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Changes in total N in a waterlogged acid soil cropped with rice and subjected to different drying phases

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Abstract

An investigation was carried out to monitor the changes in total N in a waterlogged acid soil subjected to a drying phase at different growth stages (pre-tillering and pre-flowering) of the rice crop. Total N was estimated by the method of Bremner (1996). Results revealed that irrespective of cropping, drying at pre-blowering stage decreased the loss of total N in acid soil which is not treated with inorganic N. However, in presence of N-fertilizer, the decrease in the amount of total N increased in acid soil. The acid soils that are subjected to a drying phase at pre-flowering stage of rice crop decreased the total N content in cropped over the uncropped acid soil.

Highlights

- Drying at pre-flowering stage of rice crop is more effective in accumulation of total N in rhizophore acid soil than a drying phase at pre-tillering stage of waterlogged acid soil.
- The order of increase in total N in acid soil subjected to drying phase at pre-flowering stage is of lower order in cropped over the uncropped acid soil

Keywords: Acid soil, total N, drying phase, pre-tillering stage, pre-flowering stage, rice crop.

Mineralization of N from soil varies due to various factors like soil characteristics, different management practices, climate, cropping etc. As it is now well established that native soil N- transformation is different from that of fertilizer N (Saha 1997), it is necessary to understand the N-transformation process, which ultimately influence the N-uptake by plants. Moisture is an important factor for the growth of microorganisms and in controlling the rate of organic matter decomposition. Presence of moisture corresponding to waterlogged situation is not congenial for microbial activity, because higher the moisture present in soil less the oxygen available for microbial growth. On the other hand, Stanford and Epstein (1974) reported that with increasing dryness N-mineralization tend to decrease.

Drying soils in continuously flooded situation caused an increase in the yield of rice (IRRI 1974), which was explained as possible N effects. The present

investigation was carried out to study the changes in the amount of total N in a waterlogged acid soil subjected to a drying phase either at pre-tillering or at pre-flowering or at both the stages of rice crop.

Materials and Methods

Soil (0–15 cm depth) used in the present investigation was composite sample of cultivated field and was collected from Taldangra village in the district Bankura, West Bengal. Relevant physical and chemical characteristics of the soil are: pH (1: 2.5) 5.4, Mechanical separates sand (%) 45.4, silt (%) 25.0 and clay (%) 29.4, EC (dSm^{-1}) 0.24, WHC (%) 41.94, Organic Carbon (%) 0.41, Cation exchange capacity [cmol (p+) kg^{-1}] 5.06, Available N (mg kg^{-1}) 97.74 and Total N (%) 0.061. The soils were air dried and passed through 2 mm sieve. The experiment was conducted with 1.5 kg air dried soil in each earthen pot. The holes of the pots were sealed to check the leaching loss. Three one month old rice seedlings (variety IET-4786) were transplanted in each pot. Phosphorous and potassium were added at 60 kg P_2O_5 and 60 kg K_2O ha^{-1} in the form of single superphosphate and muriate of potash respectively to each pot as basal application. Four treatments were maintained in the present investigation. The treatments were:

(1) Water logging up to maturity stage of the rice crop.

(2) Maintenance of a drying phase at pre-tillering stage.

(3) Maintenance of a drying phase at pre-flowering stage, and

(4) Maintenance of drying phases at both pre-tillering and pre-flowering stages.

An uncropped set of pot was maintained following the same treatment to study the effect of cropping. All the pots were treated with or without inorganic N at 120 kg ha^{-1} in the form of $(NH_4)_2SO_4$ as basal application. All the treatments are replicated thrice.

Soil samples were collected on 0^{th}, 25^{th}, 40^{th}, 55^{th}, 70^{th} and 90^{th} day after transplanting of rice seedlings. The 25^{th} and 40^{th} as well as 55^{th} and 70^{th} day of the experiment corresponds to time of starting and ending of the drying phases at pre-tillering and pre-flowering stages of rice crop respectively. The 90^{th} day corresponds to maturity stage of the crop. Rhizosphere soil samples were collected from cropped pots by uprooting the plants carefully as outlined by Das and Mukherjee (1998). Soil samples from uncropped pots of each treatment were also analysed immediately. Total N was estimated by the method of Bremner (1996). As the total N was estimated from the soil after removal of available N by 2 M KCl extraction, the total N was calculated as the sum of total N determined after 2 M KCl extraction and estimation of available N.

Results and Discussion

Results of changes in the amount of total N in a waterlogged acid soil in presence and absence of a drying phase at pre tillering stage of rice crop is presented in Table 1. Data reveal that irrespective of cropping and N-fertilisation, the amount of total N decreased on 40^{th} day of crop growth. Again, the decrease in total N content is more in uncropped than that of cropped system. Presence of crop changes microenvironment in rhizosphere soil. Roots of crops liberate exudates which are rich in protein. Soil microorganism utilizes these exudates for their growth and activities (Arshad and Frankenberger 1998). The increased microbial population not only fix atmospheric N_2 but also add nitrogen to the soil when they are died and results comparatively lesser amount of decrease in total N is cropped system.

Irrespective of cropping, drying at pre-tillering stage decreases the loss of total N in soil which is not treated with inorganic N. However, in presence of N-fertiliser, the decrease in the amount of total N increases. Drying creates a favourable environment for microorganisms in rhizosphere soil (Saha and Mukhopadhyay 1983) which leads to a greater decomposition of organic N and in turn loss of total N from the soil system. In presence of N certainly the loss of total N is more showing a net decrease in the system. At maturity the amount of total N increased in soil. This trend of results is obtained irrespective

of cropping, N-fertilisation and drying phases. It is interesting to note that the soils which are subjected to a drying phase at pre- tillering stage showed comparatively lesser amount of increase in total –N. This trend of result is observed irrespective of cropping and N-fertilisation. Data (Table 1) further pointed out that drying phase at pre-tillering stage of rice crop decreased the total N content in cropped over the uncropped system. The results thus leads to conclude that drying phase is beneficial for crops in utilizing total N from the rhizosphere soil either in presence or absence of inorganic N.

Table 2. Maintenance of drying phase at pre-flowering stage of rice crop completely changed the pat ern of results, which was observed at pre-tillering stage (Table 2).

Changes in the amount of total N in a waterlogged acid soil in presence and absence of a drying phase at pre-flowering stage of rice crop is presented in Here, irrespective of cropping and drying phases, the amount of total N increased in an acid soil on 90th day of crop growth. Results further reveal that the drying phase increased the total N content in soil. This trend of results is obtained in both in N-treated and untreated as well as in cropped and uncropped situations. Due to drying, certain amount of clay fixed NH_4^+ - N is released (Saha and Mukhopadhyay 1986) which in turn increased the total N content in a dried soil. At maturity, the amount of total N goes on increasing in soils which are not treated with inorganic N but decreased in N-treated system. This trend of result is obtained both in presence and

Table 1: Changes in the amount (mg kg^{-1}) of total N in a water logged acid soil in presence and absence of a drying phase at pre-tillering stage of rice crop

Treatments			Days after transplanting						
Cropping	N fertili-zation	Drying phase	0	25		40		90	
				A	B	A	B	A	B
Uncropped	Without	-	601.66	435.18	-166.48	390.60	-44.58	825.91	+435.31
		+	601.66	435.18	-166.48	400.32	-34.86	752.21	+351.89
	With	-	696.17	601.66	-94.51	434.63	-167.03	563.36	+128.73
		+	696.17	601.66	-94.51	442.89	-158.77	878.22	+435.33
Cropped	Without	-	601.66	567.94	-33.72	308.52	-259.42	881.93	+573.41
		+	601.66	567.94	-33.72	563.36	-4.58	764.64	+201.28
	With	-	696.17	648.31	-47.86	492.98	-155.33	689.46	+196.48
		+	696.17	648.31	-47.86	429.16	-219.15	738.96	+309.8
LSD (P=0.05)	Effect of treatments between days		25 and 40		0 and 40		25 and 90		0 and 90
	Drying		NS		NS		NS		NS
	Nitrogen		62.09		NS		NS		NS
	Crop		NS		NS		NS		NS
	Dr × N		87.80		NS		NS		NS
	Dr × Crop		NS		NS		NS		NS
	N × Cr		NS		NS		NS		NS
	D × N × C		124.18		NS		NS		NS

A = Amount in mg kg^{-1}
B = Decrease (-) / Increase (+) over the previous day.

Table 2. Changes in the amount (mg kg^{-1}) of total N in a waterlogged acid soil in presence and absence of drying phases at pre-flowering stage of rice crop

Treatments			Days after transplanting						
Cropping	N fertili-zation	Drying phase	O	25		40		90	
				A	B	A	B	A	B
Uncropped	Without	-	601.66	472.43	-129.23	552.1	+79.67	825.91	+273.81
		+	601.66	472.43	-129.23	555.66	+83.23	755.63	+199.97
	With	-	696.17	507.58	-188.59	716.96	+209.38	487.09	-229.87
		+	696.17	507.58	-188.59	776.76	+269.18	383.90	-392.86
Cropped	Without	-	601.66	513.99	-87.67	796.00	+282.01	881.93	+85.93
		+	601.66	513.99	-87.67	825.91	+311.92	826.15	+0.24
	With	-	696.17	609.38	-86.79	721.61	+112.23	689.45	-32.15
		+	696.17	609.38	-86.79	800.3	+190.92	587.65	-212.65

	Effect of treatments between days	25 and 40	0 and 40	25 and 90	0 and 90
LSD (P=0.05)	Drying	NS	NS	NS	NS
	Nitrogen	NS	NS	105.48	97.94
	Crop	57.03	74.29	NS	97.94
	Dr ´ N	NS	NS	NS	NS
	Dr ´ Crop	NS	NS	NS	NS
	N ´ Cr	80.65	105.06	NS	NS
	D ´ N ´ C	NS	NS	NS	NS

A = Amount in mg kg^{-1}
B = Decrease (-) / Increase (+) over the previous day.

absence of crop. However, the increase in total N is of lower order in cropped over the uncropped system because of utilization of total N by the rice. Data in Table 2 also reveal that in presence of inorganic N, the amount of total N decreased in soil which received a drying phase at pre-tillering stage of a rice crop. However, in presence of N fertilizer, the amount of total N increased but the increase is of lower order in soil which has received a drying phase at pre-tillering stage. This trend of results is obtained both in presence and absence of crop.

Irrespective of cropping and N fertilization, the amount of total N in soil decreased at pre-tillering and increased at pre-flowering stage of the rice due to maintenance of consecutive drying phases at those growth stages of crop (Table 3). The results pointed out that drying at pre-flowering stage is more effective in accumulation of total N in rhizosphere soil than a drying phase at pre-tillering stage of waterlogged acid soil. In cropped soil situation certain amount of root exudates rich in protein are liberated at pre-tillering stage and counteract the higher amount of decrease in total N which was found in uncropped situation. No doubt a drying phase at pre-flowering stage had beneficial effect so far total N accumulation in soil is concerned. The order of increase in total N at pre-flowering stage is of lower order in cropped in comparison to uncropped system. At flowering stage of a rice crop, nitrogenase activities (Saha and Das 2003) as well as the growth

Table 3: Changes in the amount (mg kg^{-1}) of total N in a waterlogged acid soil in presence and absence of a drying phase at pre-tillering and pre–flowering stage of rice crop

Treatments		Days after transplanting					
Cropping	N fertilization	25	40		55	70	
			A	B		A	B
Uncropped	Without	435.18	400.32	-34.86	557.40	793.94	+236.54
	With	724.41	442.89	-281.52	579.64	833.32	+258.68
Cropped	Without	567.94	563.36	-4.58	518.40	724.62	+206.22
	With	648.31	429.16	-219.15	606.28	843.85	+237.57
LSD (P=0.05)	Treatments	Effect between days				Effect due to drying	
		25 and 55	40 and 55	25 and 70	40 and 70	1st	2nd
	Nitrogen	101.46	NS	NS	NS	101.06	NS
	Crop	NS	NS	NS	NS	NS	NS
	N × C	NS	105.29	NS	NS	NS	NS

A = Amount in mg kg^{-1} B = Decrease (-) / Increase (+) over the previous day.

and activities of free living microorganisms which fix atmospheric nitrogen is highest (Saha and Das 2003) and as a result of which higher amount of total N is accumulated in rhizosphere soil at pre flowering stage of rice crop. Apart from that the released fixed NH_4^+ due to drying also increases the total N content in rhizosphere soil. However, plant uptake of N showed a decrease in total N content in cropped over the uncropped system.

So it can be concluded that drying at pre-flowering stage is more effective in accumulation of total N in rhizosphere soil than a drying phase at pre-tillering stage of waterlogged acid soil.

Conclusion

Maintenance of drying phase at pre-flowering stage of rice is more effective in accumulation of comparatively higher amount of total N in rhizosphere soil than that of a drying phase at pre – tillering stage of a water logged acid soil.

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