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Effect of Continuous Use of Manures and Fertilizers on the Chemistry of Phosphate in Meadow-Chernozemic Soils of U.S.S.R.

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Long term application of organic manures and inorganic fertilizers in meadow-chernozemic soils of Kiev (U.S.S.R.) increased, total organic, inorganic and available P status of soils. 43–52% of total P was in organic form. Positive correlation (r=0.927) was found between total P and organic P. Phospholipids and nucleic acids content of these soils were markedly increased by application of manures and fertilizers. The inositol phosphates content of meadow-chernozemic soils remained unaffected under long term fertilisation.

INTRODUCTION

Rational use of manures and fertilizers helps in maintenance of soil fertility. With the intensification of agriculture, the doses of fertilizers have increased significantly. Phosphate availability and transformation studies meadow-chernozemic soils of U.S.S.R. under long term fertilization are still inadequate. Application of manures and fertilizers enriches the soil with phosphorus, as indicated by Lisoval *et al*[1], Krupskiya *et al*[2], Bakal *et al*[3] and Ginzburg *et al*[4].

Soil phosphorus consists of organic and inorganic forms. Chernozem soils are rich in organic phosphates. Sinyagin[5] reported that 30–85% of total phosphate content of chernozem soils is in the organic form. Krivonosova *et al*[6] and Lisoval *et al*[7] reported that fertilizer application has a positive effect on increasing organic phosphate content of many soils of Ukraine (U.S.S.R.). On the contrary, the work of Sinyagin[5] indicated that the organic phosphate content of soils either does not change or even decreases with the application of fertilizers.

Soil organic phosphates consist of mainly phospholipids, nucleic acids and inositol phosphate[8–13]. Besides, glycerophosphates, phosphoproteins, sugar phosphates and phosphorylated carbonic acids are also present as components of soil organic phosphates[14]. Phospholipid content in soils varies from 3.1. to 7.0 ppm P, which comes to about 0.6–0.9% of total organic phosphates. Accumulation of phospholipids in soils takes place on account of biomasses of bacteria and fungi[15]. Anderson[16] reported that

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nucleic acid content of soils ranges from 0.6 to 2.4% of total organic phosphates. Bower[17] indicated that about 40–50% of organic phosphates may be hydrolysed to inositol phosphates, 2/3 of which is inositol hexaphosphates and 1/3 mainly inositol triphosphates. Inositol hexaphosphate and pentaphosphate content in soils ranges from 15% to 56% of total organic phosphates[13, 18-20]. Many workers have reported that inositol hexaphosphates and nucleic acids are available to crop plants[21-23].

Very little attention has been paid to the study of effect of fertilizers on fractional composition of soil organic phosphates and their transformations. This study aimed at studying the effect of fertilizers on phosphate availability in meadow-chernozemic soils of U.S.S.R.

EXPERIMENTAL

Field experiment on winter wheat crop with 11 treatments and 3 replications (variety—Illichovka) was conducted in Ukrainian Agricultural Academy Experimental Farm Mitnitsa (Kiev). But the following treatments have been discussed here:

S. No.	*Treatment*
1.	Control
2.	Residual effect of compost @ 20 t/ha in the 2nd year
3.	2 + P_{55}
4.	2 + $N_{70}P_{55}K_{75}$
5.	2 + $N_{85}P_{75}K_{105}$
6.	$N_{70}P_{55}K_{75}$

Sources of N, P and K were ammonium nitrate, superphosphate and potassium salt (KCl) respectively. Soil samples were collected from two depths, namely, 0–25 cm and 25–50 cms. Soil pH was determined in water extract (1 : 2 suspension). Humus, $CaCO_3$, total N, P and K, available N, P and K were determined by the standard procedures as suggested by Sokolov[24]. Total, organic and inorganic P in soil were determined as suggested by Greb and Olsen[25], inositol phosphates and nucleic acids by Anderson[18, 26] and phospholipids by Hance and Anderson[9].

RESULTS AND DISCUSSION

Agrochemical characteristics of the soil under study are presented in Table 1. Humus content of the soil (0–25 cm depth) was 4.42%. Soil reaction was slightly alkaline (pH 7.9). The soil was low in potassium and medium in nitrogen and phosphorus content.

TABLE 1
AGROCHEMICAL CHARACTERISTICS OF THE MEADOW-CHERNOZEMIC SOIL

Soil depth (cm)	Soil pH	Humus (%)	$CaCO_3$ (%)	Total (%)			Available (ppm)		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
0–25	7.9	4.42	1.9	0.26	0.15	1.73	46	31	88
25–50	7.9	4.00	3.2	0.26	0.12	1.73	38	28	82

Long term fertilization significantly increased the total P, organic P and mineral P content in soil (Table 2)

TABLE 2
EFFECT OF FERTILIZERS ON TOTAL P, ORGANIC P AND MINERAL P AT 0–25 cms DEPTH OF MEADOW-CHERNOZEMIC SOIL (ppm)

Treatments	Total P	Organic P	Mineral P
1.	678	295	383
2.	911	472	439
3.	932	405	527
4.	820	385	435
5.	1053	487	566
6.	928	437	491

Long term application of organic manures (T_2) increased total P content of soil by 233 ppm over control (678 ppm P). Similar increase was observed in T_5 over T_4. These increments in total P are due to long term application of P along with manures and fertilizers. The amount of manures and fertilizers in a complete ten year crop rotation are 60 tons compost/ha and $N_{755}P_{710}K_{930}$. An increment of 21 ppm P was observed in treatment T_3 over T_2, which clearly indicated that long term application of P fertilizer resulted in enrichment of soil with P. A positive correlation ($r=0.668$) was observed between total P content in soil and the application of P fertilizers.

For study of P regime of a soil, it is essential to know the forms of P and their transformations under the influence of manures and fertilizers.

Our experimental results (Table 2) indicate that 43–52% of the total P in meadow-chernozemic soil are in the organic forms. Positive correlation ($r = 0.927$) was found between total P and organic P. Long term application of organic manure (60 t/ha in the rotation) increased 177 ppm organic P over control. A decrease of 67 ppm organic P was observed in plot receiving T_3 over T_2. Higher rate of P mineralization in T_3 over T_2 mainly accounted for such decrease in organic P content of soil. Treatment T_4 did

not increase organic P over T_2. Treatment T_5 increased organic P by 15 ppm over T_2. Application of only inorganic fertilizers (T_6) increased organic P by 142 ppm over control.

Like organic P, mineral P content of meadow-chernozemic soil also increased under the long term effect of manures and fertilizers. Long term application of organic manure (T_2) increased mineral P by 56 ppm over control. Treatment T_3 increased mineral P content of soil by 88 ppm over T_2. There was no effect of T_4 over T_3. It was mainly due to high uptake of P in T_4. T_5 increased mineral P by 127 ppm over T_2. Long term application of inorganic fertilizer (T_6) increased mineral P content of soil by 108 ppm over control.

The experimental data indicated that increase in total P content of meadow-chernozemic soils under the influence of long term application of manures and fertilizers was mainly on account of increase in organic P content. Results of fractionation of organic P of meadow-chernozemic soil are presented in Table 3.

TABLE 3
EFFECT OF FERTILIZERS ON PHOSPHOLIPID, NUCLEIC ACID AND INOSITOL PHOSPHATE IN 0–25 cms DEPTH OF MEADOW-CHERNOZEMIC SOIL (ppm P)

Treatment	Phospholipids	Nucleic acids	Inositol phosphates		
			Orthophosphate	Penta and hexaphosphate	Total
1.	3.8	3.7	44.5	112.5	157.0
2.	5.4	6.0	24.0	83.8	107.8
3.	5.5	4.5	38.5	107.7	146.2
4.	4.6	4.6	40.7	118.2	158.9
5.	3.9	5.2	26.1	97.5	123.6
6.	4.7	5.7	33.4	120.2	153.6

Phospholipid content of meadow-chernozemic soil varied from 3.8 to 5.5 ppm P (0.8–1.3% of total organic P). Application of superphosphate (T_3) increased phospholipid content of soil by 1.7 ppm P over control (T_1). There was no increase of phospholipid content in the plot receiving T_5 over T_4. This was mainly due to higher mineralization of organic P and higher uptake of P by wheat crop in T_5 as compared to T_4.

Nucleic acid content of meadow-chernozemic soils ranged from 3.7 to 6.0 ppm P (1.1–1.3% of total organic P). Long term application of mineral fertilizers (T_6) enriched the soil with nucleic acids by 1 ppm over control (T_1). The maximum nucleic acid content (6 ppm) was observed in the plot receiving organic manure (T_2). Reduction in nucleic acids content in the

plots receiving T_3, T_4 and T_5 as compared to T_2 was mainly due to mineralization of nucleic acids and their uptake by plants.

Inositol phosphates in meadow-chernozemic soils varied from 108 to 159 ppm P (23–52% of total organic P). Inositol phosphates content in meadow-chernozemic soils did not increase due to long term application of manures and fertilizers. Inositol penta and hexaphosphates were more in meadow-chernozemic soils than inositol orthophosphates.

Thus, increase in organic phosphates of meadow-chernozemic soils as a result of long term application of manures and fertilizers was mainly due to increase in phospholipid and nucleic acids content.

Study of kinetics of available P (Table 4) in meadow-chernozemic soil revealed that maximum available P (determined by method of Machigin) was in 0–25 cm layer in early stages of crop growth of winter wheat, minimum in flowering stage and in the end of vegetative period P increases.

TABLE 4

KINETICS OF AVAILABLE P IN MEADOW-CHERNOZEMIC SOIL (ppm)

Treatment No.	Soil depth (cm)	Available P			
		C.R.I.	Tillering	Flowering	Maturity
1.	0–25	33.0	24.0	19.5	32.0
	25–50	27.5	—	—	26.0
2.	0–25	48.5	32.0	26.5	31.5
	25–50	34.5	—	—	21.0
3.	0–25	64.5	50.0	51.0	64.5
	25–50	46.5	—	—	38.0
4.	0–25	62.5	60.5	70.5	73.5
	25–50	47.5	—	—	36.5
5.	0–25	81.5	68.0	71.0	83.5
	25–50	49.0	—	—	46.0
6.	0–25	53.0	41.0	40.5	53.5
	25–50	37.0	—	—	47.5

Maximum available P was observed in plot receiving T_5 and minimum in control plots. Available P content in meadow-chernozemic soil were found to increase with increasing doses of phosphatic fertilizer. Similar type of results have also been reported by previous workers[1–4].

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