

MINERALIZATION OF INOSITOL PHOSPHATE, PHOSPHOLIPIDS AND NUCLEIC ACIDS IN SOIL UNDER WATERLOGGED CONDITION

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Abstract

Soil samples incubated with each of potassium dihydrogen phosphate, ammonium sulphate, compost, glucose and lime under submerged condition resulted rapid mineralization of inositol phosphates, phospholipids, inositol hexaphosphate, ribonucleic acid and its derivatives, and deoxyribonucleic acid and its derivatives in the first 15 days. Mineralization was moderate in the subsequent 15 days followed by a gradual disappearance in the next 30 day incubation periods. All the treatments caused a significant mineralization of organic phosphorus compounds during every sampling in all the soils. Soil containing more organic matter and mineralizable substrates, and high pH showed greater mineralization. Liming promoted mineralization as it induced conditions for the proliferation of phosphorus transforming organisms. Decrease in solubility of exchangeable Fe and Al also helped in the hydrolysis of inositol phosphate compounds. RNA and DNA alongwith their derivatives mineralized completely in 30 days of incubation in most of the treatments.

Introduction

Organic phosphorus comprising a significant proportion of total phosphorus (Cosgrove, 1967) appears in soil, to date, as most important compounds of inositol phosphates, phospholipids, ribonucleic acid and deoxyribonucleic acid. Their amounts vary from place to place depending upon various physical and chemical factors (McKercher and Anderson, 1968) and are very much important in soil fertility as an indirect source of available forms (Bray and Kurtz, 1945). But they contribute very little to phosphorus assimilation by plants unless mineralized (Eid *et al*., 1951) which again depends

to a greater extent upon the chemical nature of phosphate compounds present in organic complexes and the environmental conditions under which the biochemical transformation takes place. Mineralization of inositol phosphate as influenced by liming and submergence was reported by Islam and Ahmed (1973) but nothing was said regarding the changes of iron and aluminium during incubation which have a close bearing with the compound; and inositol hexaphosphate during submergence (Furukawa and Kawaguchi, 1969). However, no data has yet been available as to the nature of mineralization of other organic phosphorus compounds.

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Therefore, an incubation experiment was set up to evaluate the effects of various factors on the mineralization of organic phosphorus compounds in some surface soils of Bangladesh.

Materials and methods

Samples of surface soils (0-15 cm) were collected from two tracts of Bangladesh differing in their physical and chemical properties. The samples were air-dried, ground and passed through a 100-mesh sieve. General descriptions of the samples and classification of the soils according to USDA Soil Taxonomy is presented in Table 1. Certain chemical properties of the samples are presented in Table 2.

Analytical techniques :

p^H was measured electrochemically by using a Pye glass electrode, the soil and water ratio being 1 : 2.5. Organic carbon was determined by Tinsley's wet combustion method as described by Bremner and Jenkinson (1960). The method of Metha *et al.* (1954) was used for estimating organic phosphorus. Analysis were

made by methods outlined for inositol phosphates by McKercher and Anderson (1968), phospholipids by Hance and Anderson (1963), inositol hexaphosphate by Anderson and Malcolm (1974), RNA and its derivatives by Adams *et al.* (1954), DNA and its derivatives by Anderson (1961), exchangeable iron by Olson (1965), and exchangeable aluminium by McLean (1965). N was determined by Kjeldahl method.

Incubation experiments :

Experiments were carried out to study the effect of each of moisture, potassium dihydrogen phosphate, ammonium sulphate, compost, glucose and lime on the mineralization of different organic phosphorus compounds in soil samples. 500 g of soil samples were placed in 600 ml tubes (15 cm x 7 cm, locally prepared polythene tubes). Different amounts of calcium carbonate were added to bring the p^H of the samples to 8.0. Potassium dihydrogen phosphate, ammonium sulphate, compost and glucose were each added at the rate of 45 ppm independently. Mineralization has also been

Table 1. General characteristics of the soil samples examined.

Soil Series	USDA Soil Taxonomy	General soil type	Parent material	Drainage	Texture	Colour
Harta	Histosols	Peat	Peat	Poor	Clay	Black
Naldanga	Haplaquent	NDGFS	Tista floodplain	Very poor	Silt loam	Dark grey
Paysa	Typic Haplaquoll	NDGFS	Old Meghna estuarine	Poor	Silt loam	Dark grey

NDGFS=noncalcareous dark grey floodplain soil.

studied under a submerged condition without additions of these materials. Every effort was made to keep the moisture content constant (3 cm above the surface) during incubation by the addition of distilled water whenever required. Each treatment was replicated thrice and arranged in a completely randomized design. The tubes were not covered and incubation was carried out at room temperature ($27^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$). Samples were then analyzed for net changes in inositol phosphates, phospholipids, inositol hexaphosphate, RNA and its derivatives, and DNA and its derivatives levels after 0, 7, 15, 30 and 60 days from the beginning of incubation.

Results and discussion

The net changes in organic phosphorus compounds level after 0, 7, 15, 30 and 60 days from the beginning of incubation (Fig. 1-5) showed that all the treatments caused a significant mineralization of the organic phosphorus compounds in the soil samples. Soil samples treated with only moisture caused an appreciable mineralization of all the compounds but the amount mineralized was low compared to other treatments. Hayashi and Takijima (1955) and Islam and Mandal (1977) had observed that mineralization of organic phosphorus was stimulated by higher moisture levels. Furukawa and Kawaguchi (1969) also incubated submerged paddy soil at 40°C for two weeks and observed a rapid hydrolysis of inositol hexaphosphate.

Mineralization of inositol phosphates (Fig. 1 A, B & C), phospholipids (Fig. 2 A, B & C) and inositol hexaphosphate (Fig. 3 A, B & C) showed three different trends. A rapid mineralization in the first 15 days was followed by a

moderate disappearance in the next 15 days. Then a gradual mineralization was observed in all the soils irrespective of the treatments except the effects of compost and glucose on the disappearance of inositol phosphates in Harta sample (Fig. 1A). The treatments significantly enhanced the mineralization of all these compounds. However, it is clear from Fig. 2A, B & C that lipid phosphate mineralized completely when the soils were submerged with lime in 60 days of incubation. Ammonium sulphate also caused the similar effect in Harta and Naldanga samples.

The effects of various treatments on the mineralization of ribonucleic acid (Fig. 4A, B & C) and deoxyribonucleic acid (Fig. 5A, B & C) alongwith their derivatives were significant and showed first two trends as was observed with inositol phosphates (Fig. 1A, B & C) except the effect of potassium dihydrogen phosphate where the transformation of both the acids proceeded uniformly at a faster rate in 30 days of incubation in all the soil samples (Fig. 4A, B & C and Fig. 5A, B & C). However, both the acids alongwith their derivatives mineralized completely in 30 days of incubation in all the treatments except the sample treated with only moisture. Moisture alone caused an appreciable mineralization of both the acids but 0.47 to 2.14% ribonucleic acid and 1.14 to 2.12% deoxyribonucleic acid still remained after 60 days of incubation.

Liming caused the maximum mineralization of all the organic phosphorus compounds in all the samples (Figs. 1-5). Islam and Ahmed (1973) also reported that mineralization of inositol phosphate is increased by adjusting the pH values conducive to general microbial metabolism and a shift from acidity to neutrality increases phosphorus release. McConaghy

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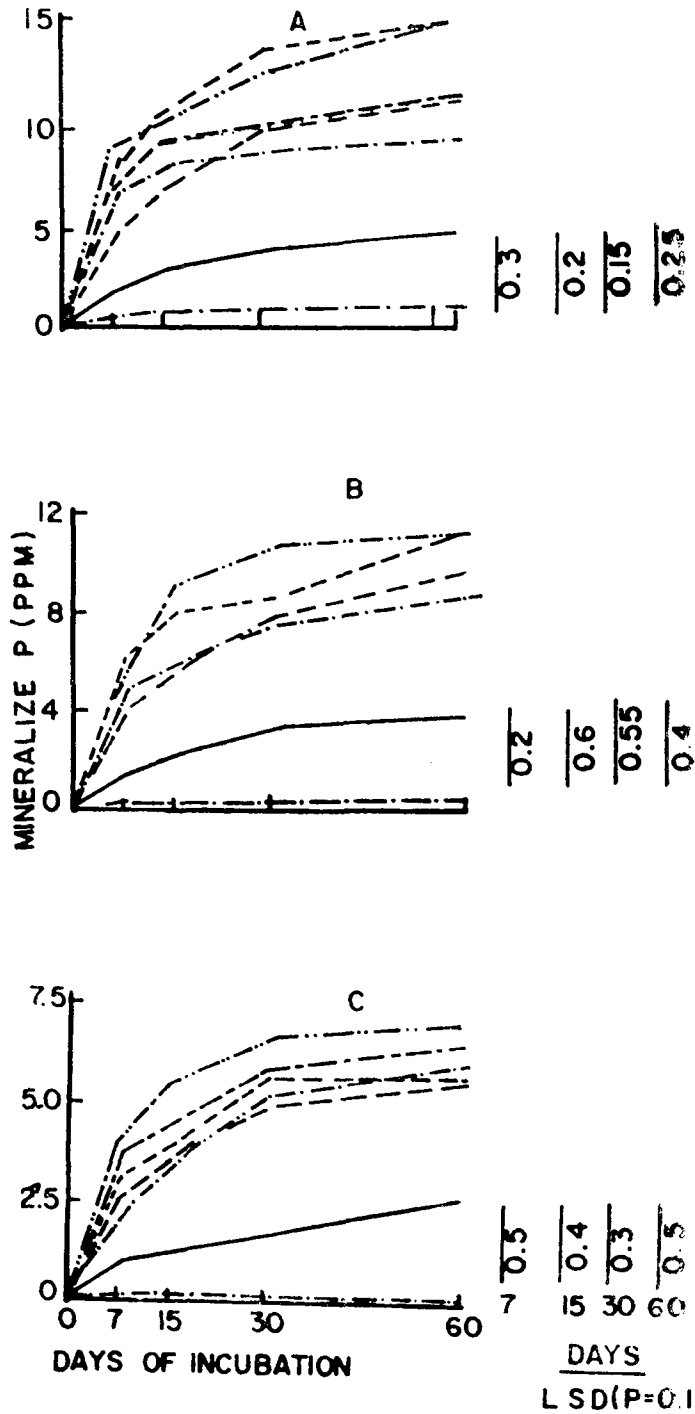


Fig. 2. Mineralization of soil phospholipids under waterlogged condition with time. Legend : see Fig. 1.

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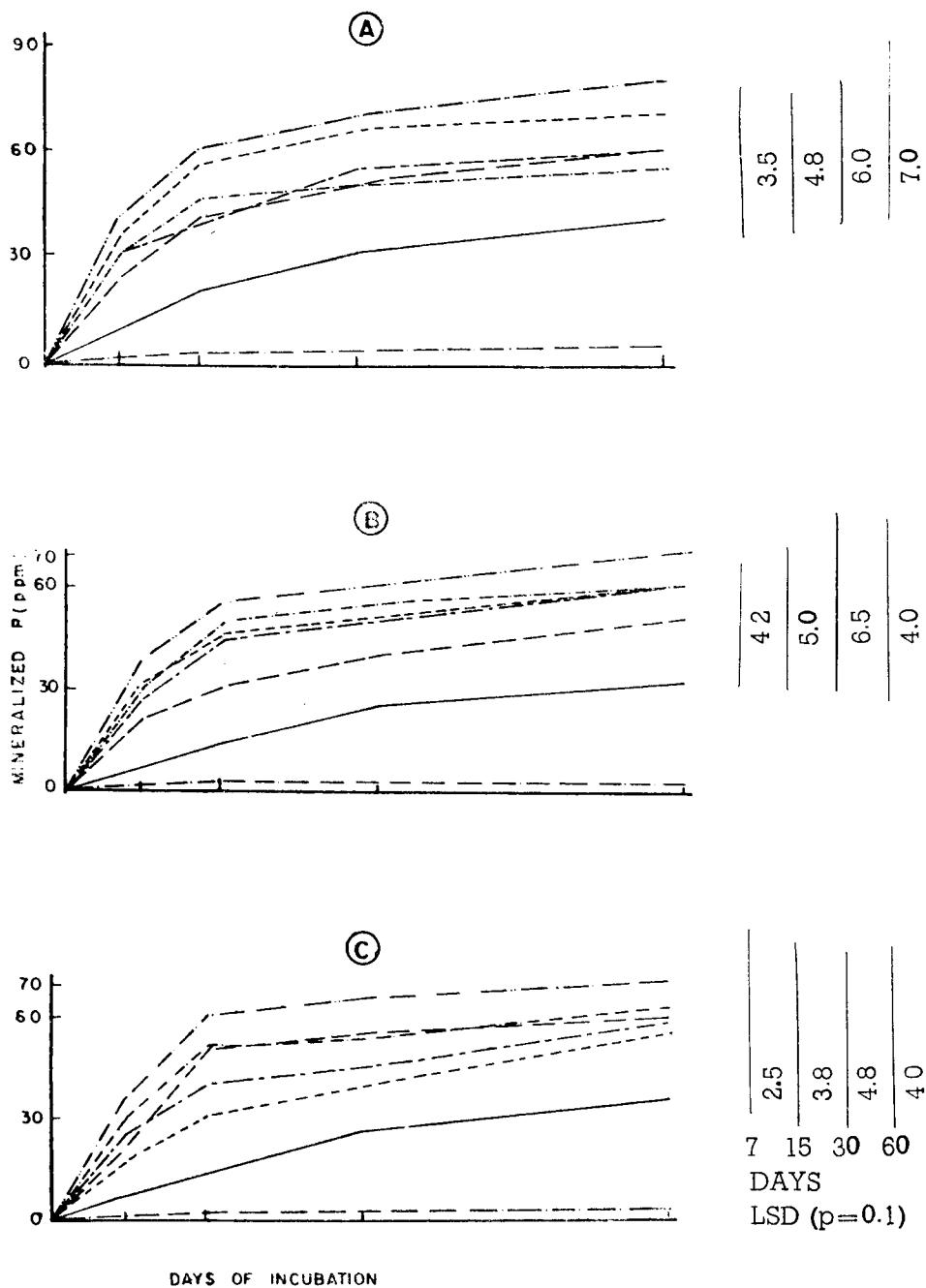


Fig. 3. Mineralization of soil inositol hexaphosphate under waterlogged condition with time. Legend : see Fig. 1.

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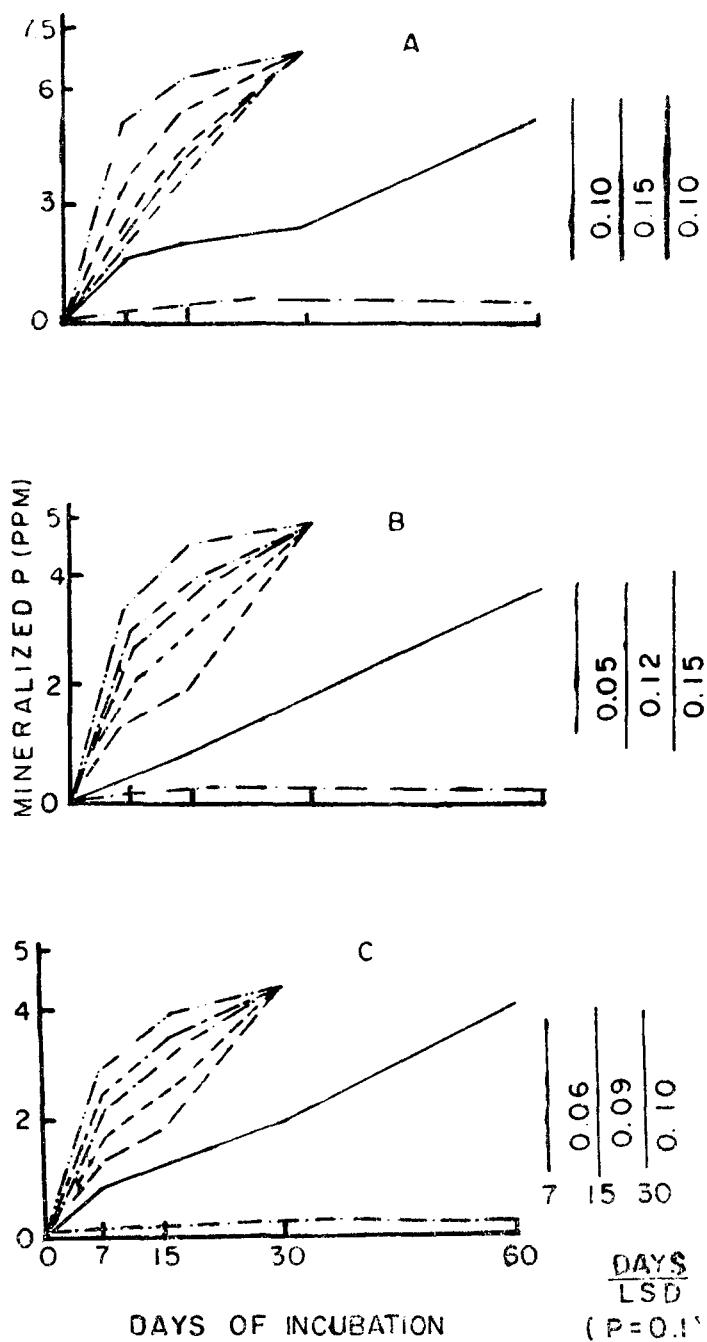


Fig. 4. Mineralization of soil RNA alongwith its derivatives under waterlogged condition with time. Legend : see Fig. 1.

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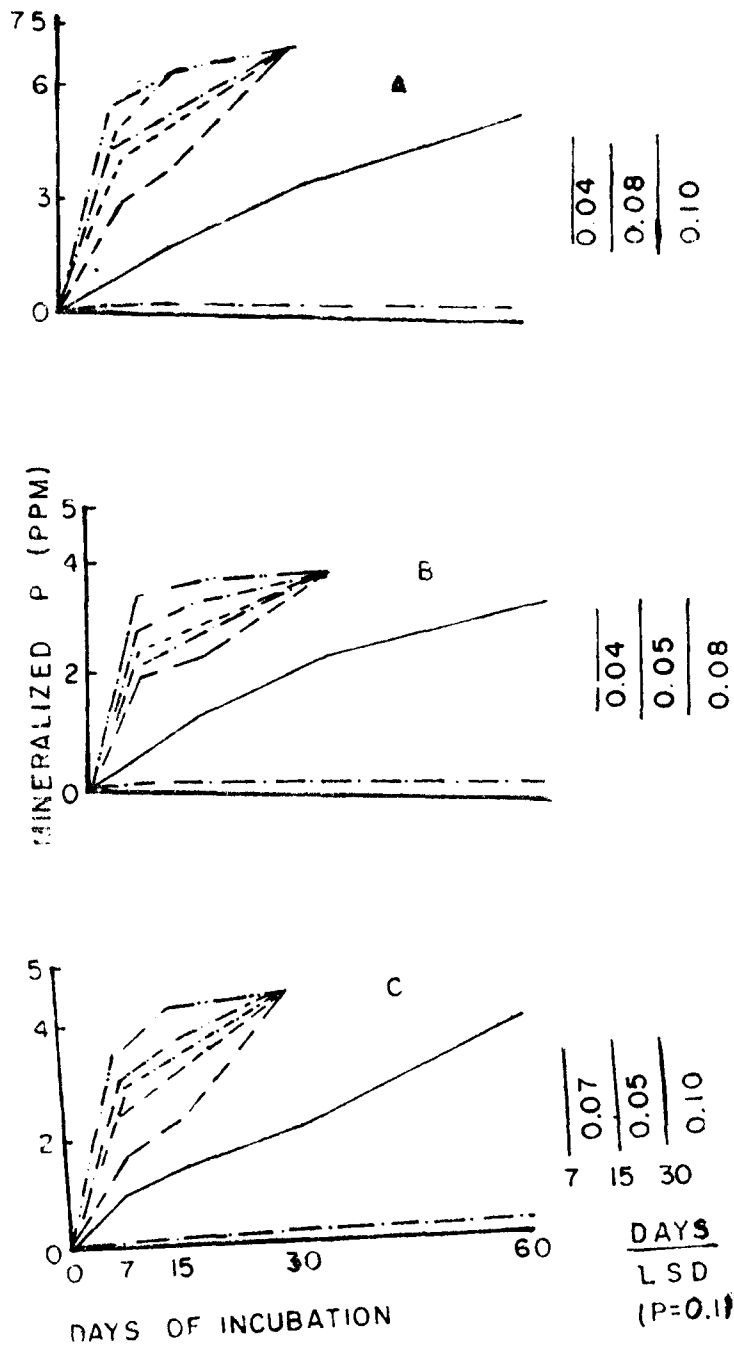


Fig. 5. Mineralization of soil DNA alongwith its derivatives under waterlogged condition with time. Legend : see Fig. 1.

Table 2. Some chemical properties of soil samples and compost.

Soil Series	pH	Organic carbon (%)	Organic phosphate (ppm)	Inositol phosphate (ppm)	phospholipids (ppm)	Inositol hexaphosphate (ppm)	RNA and its derivatives (ppm)	DNA and its derivatives (ppm)	Exchangeable Fe & Al (ppm)	Total N(%)
Harta	5.8	12.94	560	420	15.5	275.4	7.00	6.85	6.4	0.88
Naldanga	5.9	12.04	530	350	11.4	221.2	4.85	3.90	5.2	0.86
Paysa	6.6	7.09	450	275	7.2	174.8	4.24	4.40	4.0	0.58
Compost	5.1	17.00	89	34	1.4	27.0	1.60	1.30	0.8	0.93

Table 3. Changes in exchangeable Fe and Al (ppm) of the soil samples during incubation.

Treatments	Days of incubation											
	7			15			30			60		
	Harta	Naldanga	Paysa	Harta	Naldanga	Paysa	Harta	Naldanga	Paysa	Harta	Naldanga	Paysa
Control	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Moisture	2.5	1.3	1.0	0.8	0.5	0.2	0.0	0.1	0.1	0.0	0.0	0.0
Potassium dihydrogen phosphate	2.6	1.4	1.1	0.3	0.4	0.3	0.1	0.1	0.1	0.0	0.0	0.1
Ammonium sulphate	2.7	1.6	1.2	0.7	0.4	0.5	0.1	0.1	0.1	0.1	0.1	0.1
Compost	2.6	1.5	1.3	0.3	0.5	0.4	0.1	0.1	0.0	0.0	0.1	0.0
Glucose	2.0	1.4	1.0	0.2	0.4	0.6	0.1	0.1	0.1	0.0	0.0	0.0
Lime	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSD at 0.1% level	0.31	0.15	0.11	0.08	0.09	0.06	NS	NS	NS	NS	NS	NS

Table 4. Mineralization of organic phosphorus as influenced by various factors in 60 days of incubation.

Treatments	Total mineralized organic phosphorus (ppm)			Total identified mineralized organic phosphorus compounds (ppm)			Unidentified mineralized organic phosphorus fraction (ppm)		
	Harta	Naldanga	Paysa	Harta	Naldanga	Paysa	Harta	Naldanga	Paysa
	Control	8	8	7	6.45	5.90	4.70	1.55	2.10
Moisture	92	88	84	81.85	65.35	75.70	10.15	14.65	8.30
Potassium dihydrogen phosphate	150	156	136	140.35	138.75	124.40	9.65	17.25	11.60
Ammonium sulphate	192	175	168	179.35	160.15	154.65	12.65	14.85	11.35
Compost	148	144	144	135.35	132.75	129.90	12.65	11.25	14.10
Glucose	156	160	160	190.55	144.55	140.40	15.45	15.25	19.60
Lime	220	180	198	189.35	165.15	165.85	30.65	14.85	22.15
LSD at 0.1% level	6.13	13.20	7.84	11.40	9.55	10.78			

(1960) too reported that breakdown of nucleic acids was much slower in acid than in sweet soils but upon liming the acid soils caused an increase in availability of phosphorus to rye grass.

The decrease in the solubility of exchangeable Fe and Al (Table 3) due to liming also helped in the hydrolysis of inositol phosphates as well as inositol hexaphosphate into lower esters. In acid environment, phytin reacts to form insoluble iron and aluminium phosphates-highly resistant to dephosphorylation (Black and Goring, 1953) but the addition of lime caused the subsequent formation of more soluble calcium salts and results a rapid mineralization of phytin (Pierre, 1948). Furukawa and Kawaguchi (1969) also reported a rapid hydrolysis of inositol hexaphosphate due to enhanced solubilization of Fe/or Al-salts of inositol hexaphosphate during submergence. However, no such evidence has yet been available for phospholipids.

It was observed that in all the treatments, mineralization of all the organic phosphorus compounds were highest in Harta sample followed by Naldanga and Paysa samples. This might be due to the highest amount's of organic matter, and different mineralizable substrates content of the sample (Table 2). Mineralization of organic phosphorus is also related to the quantity of substrate (Alexander, 1961 ; Islam and Ahmed, 1973). However, the highest rate of mineralization of these compounds was observed in Paysa sample followed by Naldanga and Harta samples. This might be due to the favourable p^H of the sample (Table 2).

When the mineralized fractions of inositol phosphates, phospholipids, ribonucleic acid

and deoxyribonucleic acid were added together, 1.55 to 30.65 ppm organic phosphorus (Table 4) remained to be obscure that had already undergone mineralization. However, in most of the treatments more than 90% mineralized phosphorus was identified in all the soil samples.

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