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SOIL TESTING METHODS FOR NITROGEN

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Introduction

Nitrogen (N) is almost universally deficient in Indian soils. For judicious use of fertilizer N it is imperative to know the N supplying capacity of soils because soils differ in their ability to supply N to crops. Nitrogen that becomes available to crops during the growing season forms a very small fraction of the total soil N. Organic N accounts for over 90% of the total N in most soils and is made available to plants through the mineralization process which converts organic nitrogen into ammonium and is carried out by a host of heterotrophic soil microorganisms. While in the upland soils, the ammonium formed through mineralization is converted to nitrate via nitrite, in the flooded rice soils, mineralization usually stops at ammonium stage because nitrification is an aerobic process.

Several soil testing methods have been proposed for assessing the pool of available soil N. Before discussing the methods proper, it would be prudent to briefly discuss the methodologies used for taking soil samples and their processing because these affect the results obtained by the soil we tests.

Soil sampling and preparation of the samples

Soil testing for fertility evaluation involves three steps: soil sampling, processing of the soil samples, and its

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testing in the laboratory. Needless to emphasize that our soil testing would be as good as our soil samples are representative of the experimental site or plot. A number of soil core samples are taken to form a composite sample to represent a treatment or plot. The number of cores to be taken would depend on the soil variability. The experimental plot should be divided in such a way that it represents the mean fertility level of the area.

Usually more than 20 cores should be taken for normal experimental plots to form a composite sample from the surface (0-15 cm) soil. Sampling of the subsurface is usually optional but may be useful for upland crops particularly in situations where crops are grown on stored moisture. In such case, nitrate profiles would be a useful index of nitrogen supplying capacity of soils.

The diameter of the core sampler would also influence the number of soil samples to be taken. Naturally more soil cores would be needed when sampled with a soil sampler of narrower diameter. Usually a soil sampler of about 2" dia. is suggested.

After soil sampling, the composite sample is thoroughly mixed and air-dried in shade. It is usually gently ground with a procelain mortar and a wooden pestle to pass through a 2-mm sieve. The soil is again mixed and a representative sample taken. For organic C and total N determination the soil samples are ground to pass a 0.5 mm. sieve. The prepared sample is then tested in the laboratory for available N using various methods.

Soil testing methods

Several biological and chemical methods have been proposed for assessing the pool of potentially available N that may be made available for crop growth by mineralization of soil organic nitrogen during the growing season (for review and details see Keeney, 1982; Stanford, 1982; Sahrawat, 1983). These methods are briefly discussed here with examples.

Biological methods

Among the methods used for soil testing for N, the biological methods involving aerobic and anaerobic incubation methods though time consuming are useful because they measure the nitrogen released by the mineralization process. Details of these methods are given in Keeney (1982) and Sahrawat (1983).

The underlying principle of these methods is that when a soil is incubated under laboratory conditions at optimum temperature and moisture conditions for short periods (7 days to several weeks), it quickly releases the mineral N, and the amount released is an index of the capacity of the soil to supply N. Both aerobic and anaerobic incubation methods are used for assessing the availability of soil N to upland crops, and anaerobic or waterlogged incubation test is used for wetland rice soil conditions. The soil sample is incubated under aerobic or waterlogged conditions at 30°C for 2 weeks or more and the amount of mineral N released during the incubation period is determined.

The waterlogged incubation method is more simple and

easy to adopt, because only ammonium released is measured and aeration is not a problem. Also the waterlogged incubation test is very versatile to a range of temperatures. For example, incubation of soil sample at 40°C for 7 days under waterlogged conditions can be used as an index of soil N availability. Adoption of this method would shorten the incubation period from 2 weeks to 1 week and thus make it more rapid.

The results of incubation methods are affected by the way the soil samples are processed before the conduct of the test. For example, air-drying of samples and their rewetting can alter the pattern of nitrogen release. The best way out perhaps would be to air dry the soil samples quickly by spreading in thin layer in shade.

A number of studies evaluating the incubation methods (both aerobic and anaerobic) under greenhouse and field conditions have been reported. It has been generally found that these tests are more successful in predicting the availability of soil N to upland crops and wetland rice under greenhouse conditions than under field conditions (Tables 1 and 2). It is mainly due to the interactions of mineral N and water under field conditions which results in the loss of available N either by denitrification or leaching. However, it has been found that nitrate profiles of soils could be a good index of N availability particularly in situations where there is minimal interaction between rainfall and nitrogen for example, when crops are grown on the stored moisture in post rainy season.

Chemical methods

Incubation methods though useful as tests of soil nitrog availability to plants are time consumin . Apart from time-consuming, the results obtained by incubation methods are affected by the way the samples are processed or prepared before a test. On the other hand, chemical methods are rapi and simple. A number of chemical methods have been proposed for assessing the availability of soil N to crops.

Ideally chemical methods that selectively extract the fraction or fractions of soil organic N that contributes to biological mineralization of organic N can be used for asses ing the availability of soil N. However, in practice, it is rather difficult with a simple chemical method to simulate the biological process of soil N mineralization and usually chemical methods are first standardized with incubation methods before evaluating them under greenhouse and field conditions.

The chemical methods employed in soil testing for N vary from organic C content of soils to the use of various extractants under varying concentrations and experimental conditions. The underlying principle in using the chemical methods is the release of mineral N from soil organic N by the oxidative and or hydrolytic action of the reagents used. List of commonly used chemical methods is given in Table 3. The correlations between the soil test values determined by various chemical methods and organic C, total N, and the incubation methods for 30 Philippine soils are given in Table 4.

The success with chemical methods have been mixed as with the biological methods. However, it would appear from the review of the work that at times organic C measurement could be a useful index for assessing soil N availability particularly in soils with a range in organic matter content belonging to a region with similar climatic conditions. Perhaps incorporation of some aspect of the quality of organic matter in addition to its quantity might further improve its capability as a test for soil N availability (Sahrawat, 1983).

Alkaline permanganate is the most widely tested method in India for upland and wetland rice soils. Several modification of the method orginally proposed for measuring the available N in manures (AOAC, 1930) are available. The method proposed by Subbiah and Asija (1956) is widely used in India. It has been found that the method is more successful in predicting the availability of soil N to wetland rice than for the arable crops. Recently, Sahrawat and Burford(1982) suggested that the noninclusion of nitrate N that commonly accumulates in upland soils in the available N pool might be the reason for the poorer predictability usually obtained by this method for upland crops. Nitrate formed in wetland soils are of little consequence to rice because they would be lost by denitrification however, nitrate could be important for upland crops specially in the post rainy season.

Recent literature pertaining to the use of chemical methods for soil testing for N for upland crops and wetland rice have been summarised by Stanford (1982), Keeney (1982)

and Sahrawat (1983).

Summary and conclusions

Soil testing is helpful in the judicious use of fertilizer N by regulating N application as per the N supplying capacity of soils. However, soil testing for N has not been very successful because of interaction between mineral N released and soil water. Also the previous crop history for example the use of legumes in crop rotation can affect the N supplying capacity of soils. Previous crop history should be considered while using soil tests for N in different cropping systems rotations, which are becoming more common than the sole cropping.

Soil testing has been more frequently used for irrigated agriculture, where it is more likely to be successful as opposed to its use under dryland conditions. Dryland agriculture poses a great challenge to soil scientists for devising soil testing methods that take into account nitrogen and soil water regime interactions not only in the excess moisture range but also in the soil moisture deficit range. Consideration of the temperature prevalent during the growing season of a crop is also important because it not only affects N availability but also affects plant growth and the availability of other nutrients. It should,however, be, borne in mind that in review of the diverse soil and climatic conditions (where cropping is done) that affect soil N availability, a single soil test for N may not find universal acceptance.

REFERENCES

AOAC, Association of Official Agricultural Chemists 1930. Fertilizers general methods. In Official and tentative methods of analysis of the AOAC, Washington, D.C. Chap.2.

Keeney, D.R. 1982- Nitrogen-availability indices. In A.L. Page R.H. Miller, and D.R. Keeney(eds.) Methods of Soil Analysis, Part 2. American Society of Agronomy, Madison, Wisconsin, pp. 711-733.

Sahrawat, K.L. 1983. Nitrogen availability indexes for submerged rice soils. Advances in Agronomy 36: 415-451.

Sahrawat, K.L., and Burford, J.R. 1982. Modification of the alkaline permanganate method for assessing the availability of soil nitrogen in upland soils. Soil Science 133: 53-57.

Stanford, G. 1982. Assessment of soil nitrogen availability. In F.J. Stevenson (ed.). Nitrogen in Agricultural Soils. American Society of Agronomy, Madison, Wisconsin, pp. 651-688.

Subbaiah, B.V., and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. Current Science 25: 259-260.

Table 1. Correlations between values of available soil N by different methods with drymatter yield and N uptake of rice in a greenhouse pot study*

Available N method	Correlation coefficient(r	
	Drymatter weight	N uptake
Organic C	0.45**	0.82**
Total N	0.46**	0.84**
Anaerobic incubation, 30°C(2 weeks)	0.40*	0.84**
Anaerobic incubation, 40°C(1 week)	0.46**	0.82**
Alkaline $KMnO_4$	0.40*	0.81**
Acid $KMnO_4$	0.39*	0.75**
Acid $K_2Cr_2O_7$	0.39*	0.74**
H_2O_2	0.46**	0.82**
H_2SO_4(0.5M)	0.10ns	0.42**

* The study was carried out with 39 soils with a wide range in pH, texture and organic matter content.

Source: Sahrawat (1983).

G-6/10

Table 2. Correlation coefficients (r) between soil N availability methods and rough rice yields at 34 locations in Louisiana (USA) without application of fertilizer N[a]

N availability method	Correlation coefficient(r)
Total N	0.363**
Alkaline $KMnO_4$	0.273**
Anaerobic inbuation	0.560**
Aerobic incubation	0.433**
Autoclavin_ in 0.01M $CaCl_2$	0.352**

[a] Adapted from Dolmat et al (1980). Experimental plots received 24.6 kg P/ha and 46.5 kg K/ha.

Source: Sahrawat (1983)

Table 3. Some chemical methods used soil for testing [G-6] for N

Organic C* (Organic matter)
Total N
Mineral N (NH_4 + NO_3 or NO_3)
Alkaline permanganate digestion
Acid permanganate extraction
Acid dichromate extraction
Hydrogen peroxide oxidation
Extraction with dilute H_2SO_4
Autoclaving in $CaCl_2$(0.01 M)
Hydrolysis with NaOH or $Ca(OH)_2$
Boiling in $CaCl_2$ (0.01 M)

Source: Sahrawat (1983)

Table 4. Correlations between chemical methods of available N and organic C, total N, and mineralisable N measured by anaerobic incubation methods[a] G-6/12

Chemical method	Correlation coefficient(r)			
	Organic C	Total N	Incubation methods	
			30°C, 2 weeks	40°C, 1 week
Alkaline $KMnO_4$	0.855	0.882	0.859	0.812
Acid $KMnO_4$	0.839	0.845	0.800	0.768
Acid $K_2Cr_2O_7$	0.830	0.855	0.858	0.828
H_2O_2 oxidation	0.814	0.840	0.855	0.795
H_2SO_4 extraction	0.440	0.461	0.541	0.457

[a] Data obtained with 39 Philippine wetland rice soils

Source: Sahrawat (1983)