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Carbon: Nitrogen Ratio in Flooded Rice Soils under Wet Analysis Regime

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Abstract—*Rice is grown under varying degrees of submergence. In soil test based recommendation, nitrogen is applied based on the organic carbon status, assuming that the C:N ratio stabilizes at 10:1. As per recommendations, for soils with high organic matter, under submergence, nitrogen rates are to be reduced since the organic carbon content is very high. But if the nitrogen doses are reduced, crop is found to be suffering from N deficiency. Hence, it becomes mandatory to study the chemistry and pattern of decomposition of organic matter as well as carbon: nitrogen relations in these soils under anaerobic flooded conditions to know the equilibrium C:N ratio and the time taken for equilibration. Major rice growing tracts in state coming under 3 agro-ecological units (AEU's) were selected namely, Kuttanad (AEU 4), Pokkali (AEU 5), Kole (AEU 6). Soil samples were collected at 3 stages viz. the first before starting rice cultivation (initial) and the second and third at active tillering (AT) and visual panicle initiation stages (VPI) respectively. Soil sampling was done using core sampler from 0-20 cm depth without disturbing the reduced condition as far as possible. Samples were sealed as such and used for wet analysis for estimating nutrient status. Our results demonstrate that the C:N ratio in these soils was not stabilized at 10:1. This is because under anaerobic flooded conditions the rate of decomposition of organic matter is slower than under oxidized aerobic environment resulting in wider C:N ratio at equilibrium.*

Keywords*: Rice. C:N ratio. flooded condition. wet analysis*

1. INTRODUCTION

Kuttanad, *Pokkali* and *Kole* lands of Kerala are located 1-2 m below mean sea level. Kuttanad and Kole are potentially acid sulphate soils with high acidity and high organic matter content. Pokkali soils are acid saline in nature influenced by sea water inundation. These soils under flooded anaerobic environment behave differently with respect to dynamics and transformation of nutrient elements.

Soil test based fertilizer recommendation for rice at present is based on analysis of soil samples after drying and processing. However, the chemistry and dynamics of nutrient transformations under anaerobic soil environment is quite different from that of aerobic soils as detailed by Ponnamperuma (Ponnamperuma, 1972). Thus, analysis after drying definitely changes the levels of plant available forms due to oxidation and subsequent transformations. Hence, the analytical results may not reflect the actual status of plant available pools of nutrient in flooded environment. Thus, to get a real picture of nutrient availability in flooded anaerobic environment samples are to be taken as such without disturbing the reduced anaerobic environment and to be analyzed.

In general, the acid sulphate and acid saline soils of Kerala are rich in organic matter. This naturally resulted in high organic carbon status in these soils. In soil test based recommendation, nitrogen is applied based on the organic carbon status assuming that the C:N ratio tend to stabilize at 10:1. The organic carbon based nitrogen recommendation is relied on for fertilizer recommendation because more than 95 percentage of nitrogen in soil exists in organic form associated with organic matter. As per recommendations, for such soils with high organic matter under submergence nitrogen rates are to be reduced since the organic carbon content is very high. But if the nitrogen doses are reduced crop is found to be suffering from N deficiency. This is because under anaerobic flooded conditions the rate of decomposition of organic matter is a bit slower than under oxidized aerobic environment and the stabilization of C:N ratio definitely will take more time and the ratios naturally may attain stability at wider levels much above than 10:1, particularly when analysis is carried out maintaining the reduced atmosphere which is depicting the real rhizosphere environment of the standing rice crop. Further, attainment of stability of C:N ratio to a constant value (eg. 10-12:1 in tropical aerobic soils) may take different periods of time depending on the initial organic matter status of the soil, C:N ratio of added organic matter as well as the rate of decomposition. The enhanced rate of carbon sequestration as reported from flooded rice soils is due to lower rate of decomposition under anaerobic environment (Lal, 2004). Hence, it becomes mandatory to study the chemistry and pattern of decomposition of organic matter as well as carbon nitrogen relations in these soils under anaerobic flooded conditions to know the equilibrium C:N ratio and the time taken for equilibration. This in turn will definitely help to have a meaningful organic carbon based nitrogen recommendations.

The above background information necessitated the present study with the following objectives:

- Developing a methodology for sampling and analysis of flooded soils in comparison with routine analysis of dried samples
- To study the C:N ratio equilibrium under anaerobic soil environment so as to develop ratings for nitrogen fertility based on organic carbon content under submerged soil.

2. MATERIALS AND METHODS

The present investigation was carried out at Radiotracer laboratory, College of Horticulture, Kerala Agricultural University, Thrissur during 2012-2014. In order to achieve the objectives of the present investigation, major rice growing tracts in state coming under 3 agro-ecological units(AEU's) were selected namely, *Kuttanad* (AEU 4), *Pokkali* (AEU 5), *Kole* (AEU 6).The details of locations and soil samples collected are furnished in table 1.

Table 1: Locations of soil sampling, soil taxonomy and agro-ecological units

Soil sample No	Soil type	Location	Soil taxonomy	Agroecological unit
1	Kuttanad (1)	Poovathikkari,Vechoor, Vaikom N 09°41.026' E 076°26.666'	Entisol	Kuttanad (AEU 4)
2	Kuttanad (2)	C.K.N Block, Thottakam, Vaikom N 09°43.691' E 076°25.582'	Entisol	Kuttanad (AEU 4)
3	Kuttanad (2)	Kaayippadam, Karumadi N 09°22.795' E 076°23.231'	Entisol	Kuttanad (AEU 4)
4	Pokkali (1)	RRS campus, Vytilla N 09°58.568' E 076°19.34'	Entisol	Pokkali lands (AEU 5)
5	Pokkali (2)	Kottuvalli N 10°06.746' E 076°14.085'	Entisol	Pokkali lands (AEU 5)
6	Pokkali (3)	Kottuvalli N 10°06.751' E 076°14.341'	Entisol	Pokkali lands (AEU 5)
7	Kole (1)	Vadakkekonchira, Vengidangu N 10°30.773' E 076°06.292'	Entisol	Kole lands (AEU 6)
8	Kole (2)	Manalurthazhum padavu N 10°29.211' E 076°07.633'	Entisol	Kole lands (AEU 6)
9	Kole (3)	Ponnamotha N 10°30.975' E 076°07.129'	Entisol	Kole lands (AEU 6)

2.1 Collection of soil samples

Soil samples were collected at 3 stages viz. the first before starting rice cultivation and the second and third at active tillering and visual panicle initiation stages of rice crop. Plant samples were also collected during the above stages of the crop.

2.2 Method of collection and preparation of soil samples

The first sample before the rice crop was collected and air dried, sieved through 2 mm sieve and the processed samples were used for characterization. The surface soil samples (0-20 cm) collected before cropping season were used for characterization with respect to organic carbon, total C and N. Both wet and air dried samples collected during cropping season were also characterized for organic carbon, total C and N. The soil samples were collected and used for analyses as detailed below.

2.3 Procedure for sampling and analysis of soil from lowlands

Soil sampling was done using core sampler from 0-20 cm depth without disturbing the reduced condition as far as possible. Part of the sample was sealed as such and used for wet analysis, while the remaining part was dried, processed, sieved through 2 mm sieve and analyzed by routine methods (Plates 1 to 4). The initial soil samples as well as both wet and dried samples collected during 2nd and 3rd stages were analyzed for organic carbon, total carbon and nitrogen. The data on both wet and dry analysis of soil samples was correlated with nutrient content in plant at the corresponding stages.

Plate 1: Soil sampling in lowland

Plate 2: Soil samples collected using core sampler at a depth of 0 to 15cm

Plate 3: Transferring soil samples to polythene cover

Plate 4: Sealed and labeled soil sample for analysis

2.4 Expression of results of wet analysis

To express the results of wet analysis, the moisture content of the sample were estimated gravimetrically. In order to find out the moisture percentage, an initially weighed soil (W1) sample was kept in the hot air oven at 105°. After drying, the sample was again weighed (W2). Percentage of moisture= [(W1-W2)/W1] x 100. Suppose a soil contains 80 % moisture, the actual percentage weight of the soil on wet basis is 20 %. Hence, if 5 g soil was taken for analysis, actual dry weight = 5 x 20/100= 1 g.

2.5 Collection and analysis of plant samples of rice

Soil and plant samples of rice were collected from the same locations during the crop seasons at two stages viz., at active tillering and visual panicle initiation stages. The plant samples were oven dried at 70 ± 5°C, powdered and estimated the contents of total N in different plant parts namely, root, shoot and panicle.

2.6 Methods of soil and plant analysis

Total C and N were estimated by CHNS analyzer (Model: Elementar's vario EL cube)

2.7 Statistical analysis

The data on soil analysis were correlated with soil properties as well as the concentrations of different elements in the plant. Spearman's ranked correlation was done after cross tabulation based on weightage given to highly variable parameters in soils based on their ranges.

3. RESULTS AND DISCUSSION

Table 2: Changes in total C: total N (C:N) ratio under wet analysis regime

AEU	Initial	AT	VPI
Kuttanad	21.53	18.23	17.30
Pokkali lands	9.78	17.20	12.32
Kole lands	12.93	15.54	13.05

AT: active tillering; VPI: visual panicle initiation

The C: N ratio was found to be lower in Kuttanad soil when computed on wet analysis basis in comparison with initial and at active tillering stage which means that the ratio was found to steadily and slowly decreasing from 21.53 to 17.30 during the period of crop growth. The C: N ratio in Pokkali on wet basis showed a sudden increase from 9.78 (initial) to 17.20 (active tillering stage) and further reduced to 12.32 in visual panicle initiation. Here, the ratio may stabilize in and around 12. In Kole lands the trend was very similar to Pokkali soil but the increase was only marginal.

Table 3: Spearman's ranked correlations

Parameter	Spearman's correlation coefficient
Between total carbon and shoot N at AT stage	0.55**
Between total carbon and root N at VPI stage	0.46*

Between total carbon and panicle N at VPI stage	0.58**
Between OC and shoot N at AT stage	0.57**
Between OC and root N at VPI stage	0.49*
Between OC and panicle N at VPI stage	0.60**
Between C:N ratio and panicle N at VPI stage	0.63**

OC: organic carbon

Significant correlation was obtained with total carbon, organic carbon and C:N ratio based on total carbon and total nitrogen with plant nitrogen at active tillering and visual panicle initiation stages significant at 1 and 5 % levels.

4. CONCLUSION

Under anaerobic flooded conditions the rate of decomposition of organic matter is slower than under oxidized aerobic environment resulting in wider C:N ratio at equilibrium. Hence, it becomes mandatory to study the chemistry and pattern of decomposition of organic matter as well as carbon nitrogen relations in the soils under anaerobic flooded conditions to know the equilibrium C:N ratio and the time taken for equilibration. This in turn will definitely help to have a meaningful organic carbon based nitrogen recommendations which ultimately modify the present recommendation.

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