

DISTRIBUTION OF ORGANIC PHOSPHATE COMPOUNDS IN SOME SOIL PROFILES OF BANGLADESH

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ABSTRACT

Inositol phosphate, phospholipid, ribonucleic acid and deoxyribonucleic acid along with their derivatives decreased gradually with depth in the profiles, while their variable amounts were jointly correlated with organic phosphate, total phosphate, organic matter, total nitrogen, pH and clay content of the soil. However, individually inositol phosphate was significantly correlated with organic phosphate, organic matter, pH and clay at the 0.1% level, and ribonucleic and deoxyribonucleic acids and their derivatives with organic phosphate and organic matter at the 5 and 10% level respectively while phospholipids with none of the factors studied.

INTRODUCTION

Organic phosphate comprises a significant proportion of the total phosphate (1) and is important in soil fertility because in general it is an indirect source of available forms (2). This fraction occurs mostly in soil as inositol phosphate (3), phospholipids (4) and nucleic acids and their derivatives (5). Inositol phosphate forms the major portion of the organic phosphate compounds in soil which have so far been identified (3). Similar to other constituents, soil organic phosphate compounds are subjected to certain distribution throughout the profiles during soil formation depending on physical and chemical environment. Reports are available on the distribution of these compounds in the surface soils only but no work has been reported on their distribution in the profiles.

Laboratory experiments were, therefore, performed to study the distribution of inositol phosphate, phospholipid, and nucleic acids and their derivatives in six soil profiles of Bangladesh. An attempt was also made to determine the relationship of those with selected soil properties.

MATERIALS AND METHODS

Six soil series selected randomly were identified on the basis of parent material, drainage condition, sub-surface texture and colour (Table I). Some of their physical and chemical properties are presented in Table II.

Table I. General characteristics of the soils

Soil series	Location	Identifying characteristics					Surface colour
		Parent material	Soil Tract	Internal drainage	Sub-surface texture		
Mirpur	Kushtia	Calcareous alluvial deposits	Gangetic alluvium	Imperfect	Loam		Pale olive
Terchibari	Sylhet	Subrecent basin sediments	Brahmaputra alluvium	Very poor	Silty clay loam		Dark greenish grey
Astagram	Mymensingh	Old Meghna estuarine deposits	Brahmaputra alluvium	poor	Silty clay loam		Grey
Barisal	Khulna	Tidal deposits	Gangetic alluvium	Poor	Silt loam		Pale olive
Richi	Mymensingh	Old Meghna estuarine deposits	Brahmaputra alluvium	Poor	Silty clay loam		Dark grey
Fulbari	Khulna	Tidal deposits	Gangetic alluvium	Moderately well	Loam		Grey

Table II Physical and chemical properties of the soil profiles

Soil series	Depth in cm	pH	Mechanical analysis (%)			Organic matter (%)	Total nitrogen (%)	Organic phosphate (ppm)	Total phosphate (ppm)
			Sand	Silt	Clay				
Mirpur	0-15	5.6	44	44	12	0.72	0.03	88	225
	-25	6.6	40	40	20	0.24	0.01	29	108
	-63	6.7	27	54	19	0.35	0.02	40	131
	-75	6.8	55	27	8	0.20	0.01	29	84
	-122	7.3	83	13	4	0.14	0.01	18	44
Terchibari	0-12	5.1	11	59	30	2.60	0.23	191	673
	-17	5.7	18	58	24	1.63	0.15	130	456
	-38	6.1	17	65	18	1.05	0.10	85	311
	-63	6.7	20	70	10	0.72	0.08	62	188
	-89	6.2	16	76	8	0.53	0.06	48	138
	-120	7.0	11	82	7	0.38	0.04	34	102
	-132	6.2	8	88	4	0.29	0.03	26	122
Astagram	0-10	4.9	13	55	32	3.80	0.20	260	638
	-20	5.1	14	49	37	2.43	0.14	171	490
	-35	6.0	8	43	49	2.13	0.12	147	319
	50	6.2	10	35	55	1.38	0.08	101	230
	-75	6.3	10	54	36	1.03	0.06	77	150
	-106	6.2	12	60	28	0.79	0.05	61	120
	135	6.0	15	70	15	0.67	0.04	52	131
Barisal	0-18	6.3	10	74	16	2.06	0.12	105	325
	64	6.7	8	79	13	1.38	0.08	72	211
	-75	6.7	12	78	10	0.98	0.06	52	161
	-100	6.7	16	80	4	0.46	0.03	25	126
Richi	0-12	5.9	13	59	28	3.30	0.19	230	560
	-18	6.2	17	55	28	2.55	0.15	172	382
	-38	6.5	8	60	32	1.55	0.10	105	205
	-56	6.6	13	64	23	0.95	0.06	65	152
	-81	6.7	35	61	4	0.50	0.04	44	96
	-100	6.8	9	81	10	0.48	0.04	37	105
	-135	6.8	6	89	5	0.31	0.01	25	52
Fulbari	0-15	7.33	42	34	24	1.63	0.08	156	518
	-28	6.8	38	32	30	1.79	0.01	189	581
	33	7.5	42	38	20	1.51	0.09	122	408
	-56	6.3	34	43	23	2.22	0.12	156	613
	-75	5.6	32	36	32	2.70	0.12	210	676
	-89	4.4	29	35	36	2.98	0.12	221	665
	-107	4.4	32	41	27	2.75	0.11	188	476
	-125	4.5	30	40	30	2.05	0.09	160	397

CHEMICAL ANALYSIS

pH was measured electrochemically by using a Pye glass electrode the soil : water ratio being 1 : 2.5. Mechanical analysis was done by the hydrometer method, organic matter was calculated by multiplying the values of organic carbon by 1.72 where as organic carbon was estimated by the procedure of Walkley and Black (6), total nitrogen was determined by the Kjeldahl's method, The method of Mehta *et al.* (7) was used for determining organic and total phosphate. Inositol phosphate was determined by the method proposed by Omotoso and Wild (8), phospholipids by Hance and Anderson (9), ribonucleic acid and its derivatives by Adams *et al.* (10), and deoxyribonucleic acid and its derivatives by Anderson (11).

RESULTS AND DISCUSSION

The vertical distribution of inositol phosphate, phospholipids, ribonucleic acid and deoxyribonucleic acid along with their derivatives in six profiles were presented in Figs. 1-4.

Inositol phosphate concentration in the profiles exhibited three different trends with depth (Fig. 1). Astagram, Richi, Terchibari and Barisal series showed a gradual decrease with depth in inositol phosphate concentration. In Mirpur series, this value decreased abruptly in the second layer, slightly increased in the third and then decreased again. Its distribution throughout the profile of Fulbari series was irregular with occasional increase and decrease and the maximum concentration of this compound was found in 89-100 cm layer,

The nature of distribution of inositol phosphate with depth relative to that of total organic phosphate was not similar in all the profiles examined. In Barisal and Mirpur series inositol phosphate as per cent of total organic phosphate increased very slightly with depth indicating the greater rate of change of inositol phosphate than the total organic phosphate, Inositol phosphate in Astagram series as per cent of total organic phosphate increased in each alternate layer but in Richi, Terchibari and Fulbari series the distribution was much more irregular.

The differences in inositol phosphate as per cent of total organic phosphate in different layers of the same soil were probably due to

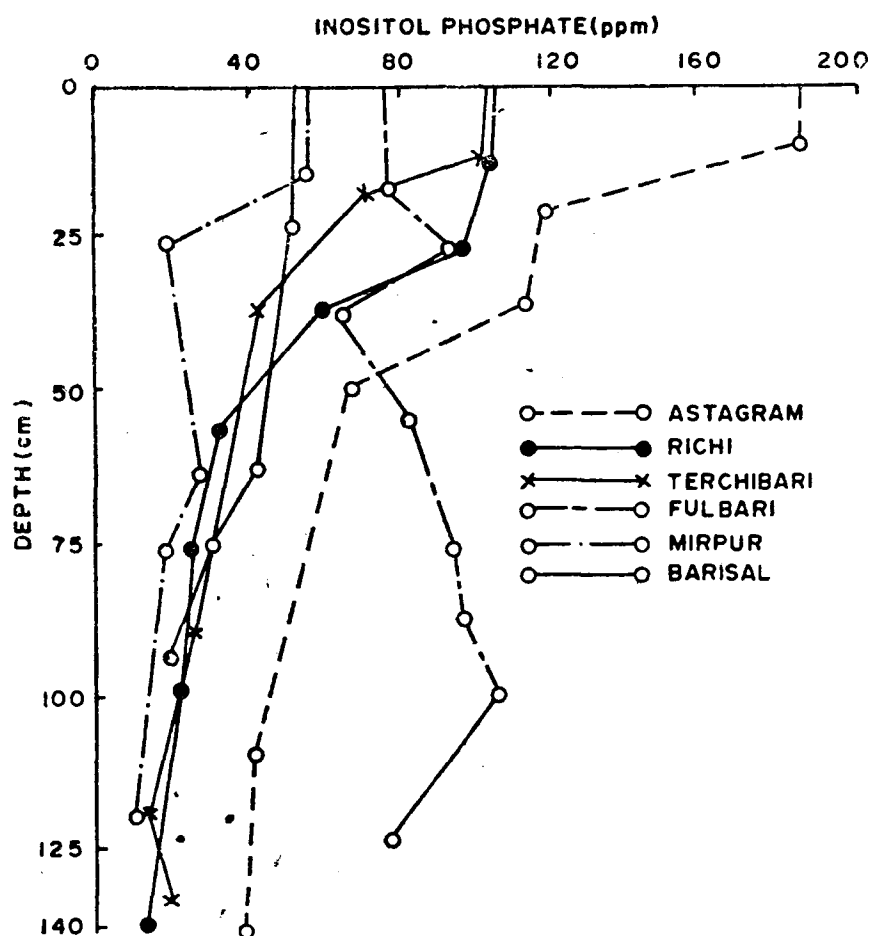


FIG. 1. DISTRIBUTION OF INOSITOL PHOSPHATE IN SOIL PROFILES

an inherent difference in the composition of organic matter. Thomas and Lynch (12) reported that the rates of mineralization of inositol phosphate were different in different layers.

Concentrations of phospholipids with increasing depth in the profiles showed two different trends (Fig. 2). Lipidphosphate decreased more or less gradually in Astagram, Richi, Terchibari, Mirpur and Barisal series but in Fulbari series this compound decreased upto 40 cm and then increased rapidly upto 100 cm beyond which a decrease was noticed.

Amount of ribonucleic acid and its derivatives in the profiles indicated two different trends (Fig. 3). The series Astagram, Barisal,

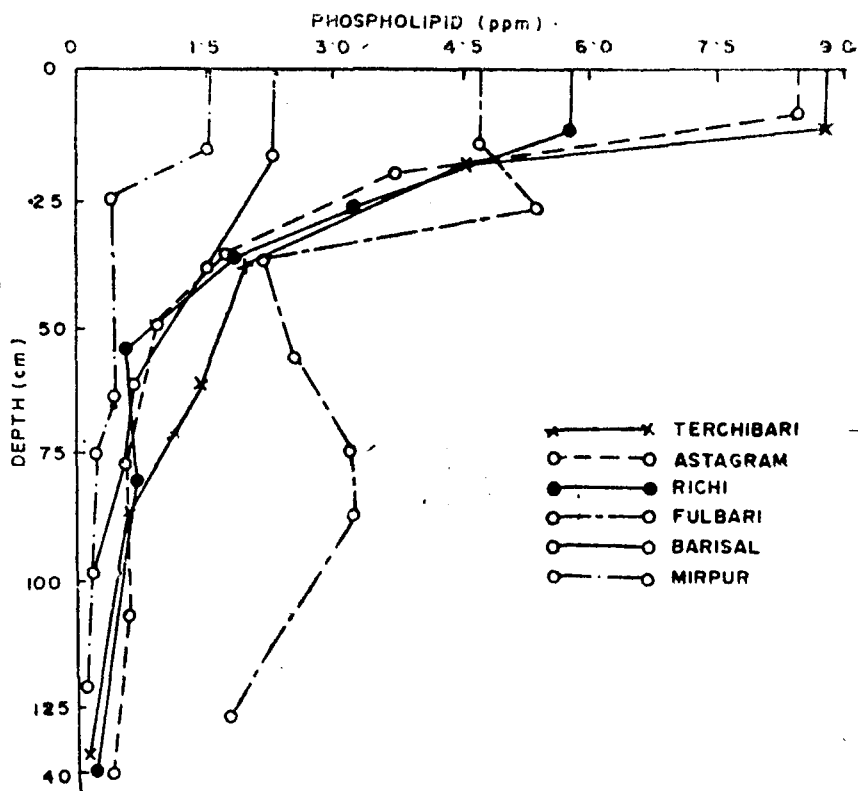


FIG. 2. DISTRIBUTION OF PHOSPHOLIPID IN SOIL PROFILES

Richi, Mirpur and Terchibari showed a gradual decrease with depth. Ribonucleic acid and its derivatives in Fulbari series increased slightly from 15 to 28 cm and considerably at a depth of 38-75 cm. However, ribonucleic acid and its derivatives could not be detected beyond 50, 75, 87, 63, 55 and 63 cm, in Astagram, Barisal, Fulbari, Mirpur, Richi and Terchibari series respectively.

The rate of decrease of ribonucleic acid and its derivatives with depth relative to that of total organic phosphate and percent organic phosphate gradually declined in all the profiles. The decrease of ribonucleic acid and its derivatives as percent of total organic phosphate with depth was probably the result of (i) greater movement of

other organic phosphate compounds specially inositol phosphate with depth, (ii) the most of the ribonucleic acid and its derivatives was precipitated or adsorbed by clays on the surface.

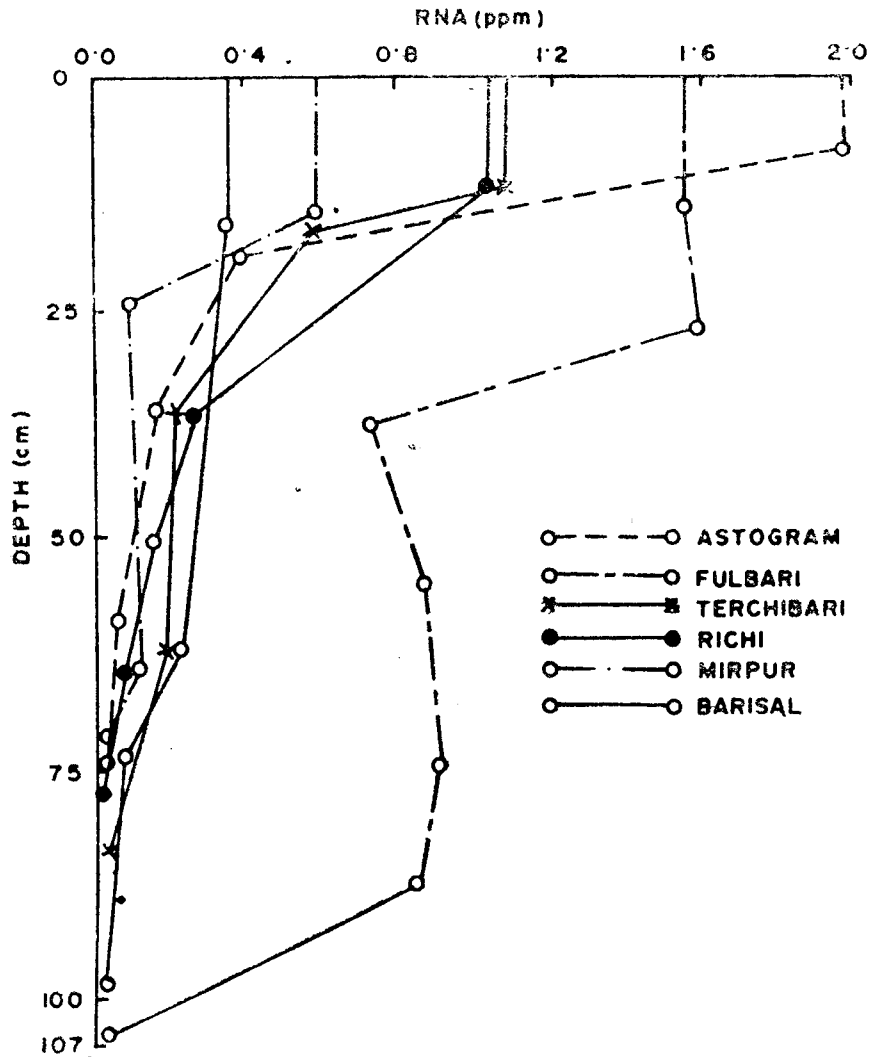


FIG. 3. DISTRIBUTION OF RNA IN SOIL PROFILES.

values for deoxyribonucleic acid and its derivatives in the profiles showed two different trends (Fig. 4). In Astagram, Barisal, Richi and Terchibari series, deoxyribonucleic acid and its derivatives bound

and deoxyribonucleic acids and their derivatives were significantly associated with organic phosphate and organic matter at the 5 and 10% level respectively. However, phospholipids were found to be significantly correlated with none of these factors under investigation.

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Conversion of urea placed at different depths and its subsequent impact on growth and yield of rice

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ABSTRACT

In a study on the effect of urea with depths in rice (*Oryza sativa* Linn.), conversion of urea into $\text{NH}_4\text{-N}$ was maximum at 15 days in most of the treatments and into $\text{NO}_3\text{-N}$ was at 7 days. But with surface placement of urea it continued up to 15 days of placement and thereafter the concentrations of both declined with time in all the treatments. Fertilizers @ 80 kg N + 60 kg P + 40 kg K/ha placed 8-cm depth produced the highest dry matter and grain yield. At this treatment, the rice plants also accumulated highest amount of N in the shoot and grain.

There is at present an increase in the high analysis of N fertilizer urea for maximizing crop production. Rice (*Oryza sativa* Linn.) plants growing under submerged condition utilize at most 60% of the applied urea, whereas the remaining 40% is lost through leaching, volatilization or denitrification (Brady *et al.*, 1974). The behaviour of urea may differ if placed at different depths. The present study was undertaken to study the mode of conversion of urea into $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ placed at different depths and its effect on the growth and yield of rice.

MATERIALS AND METHODS

The field experiment was conducted on a well-drained slightly acidic (pH 6.4) sandy clay soil, low in available N, P and K contents. The treatments consisted of urea applied at 80 or 120 kg N/ha, broadcast on the surface or placed 8 or 15 cm under the soil, each of the urea treatment combinations with one without 60 kg P/ha as triple superphosphate + 40 kg K/ha as murate of potash. The fertilizer was applied before flooding the plots. There were in all 13 treat-

ments inclusive of a no-fertilizer control replicated 3 times in a completely randomized design.

The plots were of 100 cm × 105 cm, protected by bunds. Four-week-old seedlings of rice 'BR 3' were planted at 2 seedlings/hill with a spacing of 25 cm × 15 cm. Water level in the field was maintained at 3-cm depth during the period of crop growth.

Soil samples were collected at 0, 3, 7, 15, 30, 60 days after fertilizer application and analyzed in wet condition for $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ following the method of Bremner and Shaw (1955). Plant samples (1 hill each time) were collected at 70 and 120 days after transplanting and at harvest, data on dry weight were recorded and the plants were analysed for total N.

RESULTS AND DISCUSSION

Urea converted into $\text{NH}_4\text{-N}$ showed different trends with time (Fig. 1). In the initial 3 days the conversion was very rapid, followed by a moderate increase up to 15 days, after which a more or less static change was observed up to 30 days in most of the treatments. However, in all the treatments a rapid fall in $\text{NH}_4\text{-N}$ concentration was noticed 30 days after placement. Placement of 120 kg N/ha

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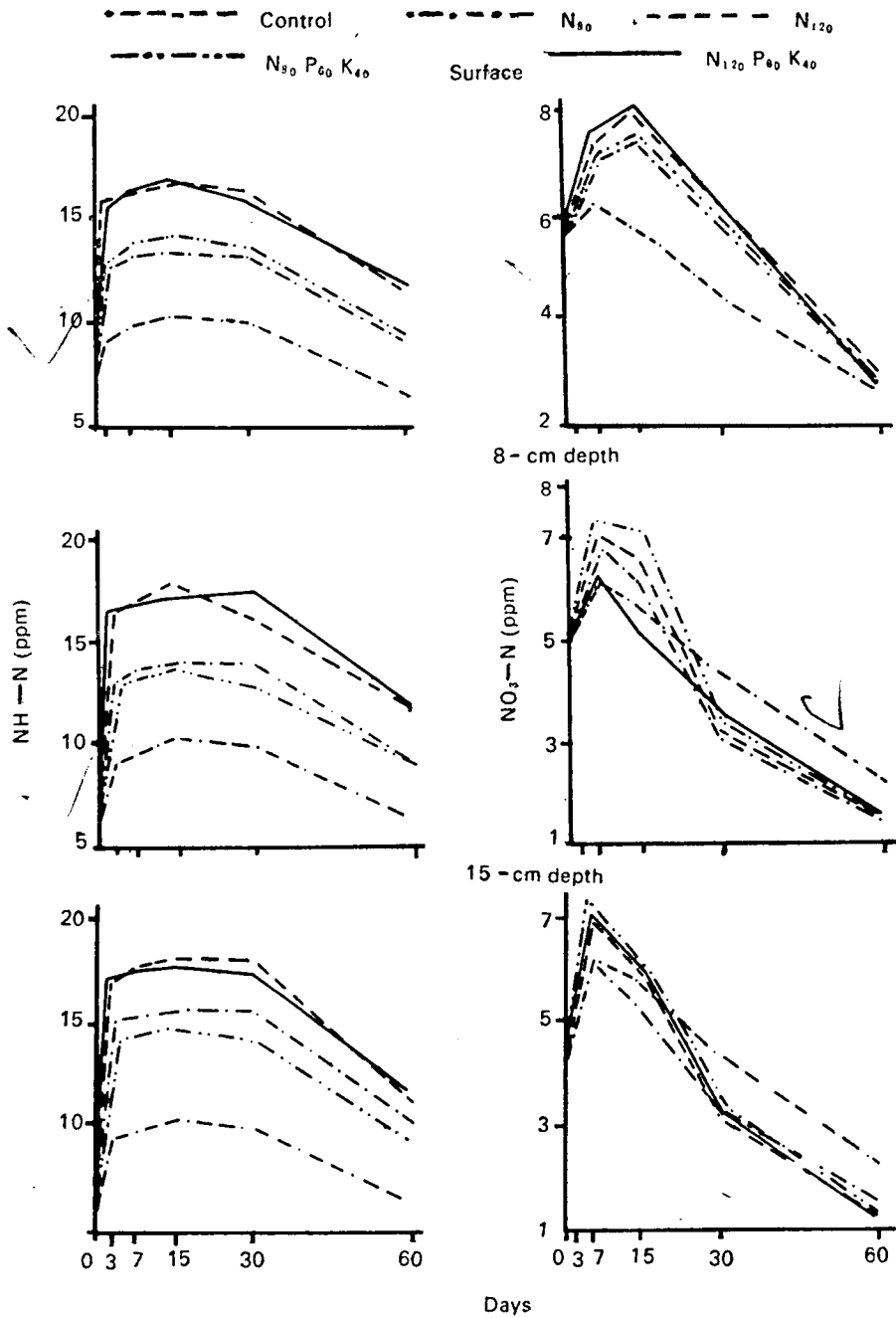


Fig. 1. Conversion of urea into $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ with time.

with P and K at surface and 8-cm depth showed the peak values. The initial increase in $\text{NH}_4\text{-N}$ was owing to the rapid hydrolysis of urea, whereas the final decrease might be owing to absorption by soil microbes and growing crops. N losses through NH_3 volatilization from urea reached maximum within the 4th to 10th days of application (Enikov and Ivanov, 1971; Idris *et al.*, 1974). Mukasa *et al.* (1973) reported that transformation of urea into $\text{NH}_4\text{-N}$ placed in the surface soil reached maximum within 10–20 days and almost disappeared after 60 days. However, a very sharp change in $\text{NO}_3\text{-N}$ concentration was followed, reaching the maximum 7 days after placement of urea, except in the surface placement where the increase continued up to

15 days and then fell rapidly with time irrespective of the treatments (Fig. 1). The initial increase was owing to partial oxidation of $\text{NH}_4\text{-N}$ ions owing to hydrolysis of urea. But with time the value decreased, probably owing to assimilation by soil anaerobes and decrease in oxygen concentration. Mikkelson and Finfrock (1956) also noted that when the concentration of oxygen in a soil solution fell below 1 ppm, anaerobes began to use nitrate as electron acceptor during their respiration, showing a decrease in the amount.

The dry weights of shoot, grain yield, and N contents of shoot and grain as influenced by the placement of urea alone and in combination with P and K fertilizer varied significantly (Table 1).

Table 1. Effect of urea placed at different depths on the dry weight, yield and N content of shoot and grain of 'BR 3' rice

✓ Treatment	Dry weight (g/hill)		Harvesting (g/hill)		N (%) in plant			Grain N (g/hill) ✓
	70 days	120 days	Grain ✓	Straw ✓	70 days	120 days	Straw	
Control	0.52	26.5	49.2	25.6	0.83	0.96	1.27	1.34
80 kg N/ha (surface)	0.72	32.6	52.1	30.3	1.47	1.81	1.48	1.95
120 kg N/ha (surface)	0.60	40.2	59.6	25.4	1.47	1.11	1.38	1.84
80 kg N/ha + PK (surface)	1.04	45.2	62.5	33.8	1.03	1.11	1.33	2.03
120 kg N/ha + PK (surface)	1.12	36.2	58.7	33.7	1.12	2.04	1.40	2.27
80 kg N/ha (8-cm depth)	1.39	35.5	63.0	34.8	1.34	2.73	1.73	2.76
120 kg N/ha (8-cm depth)	0.61	36.3	68.3	29.4	1.27	2.57	1.78	2.75
80 kg N/ha + PK (8-cm depth)	0.98	43.4	69.1	39.0	1.27	2.88	1.94	3.32
120 kg N/ha + PK (8-cm depth)	1.44	46.9	68.4	34.9	1.33	1.83	1.55	2.71
80 kg N/ha (15-cm depth)	0.77	28.5	55.2	34.3	1.15	2.11	1.57	2.13
120 kg N/ha (15-cm depth)	0.48	31.6	44.1	31.0	1.15	2.35	1.55	2.19
80 kg N/ha + PK (15-cm depth)	0.44	30.5	52.8	32.1	1.24	2.66	1.43	2.23
120 kg N/ha + PK (15-cm depth)	0.36	25.9	42.4	33.8	1.11	2.22	1.55	1.85
CD at 5%	0.18	7.27	6.51	3.91	0.095	0.176	0.176	0.135

The best dry weight of straw was obtained at the vegetative and maturity stage when 120 and 80 kg N/ha, respectively, was placed, along with P and K 8-cm deep. The data were statistically significant. Grain yield significantly increased at 5% level by different treatment combinations. The highest (69.1 g/hill) yield was obtained when 80 kg N/ha + 60 kg P/ha + 40 kg K/ha placed at 5-cm depth. The highest grain yields in general were obtained when the fertilizers were placed at 8-cm depth. Wahhab and Azim (1958) reported that highest dry matter and grain yield of paddy were obtained when urea was placed at 5-cm depth. Dalal (1975) observed that urea placed at 5-cm depth was more efficient in maize production than when applied on the surface.

Rice plants showed a significant uptake of N and progressive accumulation of N throughout the growing period. However, the rate of uptake was higher at the growth stage between 70 and 120 days. This suggests that rice plants assimilated more N up to flowering stage for later utilization during the synthesis of body materials in the seed-forming stage. Rice plants accumulated the highest amount of N in the shoot (at 120 days and at maturity) and grain when 80 kg N/ha + P + fertilizers were placed

8 cm deep.

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