++,mg++ according to 8.5, 1.42, 2.51& EC 9.8 c mol kg^{-1} by Jackson method employ [5,6]. Field capacity is 22.42 %, by Piper [7], and organic carbon is 0.4 % by Walkley and Black,[8]. Total nitrogen 0.44 kg/ha by Jackson, [9], available major nutrient as N 180 kg by Subbiah and Asija [10] and available P 13.0 kg/ha by Olsen et.al [11] method and available Ca- P, Al-P and Fe-P of 272,70.7 & 12.2 ppm used employed method by Jackson,1957.

An incubation study was carried out to obtain the objectives of the present investigation at C.S. Azad University of Agriculture and Technology, Kanpur from Jan. 2020-May 2020 under laboratory conditions. To obtain a different fraction of phosphorus under field capacity, all three experiments were conducted in kankar soil conditions to determine Ca-P, Al-P and Fe-P as influenced by different treatments. The experiment comprises six treatments. Gas control (T1), Sun hemp 10 tones/hr(T2), FYM@10 to/ha (T3), 100ppm phosphorus (T4), 100 ppm phosphors + sun hemp(T5) and 100ppm phosphors+ FYM(T6) Moisture at field capacity condition were maintained in all the 6 experiments. Field capacity condition was maintained by weighing the beaker and adding loss of water every day. 50g of well-ground soil was kept in a 500ml beaker. Organic matter (through FYM and Sunhemp) @ 10 tonnes ha^{-l} was incorporated in respective beakers and inorganic P was added through KH_2PO4 solution @ 100 ppm. Soil samples were collected with the help of a stainless-steel spatula after homogenizing the whole material for evaluating inorganic P fraction at different intervals (0, 15, 30, 60, and 90 days).

3. RESULTS AND DISCUSSION

3.1 Availability of Ca-P Fraction

Observation presented in the Table showed that the addition of organic matter either in the form of FYM or Sunhemp (*C. juncea*) increases the Availability of Ca-P. The availability of Ca-P was observed to have further enhanced when organic matter (Sunhemp or FYM) was supplemented with phosphorus. Application of phosphorus alone, however, did not have a significant effect on the increase of Ca-P. Among organic materials, Sunhemp (*C. juncea*) appeared to be more effective than FYM in improving the Ca-P content of the soil. Observation further revealed that irrespective of the incubation period, the maximum available Ca-P to the extent of 308 ppm was noted in the treatment T_5 followed by T_6 with a value of 295. With the advancement of the incubation period, Ca-P decreased in all treatments significantly. The lowest content of Ca-P was recorded in the T_1 control (243 ppm). The maximum value of Ca-P to the extent of 357 ppm was recorded on the first day of incubation in treatment T_5 followed by the T_6 value being 336 ppm. Irrespective of treatment, available Ca-P was maximum i.e., 308.2 ppm at the first day of incubation and was lowest at the 90th day of incubation (235.3 ppm). These results are by the findings of Saha et al., [12], Zhao et al., [13] and Meena et al., [14].

3.2 Availability of Al-P Fraction

Results presented in Table 2 clearly showed that the incorporation of organic matter either in the form of Sunhemp or FYM increased Al-P significantly, with Sunhemp being more effective than FYM. It was further observed that the application of phosphorus either alone or in combination with organic matter enhanced Al-P content significantly over control. The maximum Al-P content, irrespective of the incubation period, was recorded under treatment T_5 (80.9ppm) followed by T_6 (76.3ppm). Observation further revealed that with an increase in the incubation period, Al-P content invariably decreased in all treatments including control. The maximum Al-P content to the level of 105.5 ppm was noted on the initial day of incubation in the treatment T_5 followed by T_6 (100.2 ppm). Irrespective of the treatment available Al-P was maximum to the extent of 89.5ppm at the initial day of incubation which gradually decreased to the minimum value of 44.9 at the end of the 90th day of incubation. These results are in confirmation with findings of Bhattacharya et al., [15], Pal et al., [16], Patel et al., [17] and Dotaniya et al., [18].

3.3 Availability of Fe-P Fraction

Observation recorded in Table 3 showed a substantial increase in the availability of Fe-P due to the application increase of either Sunhemp or FYM when supplemented with or without phosphate. Right from the start

incubation period, Maximum available Fe-P content was recorded under T_5 (16.0 ppm) followed by T_6 (15.7 ppm). This trend continued till the 90th day of the incubation period. The lowest mean value of Fe-P content to the extent treatment T_1 (control). Fe-P (9.3 ppm) was recorded under treatment T_1 (control). A scrutiny of the data presented in the table further revealed that the concentration of Fe-P, irrespective of treatments, slightly decreased on the 15th day of incubation over initial value which afterwards gradually increased up to the 90th day of incubation period. Maximum Fe-P content to the level of 16.0 ppm was recorded under treatment T_5 followed by treatment T_6 (15.7 ppm). Irrespective of treatments, available Fe-P was maximum to the level of 13.8 ppm on the initial day while the lowest of 10.6 ppm was recorded on the 15th day of incubation. These results conform with the finding of Von Wandraszka [19], Mishra [20] and Mitran et al.,[2]

3.4 Available Phosphorous

Results presented in Table 4 indicated the beneficial effect of organic matter on enhanced content of Olsen's 'P. Significantly increased content of Olsen's 'p' was perceptible when soil was mixed with phosphorus. Available 'P' content further increased when phosphorus was mixed with organic matter, Sunhemp being more effective than FYM. The maximum content of Olsen's 'P' to the extent of 19.3ppm was recorded on the initial day in the treatment T_5 followed by T_6 (18.4 ppm) which maintained its increase with the advancement of the incubation

Table 1. Effect of added phosphorus and organic matter on the availability of Ca-P fraction in normal soil at field capacity

Treatments	The incubation period (days)					Mean
	0	15	30	60	90	
T_1: Control	280	240	248	225	220	243
T_2: Sunhemp (10 tons ha^{-1})	299	265	275	240	238	263
T_3: FYM (10 ton ha^{-1})	290	250	261	231	228	252
T_4: 100 ppm Phosphorus	285	245	255	227	222	247
T_5: 100 ppm Phosphorus + Sunhemp	357	320	325	280	259	308
T_6: 100 ppm Phosphorus + FYM	336	309	313	270	245	295
Mean	308.2	271.5	279.5	245.5	235.3	

Table 2. Effect of added phosphorus and organic matter on the availability of Al-P fraction in normal soil at field capacity

Treatments	The incubation period (days)					Mean
	0	15	30	60	90	
T_1: Control	67.0	60.0	53.2	40.2	33.0	50.7
T_2: Sunhemp (10 tons ha^{-1})	90.3	72.0	63.2	47.3	40.0	62.6
T_3: FYM (10ton ha^{-1})	75.5	67.3	60.2	44.2	36.3	56.7
T_4: 100 ppm Phosphorus	98.5	83.0	70.2	58.3	48.3	71.7
T_5: 100 ppm Phosphorus + Sunhemp	105.5	90.3	79.3	71.3	58.3	80.9
T_6: 100 ppm Phosphorus + FYM	100.2	88.3	75.3	64.3	53.2	76.3
Mean	89.5	76.8	66.9	54.3	44.9	

Table 3. Effect of added phosphorus and organic matter on the availability of Fe-P fraction in normal soil at field capacity

Treatments	Incubation period (days)					Mean
	0	15	30	60	90	
T_1: Control	11.5	7.5	8.8	9.0	9.5	9.3
T_2: Sunhemp (10 tons ha^{-1})	13.0	8.9	9.2	9.8	11.0	10.4
T_3: FYM (10 ton ha^{-1})	12.3	8.0	9.0	9.6	10.6	9.8
T_4: 100 ppm Phosphorus	14.2	10.2	11.8	12.8	13.0	12.4
T_5: 100 ppm Phosphorus + Sunhemp	16.0	15.0	16.1	17.0	17.8	16.4
T_6: 100 ppm Phosphorus + FYM	15.7	14.2	15.3	16.1	16.8	15.6
Mean	13.8	10.6	11.7	12.4	13.1	

Table 4. Effect of added phosphorus and organic matter on the availability of Olsen 'P' in normal soil at field capacity

Treatments	Incubation period (days)					Mean
	0	15	30	60	90	
T_1: Control	6.5	8.5	10.3	11.0	6.0	8.46
T_2: Sunhemp (10 tons ha^{-1})	7.5	10.5	12.5	13.5	9.8	10.76
T_3: FYM (10 ton ha^{-1})	7.0	9.5	11.5	12.5	8.7	9.84
T_4: 100 ppm Phosphorus	17.8	20.2	22.3	24.7	22.3	21.46
T_5: 100 ppm Phosphorus + Sunhemp	19.3	23.5	25.6	27.6	25.6	24.32
T_6: 100 ppm Phosphorus + FYM	18.4	22.3	24.2	26.7	24.5	23.22
Mean	12.75	15.75	17.7	19.3	16.15	

period to the extent of 27.6 ppm and 26.7 ppm respectively till 60th day. These values, however, declined on the 90th day to 25.6 ppm and 24.5 ppm in the treatment T_5 and T_6 respectively. Irrespective of treatments the initial value of Olsen's 'P' to the extent of 12.75 ppm increased to a value of 19.3 ppm on the 60th day which subsequently decreased to a value of 16.15 ppm. This is consistent with the finding of Trivedi et al. [22], Meena et al. [14] and Krishna et al. [23], [24].

4. CONCLUSION

Based on a laboratory experiment, it was concluded that with advancement in time of incubation the attainability of Al-P, and Ca-P decreased under field capacity while Fe-P either increased marginally at field capacity in kankar soil condition. Application of organic matter either in the form of Sunhemp or FYM along with phosphorus proved very useful in improving the available-P content of the soil. Sunhemp proved more beneficial than FYM in increasing Fe-P, Al-P, and Ca-P as also Olsen's P content in the soil. Application of phosphorus alone produced a significant effect on Al-P, Fe-P as also on Olsen's P. Ca-P, however, did not increase significantly with the application of phosphorus. Based on experimental results it can be inferred that native as well as fertilizer phosphorus efficiency can be insured if the soil is supplemented with organic matter preferably through Sunhemp as green manuring.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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