Influence of Drying Phases in a Continuous Flooded Situation on Liberation of Different Forms of Inorganic and Organic N in Soil

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Abstract

Nitrogen is one of the major nutrients required for plant growth and metabolic activities. The efficient use of N depends on different transformation processes-mineralization and immobilization, in soil. The present investigation was conducted with a view to know the release pattern of different forms of inorganic and organic N in soil maintained under waterlogged situation but subjected to one or two drying phases. Results revealed that irrespective of soils, cropping and stages of plant growth as well as phases of drying and submergence, the amount of native exchangeable NH_4^+decreased over 0th day of plant growth. Maintenance of a drying phase either at pre-tillering or at pre-flowering stage of rice showed an accumulation of higher amount of exchangeable NH_4^+, where as comparatively lower amount of NO_3^- -N is registered over the continuous flooded situation. This decrease of soluble NO_3^- -N was more in pre-flowering than pre-tillering stage of rice. Again, irrespective of soils, cropping and drying phases, the amount of hydrolysable $NH_4^+$and amino acid-N increased at pre-tillering but decreased at pre-flowering stage when the soils are subjected to drying phase at both the stages of crop growth. Addition of inorganic N has no drastic influence on accumulation of hydrolysable organic $NH_4^+$and amino acid-N in waterlogged soils. Maintenance of a drying phase either at pre-tillering or at pre-flowering stage favours consumption of higher amount of N from the soil system at the maturity stage of rice. This trend of results is also observed in N fertilized soil

1. Introduction

Moisture is an important factor for the growth of microorganisms and in controlling the rate of organic matter decomposition. Although presence of moisture above a certain level is not congenial for microbial activity (Hueso et al., 2012), indirectly it is important, because higher the moisture present in soil lesser the oxygen available for microbial growth. Stanford and Epstein, (1974) reported a near linear relationship between N mineralization and soil water content in the range of ⅓ to 15 bar. With increasing dryness, N mineralization tended to decrease.

Matsushima (1962) regarded a short period of dryness under waterlogged condition as indispensable for producing a drastic increase in the amount of available N in soil. Drying soils at mid season in continuously flooded situation caused an increase in the yield of rice (IRRI, 1974). This was explained as possible N effect. Drying soon after transplanting instead of mid season also increased the yield of rice crop due to the release of extra N (IRRI, 1974). Saha and Mukhopadhyay (1985a) are of opinion that the net increase in the amount of mineral N vis-à-vis the net decrease in the amount of fixed NH_4^+-N in a soil maintained under different moisture regimes and subjected to short period of dryness suggest a part of the released fixed NH_4^+contributed to the increase in the amount of mineral N during the process.

Presence of plant will change the micro environment in the soil. When the plants are growing, during respiration the root excretes exudates which are beneficial for microbial growth and their activities. The increased population of microbes, due to the presence of crops, will promote mineralization of organic N present in soil. The addition of inorganic N in soil, will further influence the mineralization rate of organic N. It is also logical to note that density of plant population in the field (Saha et al., 1982) will greatly influence the microbial activities and eventually influences the mineralization rate of organic N present in the soil.

2. Materials and Methods

Soil samples were collected from the village Chakdaha (23.08°N and 88.52°E) and Taldangra (23.02°N and 87.11°E) in the district of Nadia and Bankura respectively, West Bengal, India. The soils were belonged to Aeric *Endo aquepts* and Typic *Endo aquepts* (clay 44.05 and 37.87%, pH 7.17 and 5.40, CEC 11.39 and 8.01 cmol (p^+) kg^{-1} soil, OC 0.79 and 0.41%, exchangeable NH_4^+49.64 and 65.33 kg ha^{-1}, soluble NO_3^- 23.48 and 45.71 kg ha^{-1}, available nitrogen 73.12 and 10.71 kg ha^{-1}) soil series.

Each of the two soil samples, at the rate of 1.5 kg air dried, were taken in earthen pots. The holes of the pots were cemented to check the leaching loss. Three, one month old rice seedlings (variety-IET 4786) were transplanted in each pot where the effects of drying phases were studied in presence of rice crop. Phosphorous and potassium were added at recommended dose (60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1}) in the form of single super phosphate and muriate of potash, respectively to each pot as basal application.

First set of pots were kept waterlogged throughout the experiment upto maturity stage of the rice crop. Second and third set of pots were kept waterlogged upto pre-tillering (20 DAT) and pre-flowering (50 DAT) (DAT=Days After Tranplanting), respectively, where as drying phase i.e. development of microcracks, (20 to 35 DAT) and (50 to 65 DAT) were given after pre-tillering and pre-flowering, respectively, and then again the soils were made waterlogged to its pre-dried waterlogged stage and maintained upto maturity of the rice crop. Fourth set of pots were included in the experiment in the waterlogged system where two drying phases, 1st at pre-tillering and 2nd at pre-flowering stage of rice crop were given and again waterlogged to its pre-dried stages. Similarly another set of soils were maintained uncropped following same management practices.

All the treatments were replicated three times. Demineralised water was added on every alternate day to maintain a constant water head of waterlogged condition throughout the investigation as per sets of treatments of the experiments wherever and whenever necessary.

Soil samples were collected from both the uncropped and cropped pots on 0th, 20th, 35th, 50th, 65th and 90th day of experiment. The 20th and 35th day correspond to start and end of the drying phase respectively at pre-tillering stage whereas, 50th and 65th day correspond to start and end of the drying phase respectively at pre-flowering stage of rice crop. The 90th day corresponds to maturity stage of the rice crop. Loss of moisture due to evaporation was replenished by the addition of distilled water on every alternate day by difference in weight. Rhizosphere soil samples were collected for determination of exchangeable NH_4^+ and soluble NO_3^- -N by the method of Bremner and Keeney (1966); hydrolysable $NH_4^+$and amino acid N by the method of Stevenson (1996).

The data of exchangeable NH_4^+, soluble NO_3^- and hydrolysable organic $NH_4^+$and amino acid N at each stage were statistically analysed for analysis of variance as well as critical difference were calculated at 5% level of significance to test the significance of means for the treatment difference.

3. Results and Discussion

Irrespective of soils, cropping and stages of plant growth as well as phases of drying or submergence, the amount of exchangeable NH_4^+decreased over the 0th day during the period of investigation (Table 1). Maintenance of drying phase either at pre-tillering or at pre-flowering stage showed an accumulation of higher amount of exchangeable NH_4^+over the continuously submerged condition, due to release of fixed NH_4^+-N in soil (Saha and Mukhopadhyay, 1983b). In both cropped and uncropped systems either at pre-tillering or pre-flowering stage, the amount of exchangeable $NH_4^+$was recorded very low at maturity due to release of fixed $NH_4^+$and its subsequent conversion to exchangeable NH_4^+-N. This conversion was reported earlier by Pal et al. (1987) and Ghosh et al. (1990). Similar trend of result was also observed in the soil fertilized with added inorganic N. The decrease in exchangeable NH_4^+-N over the experimental period is due to the conversion of exchangeable $NH_4^+$to NO_3^--N (Saharawat, 1982).

Irrespective of soils, cropping and drying phases, the amount of soluble NO_3^--N decreased at pre-tillering but increased at pre-flowering stage of crop growth (Table 2). Results further showed that in general, irrespective of soils and cropping, the amount of soluble NO_3^--N decreased in soil subjected to a drying phase both at pre-tillering and pre-flowering stages of crop growth. Again, the decrease was more at pre-flowering than the pre-tillering stage of rice crop. The increased amount of accumulation in soluble NO_3^--N at pre-flowering stage after drying or submergence phase was due to higher order of microbial activities in presence of larger amounts of exudates liberated by larger number of roots (Saha et al., 1982). The recorded decrease in soluble NO_3^--N in soil subjected to a drying phase at both the pre-tillering and pre-flowering stage was due to loss of N through de-nitrification process (IRRI, 1974, 1975). At maturity, the increase or decrease in soluble NO_3^--N content over 0 day did not show any definite trend of results. However, the amount of soluble NO_3^--N increased in Chakdaha and decreased in Taldangra soil which received a drying phase both at pre-tillering and pre-flowering stages of crop growth. This trend of results was observed both in presence and absence of crop. Higher amount of accumulation

Table 1: Effect of drying and submergence at pre-tillering and pre-flowering stage on changes in the amount (mg kg^{-1}) of exchangeable NH_4^+in N fertilized and unfertilized submerged soils cropped with or without rice.

Soil	N-fertilization	Cropping	Drying phase	Stages after transplanting										
				0 days	Pre-tillering: Effect of dryness or submergence			Maturity		Pre-flowering: Effect of dryness or submergence			Maturity	
					Before	After	Increase (+) or Decrease (-) due to drying or submergence	Amount	Increase (+) or Decrease (-) over 0-day due to drying or submergence	Before	After	Increase(+) or Decrease(-) due to drying or submergence	Amount	Increase (+) or Decrease (-) over 0-day due to drying or submergence
Chakdaha	Unfertilized	Without	-	72.40	69.30	50.40	-18.90	39.06	-33.34	69.30	32.76	-36.54	39.06	-33.34
			+			56.70	-12.60	47.88	-24.52		40.32	-28.98	42.84	-29.56
		With	-		61.74	37.80	-23.94	32.76	-39.64	54.18	44.10	-10.08	32.76	-39.64
			+			46.62	-15.12	35.26	-37.14		49.14	-5.04	35.28	-37.12
Taldangra		Without	-	68.04	63.00	45.36	-17.64	49.14	-18.90	65.52	37.80	-27.72	49.14	-18.90
			+			56.70	-6.30	56.70	-11.34		54.18	-11.34	71.82	3.78
		With	-		51.66	39.06	-12.60	44.10	-23.94	52.92	32.76	-20.16	44.10	-23.94
			+			54.18	2.52	49.14	-18.90		50.40	-2.52	56.70	-11.34
CD (p=0.05)		Drying phase (D)			0.0159			0.024		0.0197			0.0354	
		Crop (C)			0.0159			0.024		0.0197			0.0354	
		Soil series (S)			0.0159			0.024		0.0197			0.0354	
		D×C×S			0.0318			0.0479		0.0394			0.0709	
Chakdaha	Fertilized	Without	-	135.60	70.56	55.44	-15.12	70.56	-65.04	80.64	35.28	-45.36	70.56	-65.04
			+			56.70	-13.86	100.8	-34.80		40.32	-40.32	69.30	-66.30
		With	-		65.52	49.14	-16.38	26.46	-109.14	57.96	36.54	-21.42	26.46	-109.14
			+			51.66	-13.86	28.98	-106.62		51.66	-6.30	25.20	-110.40
Taldangra		Without	-	124.04	79.39	65.52	-13.87	45.36	-78.68	73.08	30.24	-42.84	69.30	-54.74
			+			68.04	-11.35	56.70	-67.34		42.84	-30.24	42.84	-81.20
		With	-		61.74	44.10	-17.64	42.84	-81.20	42.84	32.76	-10.08	46.62	-77.42
			+			46.62	-15.12	46.62	-77.42		36.54	-6.30	39.06	-84.98
CD (p=0.05)		Drying phase (D)			0.5288			5.9892		1.1758			1.0194	
		Crop (C)			0.5288			5.9892		1.1758			1.0194	
		Soil series (S)			NS			NS		1.1758			1.0194	
		D×C×S			NS			NS		2.3516			2.0388	

in NO_3^--N in Chakdaha soil at maturity was due to the presence of higher amount of fixed NH_4^+, which was released during the maintenance of a drying phase both at pre-tillering and pre-flowering stage. N-fertilization did not show any significant deviation in result from that of native soluble NO_3^-. This trend of result was true for both cropped and uncropped soils.

Perusal of data in Table 3 revealed that irrespective of soils and cropping, the amount of hydrolysable NH_4^+-N increased at pre-tillering but decreased at pre-flowering stage when the soils were subjected to a drying phase at both the stages of crop growth. The decrease in hydrolysable NH_4^+-N was due to mineralization of this fraction of organic N. Results further showed that comparatively lower amount of hydrolysable NH_4^+-N was accumulated at pre-flowering stage in Chakdaha soil which received a drying phase than at both the pre-tillering and pre-flowering stages of crop growth. But on the other hand, completely opposite trend of results was obtained in Taldangra soil. This was perhaps due to the type of the soils under investigation. Drying phase favoured mineralization of hydrolysable NH_4^+in Chakdaha soil but immobilization process was encouraged in Taldangra soil. Data also showed that the amount of hydrolysable NH_4^+-N increased at maturity stage

Table 2: Effect of drying and submergence at pre-tillering and pre-flowering stage on changes in the amount (mg kg^{-1}) of soluble NO_3^- in N-fertlized and unfertilized submerged soils cropped with or without rice

Soil	N-fertilization	Cropping	Drying phase	Stages after transplanting										
				0 days	Pre-tillering: Effect of dryness or submergence			Maturity		Pre-flowering: Effect of dryness or submergence			Maturity	
					Before	After	Increase (+) or Decrease (-) due to drying or submergence	Amount	Increase (+) or Decrease (-) over 0-day due to drying or submergence	Before	After	Increase(+) or Decrease(-) due to drying or submergence	Amount	Increase (+) or Decrease (-) over 0-day due to drying or submergence
Chakdaha	Unfertilized	Without	-	46.62	70.56	46.62	-23.94	50.40	3.78	59.22	65.52	6.30	47.88	1.26
			+			44.10	-26.46	47.88	1.26		63.00	3.78	52.92	6.30
		With	-		41.58	34.02	-7.56	32.76	-13.86	51.66	61.74	10.08	36.54	-10.08
			+			28.98	-12.60	31.50	-15.12		60.48	8.82	47.88	1.26
Taldangra		Without	-	44.10	52.92	52.92	0.00	65.52	21.42	74.34	61.74	-12.60	63.00	18.90
			+			39.06	-13.86	65.52	21.42		50.40	-23.94	65.52	21.42
		With	-		50.40	37.80	-12.60	39.06	-5.04	47.88	49.14	1.26	51.66	7.56
			+			35.28	-15.12	36.54	-7.56		47.88	0.00	52.92	8.82
CD (p=0.05)		Drying phase (D)			0.5721			0.5684		0.9148			0.6598	
		Crop (C)			0.5721			0.5684		0.9148			0.6598	
		Soil series (S)			0.5721			0.5684		0.9148			0.6598	
		D×C×S			1.1442			1.1369		1.8297			1.3196	
Chakdaha	Fertilized	Without	-	46.62	52.92	44.10	-8.82	47.88	1.26	40.32	63.00	22.68	47.88	1.26
			+			36.54	-16.38	85.68	39.06		57.96	17.64	49.14	2.52
		With	-		44.10	36.54	-7.56	27.72	-18.90	37.80	61.74	23.94	27.72	-18.90
			+			32.76	-11.34	32.76	-13.86		54.18	16.38	42.84	-3.78
Taldangra		Without	-	44.10	49.14	32.76	-16.38	42.84	-1.26	40.32	40.32	0.00	42.84	-1.26
			+			31.50	-17.64	54.18	10.08		39.06	-1.26	46.62	2.52
		With	-		39.06	45.36	6.30	73.08	28.98	36.54	46.62	10.08	52.92	8.82
			+			37.80	-1.26	57.96	13.86		41.58	5.04	61.74	17.64
CD (p=0.05)		Drying phase (D)			0.5137			1.3941		0.955			1.2458	
		Crop (C)			0.5137			1.3941		0.955			NS	
		Soil series (S)			0.5137			1.3941		0.955			1.2458	
		D×C×S			1.0274			2.7883		NS			2.4916	

over 0-day except uncropped Chakdaha soil. Higher amount of accumulation of hydrolysable NH_4^+-N in cropped over uncropped system was due to the liberation of root exudates which was rich in organic nitrogen (Arshad and Frankenberger, 1998). In N-fertilized soil exactly similar trend of results was observed before the maintenance of a drying phase at pre-flowering stage as was found in unfertilized systems. This trend of results was true both in presence and absence of rice crop. Maintenance of a drying phase at pre-flowering stage decreased the hydrolysable NH_4^+-N in soils which was at par with the previous results of unfertilized soils. But in case of added inorganic N the amount of hydrolysable NH_4^+-N decreased at maturity, due to conversion of hydrolysable NH_4^+-N to other forms of N and or losses from the soil system through plant uptake or volatilization (Ghosh et al., 1990).

Irrespective of soils, cropping and drying phases, the amount of amino acid N decreased at pre-tillering over 0-day of the experiment (Table 4). Maintenance of a drying phase or submerged condition at pre-tillering stage decreased the amino acid N content except cropped Taldangra soil. Certainly the drying phase encourages converting amino acid N to other forms of organic N particularly to hydrolysable NH_4^+-N fractions. Higher amount of decrease in amino acid-N in cropped soil leads to suggest that a portion of amino acid N had been utilized by the growing rice crop (Salam et al., 1990). Maintenance of a drying phase or waterlogged situation at pre-flowering stage increased the amino acid-N in both the cropped and uncropped Chakdaha soil. However, a completely reverse trend of results was obtained in Taldangra soil. The decrease in amino acid N in Taldangra soil at pre-flowering stage was due to higher rate of mineralization of this fraction of organic N in soil. This was true for both the cropped and uncropped situations as well as in soils receiving a drying phase or kept waterlogged at pre-flowering stage of the crop. In general, at maturity, the amino acid-N content was found to decrease over 0-day. However, the amount of amino acid N was increased in both the cropped soils which received drying phases at both the pre-tillering and pre-flowering stages of the rice crop. N-fertilization did not show any change in the amount of amino acid N upto pre-tillering stage of the rice crop as was found for unfertilized system. The amino acid N which was temporarily tied up by the microorganisms at pre-tillering stage, was released at maturity showing a net effect of increase in N-fertilized soil (Das and Saha, 2003). Irrespective of soils

Table 3: Effect of drying and submergence at pre-tillering and pre-flowering stage on changes in the amount (mg kg^{-1}) of hydrolysable organic NH_4^+in N-fertlized and unfertilized submerged soils cropped with or without rice

Soil	N-fertilization	Cropping	Drying phase	0 days	Stages after transplanting: Pre-tillering: Effect of dryness or submergence: Before	After	Increase (+) or Decrease (-) due to drying or submergence	Maturity: Amount	Increase (+) or Decrease (-) over 0-day due to drying or submergence	Pre-flowering: Effect of dryness or submergence: Before	After	Increase (+) or Decrease (-) due to drying or submergence	Maturity: Amount	Increase (+) or Decrease (-) over 0-day due to drying or submergence
Chakdaha	Unfertilized	Without	-	290.85	294.00	303.80	9.80	196.00	-94.85	296.10	215.60	-80.50	219.52	-71.33
			+			319.20	25.20	215.60	-75.25		226.80	-69.30	240.80	-50.05
		With	-		259.00	306.74	47.74	272.65	-18.20	288.12	219.52	-68.60	245.00	-45.85
			+			331.10	72.10	245.00	-45.85		284.20	-3.92	303.80	12.95
Taldangra		Without	-	200.55	245.00	288.12	43.12	284.90	84.35	219.80	107.80	-112.00	284.90	84.35
			+			303.80	58.80	207.90	7.35		154.00	-65.80	254.10	53.55
		With	-		238.70	319.20	80.50	303.80	103.25	277.20	182.70	-94.50	392.00	191.45
			+			313.10	74.40	306.74	106.19		192.85	-84.35	303.80	103.25
CD (p=0.05)		Drying Phase (D)			0.5984			0.637		0.6439			0.6953	
		Crop (C)			0.5984			0.637		0.6439			0.6953	
		Soil Series (S)			0.5984			0.637		0.6439			0.6953	
		D×C×S			1.1968			1.2741		1.2878			1.3906	
Chakdaha	Fertilized	Without	-	297.15	306.00	364.00	58.00	178.36	-118.79	303.80	238.14	-65.66	245.00	-52.15
			+			319.20	13.20	303.80	6.65		245.00	-58.80	294.98	-2.17
		With	-		288.12	406.00	117.88	456.68	159.53	296.10	254.10	-42.00	303.80	6.65
			+			331.10	42.98	306.74	9.59		245.00	-51.10	306.74	9.59
Taldangra		Without	-	227.50	280.00	315.00	35.00	186.90	-40.60	254.10	176.40	-77.70	186.90	-40.60
			+			281.40	1.40	205.80	-21.70		215.11	-38.99	245.00	17.50
		With	-		270.90	340.20	69.30	226.38	-1.12	245.70	205.80	-39.90	226.38	-1.12
			+			284.90	14.00	272.65	45.15		238.14	-7.56	254.10	26.60
CD (p=0.05)		Drying Phase (D)			0.5613			0.9424		0.2702			0.3963	
		Crop (C)			0.5613			0.9424		0.2702			0.3963	
		Soil Series (S)			0.5613			0.9424		0.2702			0.3963	
		D×C×S			1.1227			1.8849		0.5403			0.7926	

Table 4: Effect of drying and submergence at pre-tillering and pre-flowering stage on changes in the amount (mg kg^{-1}) of amino acid N in N-fertlized and unfertilized submerged soils cropped with or without rice

Soil	N-fertilization	Cropping	Drying phase	Stages after transplanting										
					Pre-tillering			Maturity		Pre-flowering			Maturity	
					Effect of dryness or submergence					Effect of dryness or submergence				
				0 days	Before	After	Increase (+) or Decrease (-) due to drying or submergence	Amount	Increase (+) or Decrease (-) over 0-day due to drying or submergence	Before	After	Increase (+) or Decrease (-) due to drying or submergence	Amount	Increase (+) or Decrease (-) over 0-day due to drying or submergence
Chakdaha	Unfertilized	Without	-	343.00	406.00	312.20	-93.80	196.00	-147.00	378.00	223.30	-154.70	190.40	-152.60
			+			264.60	-141.40	246.40	-96.60		246.96	-131.04	196.00	-147.00
		With	-		504.00	453.60	-50.40	274.40	-68.60	277.20	372.40	95.20	274.40	-68.60
			+			274.40	-229.60	246.40	-96.60		374.52	97.32	277.20	-65.80
Taldangra		Without	-	342.30	490.00	453.60	-36.40	240.80	-101.50	233.24	224.00	-9.24	200.20	-142.10
			+			340.20	-149.80	226.80	-115.50		246.96	13.72	240.80	-101.50
		With	-		350.00	392.00	42.00	332.00	-10.30	302.40	342.30	39.90	332.00	-10.30
			+			319.42	-30.58	246.40	-95.90		345.80	43.40	336.00	-6.30
CD (p=0.05)		Drying Phase (D)			0.5173			0.5829		0.5084			0.7450	
		Crop (C)			0.5173			0.5829		0.5084			0.7450	
		Soil Series (S)			0.5173			0.5829		0.5084			0.7450	
		D×C×S			1.0347			1.1659		1.0169			1.4900	
Chakdaha	Fertilized	Without	-	407.40	504.00	378.00	-126.00	319.20	-88.20	340.20	493.92	153.72	411.60	4.20
			+			260.40	-243.60	411.60	4.20		444.92	104.72	384.16	-23.24
		With	-		448.00	390.60	-57.40	438.90	31.50	378.00	411.60	33.60	438.90	31.50
			+			387.80	-60.20	478.80	71.40		370.44	-7.56	405.72	-1.68
Taldangra		Without	-	325.50	352.00	223.30	-128.70	352.80	27.30	256.06	274.40	18.34	223.30	-102.20
			+			201.60	-150.40	372.40	46.90		268.80	12.74	205.80	-119.70
		With	-		336.00	325.50	-10.50	370.67	45.17	267.40	384.16	116.76	392.00	66.50
			+			268.80	-67.20	384.16	58.66		356.72	89.32	370.44	44.94
CD (p=0.05)		Drying Phase (D)			0.5198			1.0123		0.509			0.9372	
		Crop (C)			0.5198			1.0123		0.509			0.9372	
		Soil Series (S)			0.5198			1.0123		0.509			0.9372	
		D×C×S			1.0397			2.0246		1.018			NS	

and cropping, the amount of amino acid N increased and then decreased in soils subjected either to a drying phase or kept under waterlogged situation upto pre-tillering stage of the rice crop. The amount of amino acid N was found decreased further and then increased in soils subjected either to a drying phase or kept at waterlogged situation upto pre-flowering stage of the crop. The amount of amino acid N again decreased at maturity stage of the crop and this was observed irrespective of soils, cropping and drying phases either at pre-tillering or at pre-flowering stage of the crop. In general, under N-fertilized system, the amount of amino acid N decreased after the pre-tillering stage but increased after the pre-flowering stage of the crop.

Irrespective of soils and stages of the crop growth, the amount of N-uptake was higher in N-fertilized over the unfertilized system (Table 5). Certainly this was the effect of inorganic N addition. Again, the maintenance of a drying phase either at pre-tillering or at pre-flowering stage increased the amount of N-uptake by the growing rice. This trend of results was observed in both the Chakdaha and Taldangra soils fertilized with or without added inorganic N. Drying caused a higher amount of release of inorganic N from both the fixed as well

Table 5: Effect of drying and submergence at pre-tillering and pre-flowering stage on changes in the amount (mg kg^{-1}) of N uptake by rice cropped in Chakdaha and Taldangra soils in presence and absence of added inorganic nitrogen

Soil	N-fertilization	Drying phase	Stages after transplanting									
			Pre-tillering			Maturity		Pre-flowering			Maturity	
			Effect of dryness or sub-mergence					Effect of dryness or sub-mergence				
			Before	After	Increase (+) or Decrease (-) due to drying or submergence	Amount	Increase (+) or Decrease (-) in post submergence or drying phase	Before	After	Increase (+) or Decrease (-) due to drying or submergence	Amount	Increase (+) or Decrease (-) in post submergence or drying phase
Chak-daha	Without	-	8.74	17.46	8.72	10.75	-6.71	9.41	13.79	4.38	10.73	-3.06
		+		18.20	9.46	16.13	-2.07		18.82	9.41	16.17	-2.65
	With	-	10.56	20.26	9.70	20.85	0.59	13.45	16.46	3.01	20.83	4.37
		+		20.85	10.29	21.80	0.95		18.83	5.38	21.03	2.20
Taldan-gra	Without	-	8.39	16.81	8.42	12.82	-3.99	12.79	14.46	1.67	12.79	-1.67
		+		17.08	8.69	15.54	-1.54		19.49	6.70	13.46	-6.03
	With	-	15.84	18.82	2.98	13.91	-4.91	19.16	19.14	-0.02	13.41	-5.73
		+		19.46	3.62	17.70	-1.76		19.79	0.63	14.59	-5.20
CD (p=0.05)	Drying Phase (D)		NS			2.1486		1.6671			NS	
	Nitrogen (N)		2.0628			2.1486		1.6671			1.6310	
	Soil Series (S)		2.0628			NS		1.6671			1.6310	
	D×N×S		NS			NS		NS			3.2620	

as from the organic forms of N (Chakraborty, 2001) which was taken up by the crop showing the net effect of increase in N-uptake by the rice crop grown in soils subjected to a drying phase either at pre-tillering or at pre-flowering stage over that of soil maintained under continuous submergence. Results further showed that in general, irrespective of soils and drying phases, the amount of N-uptake was found to decrease at maturity over that of pre-tillering and pre-flowering stages of the crop. This was because of the lower N-content as well as dry matter yield of the rice plant at maturity stage (Saha and Mukhopadhyay, 1986b). Maintenance of a drying phase either at pre-tillering or at pre-flowering or at both the stages favoured to consume higher amount of nitrogen from the soil systems by the of rice crop.

4. Conclusion

Maintenance of drying phases at both the pre-tillering and pre-flowering stages of rice increased exchangeable NH_4^+but decreased soluble NO_3^--N content in soils. However, maintenance of drying phase at both the stages of crop growth did not follow similar trend of results particularly with respect to hydrolysable NH_4^+fraction. Conversion from one form to another form of organic N is recorded. Comparatively higher amount of N is taken up by the rice which is subjected to drying phases at both the stages of crop growth.

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