Omonrice 9: 46-54 (2001)

Prediction of crop nitrogen uptake and grain yield response by soil nitrogen availability tests for irrigated lowland rice and comparison to laboratory indices

Thach Thi Ngoc Anh[1], Daniel C. Olk[2]

ABSTRACT

Nitrogen (N) fertilizer use efficiency in irrigated lowland rice could be improved if fertilizer recommendations were based on the native soil fertility, or indigeous N supply (INS), the primary objective of this study was to identify simple laboratory tests that reasonably approximate the INS in farmers' fields when defined as the differences in plant N uptake (PNU) or grain yield (GY) in unfertilized (-F) plots and plots located within the same farmers' field that received adequate levels of N and K fertilizers (+NK) as well as in sections of immediately adjacent fields that received fertilizer rates estimated by other researchers as promoting improved fertilizer use efficiency for each field, the site-specific nutrient management (SSNM) treatment. Twenty-six soil N availability indices and intrinsic soil properties were not correlated with GY and PNU response. Most soil measurements provided extremely weak predictions of GY or PNU response to N fertilizer, with coefficients of determination for multiple regression equations ranging from 14-77%. Most of the soil N availability indices that were correlated with NET63 were not correlated with GY and PNU in -F plots, but some of them were correlated with GY and PNU response. These results contradict the presumption of other studies that anaerobic incubations are adequate proxies for field N availability and that highly correlated rapid analyses may be considered as effective predictors of the INS. The anaerobic incubation, mobile humic acid, and light absorption indices were the most common N availability indices in the multiple regression equations for GY and PNU responses, and they also appeared in the NET63 equations. The N availability indices varied considerably in their sensitivity, simplicity and reproducibility, as measured through laboratory soil replicates.

Keywords: Nitrogen availability tests, irrigated rice, crop response, sampling time.

INTRODUCTION

For irrigated rice cropping, high yields are achievable when PNU is adequate to maintain dry matter production and sink formation throughout the growing period (Cassman et al. 1994). The N supply environment is governed by availability of N from indigenous soil resources and from applied fertilizer inputs, and the capacity of the root system to take up available N (Cassman et al. 1994, 1995, 1996a). Contribution to crop N uptake from both the indigenous N pool and applied fertilizer N to crop N uptake should be known so that the rice plant is not limiting in N at any stage of the crop growth period, and maximum yields with high fertilizer use efficiency are attained.

A major problem in achieving optimum N fertilization is the difficulty of predicting the contribution of the INS through N mineralization. Other studies have equated the INS with PNU at maturity or GY in -F treatments in which other nutrient deficiencies or growth-limiting factors are negligible (Janssen et al. 1990, Schepers and Meisinger 1994). However this method is laborious and not practical for widespread use. Soil organic C (SOC) or total soil N (TN) have been widely used, but recent data across different spatial and temporal scales have shown that they do not provide enough information about the INS in tropical lowland rice (Cassman et al. 1996b). However some tests are too complicated or time-consuming for use in soil testing laboratories. There is clear need for simple and rapid chemical methods of assesing potentially available organic N in soil. Limited evidence in the literature suggests that analyses for soil N availability might also support prediction of crop response to fertilizer N application (Grunes et al. 1963). This study was therefore conducted to (1) test for any relationships between N availability tests or intrinsic soil properties and crop response to N fertilizer applied to the farmers' fields surrounding the unfertilized plots, (2) predict cumulative NH_4 mineralized during the anaerobic incubation on intrinsic soil properties and soil N availability indices, (3) provide insights into the behavior of the tested soil N availability indices.

MATERIALS AND METHODS

Monitored farmers' fields were located within 30 km of the Philippine Rice Research Institute (PhilRice) in Nueva Ecija with nine selected farmers in three villages in 1997 wet season (WS), 1997-1998 dry season (DS), and 1998 WS. All fields support double-cropped irrigated lowland rice. The soils in these fields are mapped for the Lagare village as the Prensa silt loam (Chromic Vertic Epiaqualf, USDA Taxonomy.), for the Burgos village as either the Quingua silt loam (Fluvaquentic Epiaquoll) or the Quingua clay loam (Typic Ustropept), and for the Bantug village as the Maligaya clay loam (Oxyaquic Ustropept) (Philippine Bureau of Soils 1957; Miura et al. 1995).

A total of 27 farmers' fields were studied. Soil samples were taken from two unfertilized (-F) plots located in each field. Neither mineral fertilizer nor organic manure was applied to these unfertilized plots.

Samples were taken from the 0-15 cm depth. All N availability analyses were conducted in the 1997 WS and 1998 DS samplings. Intrinsic soil properties were measured in the 1997 WS, and selected intrinsic properties were measured in the 1998 DS. Samplings in both seasons were taken 25-40 days after sowing (DAS). To evaluate the effect of crop growth stage and sampling time on the prediction of crop performance, two samplings were collected in the 1998 WS (0-10 DAS and 25-40 DAS) for analysis by selected tests of N availability and intrinsic soil properties. Thus three soil N availability parameters AUTO, TAUTO and TPBB were examined in the 1998 WS, along with the soil properties of TN and extractable K, and Mg.

Measurement of intrinsic soil properties: Organic C was measured by a Walkley-Black procedure (Walkley and Black 1934). Total N was determined by a macro-Kjeldahl method (Stumpe et al. 1985). Soil pH was measured with a glass electrode for a soil-water mixture with a ratio of 1:1 (w/v). Textural analysis for sand, silt and clay were obtained by the hydrometer method. One molar NH_4-extractable cations (Ca, Mg, K, Na) were determined by atomic absorption spectrophotometry.

Grain yield and PNU were measured in two replicates of the -F treatment for each farmer's field. In order to test for any correlations between soil N indices or soil properties and crop response to fertilizer N application, GY and PNU were also measured in +NK plots and in SSNM treatment.

Chemical indices of N availability that were evaluated were phosphate buffer, hot 2M KCl extraction, room temperature KCl extraction, ultraviolet light absorption at 200 and 260 nm, NaOH and $NaHCO_3$ extraction, alkaline permanganate, acidified $KMnO_4$, phosphate borate buffer, and autoclaving in $CaCl_2$ solution. Several properties of the MHA fraction were evaluated, and a biological index was anaerobic incubation with K-saturated cation exchange resin.

Recommended N fertilizer rates to the adjacent field under farmer's fertilizer management determined by other researchers on a field-specific basis, based on earlier estimates of the INS. Nitrogen fertilizer rates to the +NK treatment were 180 kg N ha^{-1} for the DS and 120 kg N ha^{-1} for the WS in all farmers' fields.

RESULTS

Soil properties

Selected physical and chemical properties of the soil in the -F plots of 27 farms in the 1997 WS, 1998 DS and 1998 WS are presented in OmonRice 2000 (Anh et al 2000) Table 1. Generally, all soil chemical and physical properties varied greatly on a proportional basis among all farmers' field.

Grain yield and plant nitrogen uptake response

In the 1997 WS, 1998 DS and 1998 WS grain yield and plant N uptake of the -F treatment plots had relatively high CV values across all farmers (Anh et al. 2000). In the 1997 WS, 1998 DS grain yield response and plant N uptake response for the +NK and the site specific nutrient management (SSNM) treatments also had relatively high CV values across all farmers (Table 1). This high variability is most likely due to measurement errors or crop damage due to factors other than N.

Table 1: Grain yield (GY) and plant N uptake (PNU) response to N fertilizer for the +NK fertilizer treatment and site specific nutrient management (SSNM) treatment in farmers' fields, 1997 WS and 1998 DS.

	1997 WS		**1998 DS**	
	+NK	SSNM	+NK	SSNM
GY response	-674-2588 kg/ha	-1135-2914 kg/ha	146-3443 kg/ha	1193-3969 kg/ha
PNU response	-	15-81 kg/ha	-	10-122 kg/ha

Soil N availability indices

Salt extraction indices

Phosphate buffer, pH 7: Organic N (PB) and total N extracted by phosphate buffer (TPB); Hot KCl: Organic N extracted by hot KCl (HOT KCl) and total N extracted by this analysis (THOT KCl) and room temperature KCl: Inorganic N extracted by this analysis (KCl) of the soil in the -F plots in the 1997 WS and 1998 DS are showed in OmonRcie 2000. 8: 74-85. Table 3. Generally, all parameters had relatively high CV values across all farmers. The HOTKCl had the highest CV values.

Light absorption indices

Ultraviolet light absorption for soil in 0.01M sodium bicarbonate: The difference in light absorption between 200 and 260 nm (UV), often attributed to nitrate and light absorption at 200 nm (TUV), often attributed to nitrate plus solubilized SOM in the 1997 WS and 1998 DS were presented in OmonRcie 2000, Table 3 (Anh et al. 2000).

Visible light absorption in NaOH: Visible light absorption in this analysis (NaOH), perhaps related to properties of the MHA in both of seasons are presented in OmonRcie 2000. 8: 74-85. Table 3.

Visible light absorption in 0.01M $NaHCO_3$: Visible light absorption in this analysis ($NaHCO_3$), perhaps related to properties of easily solubilized SOM are showed in OmonRcie 2000. 8: 74-85. Table 3.

Oxidative, hydrolytic, and autoclaving indices

Alkaline permanganate: Soil N extracted by this analysis ($KMnO_4$) in the 1997 WS and 1998 WS are listed in OmonRcie 2000. 8: 74-85. Table 3.

Acidified permanganate: Nitrogen extracted by this analysis (ACID) in the 1997 WS and 1998 DS are presented in OmonRcie 2000. 8: 74-85. Table 3.

Phosphate borate buffer, pH 11.2: Organic N (PBB) and total N (TPBB) are extracted by this analysis in the 1997 WS and 1998 DS that were presented (Anh et al. 2000).

Autoclaving in $CaCl_2$ solution: Organic N (AUTO) and total N extracted after autoclaving (TAUTO) in the 1997 WS and 1998 DS are listed in OmonRcie 2000. 8: 74-85. Table 3.

In the 1998 WS the effect of sampling time on the respective predictive powers of soil N availability indices was examined. Soil samples were taken at 0-10 DAS and 25-40 DAS and analyses identified in the results of the 1997 WS and 1998 DS. Thus three soil N availability parameters AUTO, TAUTO and TPBB were examined in the 1998 WS, along with the soil properties of TN and extractable K, and Mg. So AUTO, TAUTO and TPBB were also showed (Anh et al. 2000).

Mobile humic acid indices

Properties of the mobile humic acid fraction: The amount of C extracted as this labile SOM fraction (MHA-C), the amount of N extracted as MHA (MHA-N), the C:N ratio of the MHA (MHA-CN) and light absorption of the MHA dissolved in 0.05 M $NaHCO_3$ (LIGHT) in the 1997 WS and 1998 DS were presented in OmonRcie 2000 (Anh et al. 2000).

Generally, the MHA parameters varied greatly among farmers. Rooting depth at harvest varied from 9.30 to 14.3 cm strictly controlled by mode of planting.

Indices derived from the anaerobic incubation with K-saturated resin

The total size of labile or readily mineralizable N pool (N1), the rate constant of the labile or readily mineralizable N pool (K1) and the rate constant of the more stable, recalcitrant mineralizable N pool (K2) in the 1997 WS and 1998 DS were listed (Anh et al. 2000)

Net mineralized N, defined as the difference between the amount of N extracted after 7 days incubation and the amount of N extracted at 0 day (Net 7), net mineralized N, defined as the difference between the amount of N extracted after 21 days incubation and the amount of N extracted at 0 day (Net 21) and net mineralized N, defined as the difference between the amount of N extracted after 63 days incubation and the amount of N extracted at 0 day (Net 63) of the 1997 WS and 1998 DS were noticed (Anh et al. 2000)

Correlations among grain yield response or plant N uptake response and soil properties and soil N availability indices

Using simple linear regression, no soil property was significantly correlated with GY response in the +NK treatment in the 1997 WS and 1998 DS. Among the soil N availability indices, the only significant correlation with GY response in the +NK treatment was $NaHCO_3$ in the 1997 WS and this correlation was negative. This relationship might reflect unfavorable chemical properties of the solubilized SOM. In the 1998 DS, only $KMnO_4$ had a significant correlation with GY response in the +NK fertilizer treatment(0.275*).

For the SSNM treatment, of all intrinsic soil properties and soil N availability indices, only ACID and $NaHCO_3$ were significantly correlated with GY response, and the $NaHCO_3$ correlation was negative in the 1997(-0.42*) WS. In the 1998 DS, only ACID was significant correlated with PNU response, and this correlation was also negative (-0.463*).

All soil properties and soil N availability analyses were also used in Stepwise multiple linear regression to predict GY crop response in the +NK fertilizer treatments and also GY or PNU crop response in the SSNM treatment for all farmers in the 1997 WS and 1998 DS (Table 2)

Table 2: Multiple regression equations for grain yield and plant N uptake response in the 1997 wet season, 1998 dry season

Season	Equation Grain yield or plant N uptake VS soil properties & soil N availability indices	
In 1997's wet season	GY response in the +NK treatment= $-709 + 50^{ns}$ACID- 67*AUTO - 2.48**$NaHCO_3$ +22*NET63 +57^{ns}SAND.	r^2=0.43
	GY response in the SSNM treatment= 1151 +940*LIGHT -37.4**$NaHCO_3$.	r^2=0.30
	PNU response in the SSNM treatment= -99 +24^{ns}pH -2.63*PBB +1.86^{ns}TPBB.	r^2=0.24
In 1998's dry season	GY response in the +NK treatment= -4595^{ns} +663^{ns}pH +2629*K +134040*TUV	r^2=0.14
	GY response in the SSNM treatment= -702^{ns} -62^{ns}ACID +537^{ns}MHA-CN +4456**K	r^2=0.25
	PNU response in the SSNM treatment= 126^{ns} -34*pH +3.28**TPB - 3.50**ACID +438*MHA-N +38*MHA-CN -45**LIGHT -0.69**NET63.	r^2=0.77

Multiple regression analysis for mineralized N in the anaerobic incubation.

Some earlier N studies defined availability of soil N as mineralizable N measured in incubations, not as GY or PNU (Gianello and Bremner 1986a, 1986b, 1988; Mary and Recous 1994; Wilson et al. 1994). Any soil N availability index or soil property that was well correlated with mineralizable N was then considered as an accurate predictor of soil N availability. To repeat this correlation, here a multiple regression analysis was performed between all soil N availability indices and soil properties with the best estimate of mineralizable N, NET63.

In the 1997 WS, the best fitting multiple regression equation was:

NET63 = -40^{ns} + 0.84**ACID - 3.8**MHA -CN +20^{ns}K - 1.6** KCl + 2.3** Mg + 31** MHA - C + 277** TN + 10** pH + 0.59* SILT, r^2= 0.93

In the 1998 DS, NET63 was correlated with soil properties and soil N availability indices in the following equation:

NET63 = - 58* + 1.06^{ns} ACID - 54* K + 381^{ns} TN + 0.001^{ns} NaOH + 2040^{ns} NM260 + 58** SOC + 1.04** PB,r^2 = 0.89

Correlations among soil properties and soil N availability indices in the 1997 WS

To determine whether related analyses provided comparable results and to identify the degree of cross-correlation for each parameter to be regressed against crop parameters, simple correlation coefficients were computed among all soil N availability indices and other soil properties for the 1997 WS (Table 4), parameters that were correlated with at least 15 of the other 35 parameters were PB, TPB, THOTKCl, AUTO, TAUTO, MHA-C, MHA-N, NET21, NET63, Ca, SOC, TN, and SAND. Parameters that were correlated with 5 parameters or fewer were HOTKCl, MHA-CN and K. Parameters had mostly positive correlations with other parameters. Those parameters with at least half of their significant correlations being negative were $NaHCO_3$ (4 of 8), MHA-CN (1 of 1), LIGHT (8 of 13), and SAND (15 of 17). Each parameter tended to be better correlated with related parameters than with all parameters, intragroup correlations were significant in 56 of 101 cases (55%), compared to 232 of 630 cases (37%) overall. All groups had similar proportions of significant correlations with all parameters (35-38%), except for the light absorption indices (28%).

	SOC	TN	pH	CLAY	SILT
SOC[a]	1				
TN	0.957**	1			
pH	0.192	0.304	1		
CLAY	0.543**	0.494**	-0.098	1	
SILT	-0.197	-0.102	0.203	-0.838**	1
SAND	-0.684**	-0.744**	-0.140	-0.512**	-0.038

[a] Abbreviations are explained in Tables 2; * Significant at P< 0.05; ** Significant at P< 0.01; unmarked: not significant

Correlations among soil properties and soil N availability indices in the 1998 DS

Simple correlation coefficients among soil N availability indices and other soil properties for the 1998 DS were tested. Parameters that were correlated with at least 15 of the other 30 parameters were PB, TPB, ACID, AUTO, TAUTO, MHA-N, and NET21. Parameters that were correlated with 5 parameters or fewer were KCl, UV, TUV, $NaHCO_3$, PBB, TPBB, LIGHT, and pH.

Parameters had mostly positive correlations with other parameters. Those parameters with at least half of their significant correlations being negative were NM260 (4 of 7), MHA-CN (7 of 10), and K2 (5 of 6).

Each parameter tended to be better correlated with related parameters than with all parameters, except the oxidative, hydrolytic, and autoclaving group. Similar to the 1997 WS, all groups had similar proportions of significant correlations with all parameters (30-35%), except for the light absorption indices (13%).

Correlations among soil properties and soil N availability indices in the 1998 WS

Simple linear correlations among soil N availability indices and other soil properties in the 1998 WS are presented in Table 6. The majority of correlations were significant and positive, although many were of modest strength. Only 20 of the 66 correlation coefficients surpassed 0.50, and four of these twenty were between different sampling times of the same analysis. The six correlation coefficients for the different sampling times of the six analyses ranged from 0.29 to 0.98, all being significant (P<0.05). The highest correlation coefficients of the six were for MG, TN, and POT, respectively. Correlation coefficients for the N availability indices were modest.

Table 3: Simple correlation coefficients among soil N availability indices and other soil properties for individual unfertilized plots across all farmers, 1998 wet season

	AUTO1	AUTO2	TAUTO1	TAUTO2	TPBB1	TPBB2	POT1	POT2	MG1	MG2	TN1	TN2
AUTO1[a]	1											
AUTO2	0.389**	1										
TAUTO1	0.483**	0.437**	1									
TAUTO2	0.351*	0.848**	0.566**	1								
TPBB1	0.117	0.348*	0.687**	0.460**	1							
TPBB2	0.118	0.622**	0.302*	0.742**	0.289*	1						
POT1	0.222	0.066	0.307*	0.277*	0.237	0.212	1					
POT2	0.285*	0.057	0.209	0.181	0.155	0.090	0.770**	1				
MG1	0.320*	0.464**	0.219	0.420**	0.159	0.432**	0.066	0.168	1			
MG2	0.323*	0.477**	0.258	0.406**	0.203	0.415**	0.072	0.147	0.984**			
TN1	0.548**	0.495**	0.557**	0.654**	0.342*	0.566**	0.408**	0.219	0.546**	0.560**	1	
TN2	0.570**	0.507**	0.457**	0.646**	0.219	0.536**	0.315*	0.263	0.555**	0.531**	0.903**	1

AUTO1= organic N extracted after autoclaving in dilute $CaCl_2$ solution at the early sampling; TAUTO1= total N extracted after autoclaving in dilute $CaCl_2$ solution at the early sampling; AUTO2= organic N extracted after autoclaving in dilute $CaCl_2$ solution at the later sampling; TAUTO2= total N extracted after autoclaving in dilute $CaCl_2$ solution at the later sampling; TPBB1= total N extracted by phosphate borate buffer at the early sampling; TPBB2= total N extracted by phosphate borate buffer at the later sampling; POT1, MG1; TN1= 1M NH_4-extractable K and N contents at the first soil sampling; POT2, MG2, TN2= 1M NH_4- extractable K and N contents at the later sampling.
* Significant at P< 0.05; **Significant at P< 0.01; unmarked: not significant.

Predictive powers of the first versus second soil sampling

Most of the independent variables identified by the multiple regression analyses as contributing significantly to prediction of GY or PNU were associated with the first soil sampling. Few parameters were associated with the second soil sampling . Multiple regression analysis was also correlated on all indices of the first soil sampling plus intrinsic soil properties separately from all indices of the second soil sampling plus intrinsic soil properties. For the complete farmer set, the first soil sampling provided similarly weak predictions as did the second sampling for GY (r^2= 0.27 vs 0.28) and PNU (r^2= 0.35 vs 0.28). For the smaller set of farmers having crop growth limited solely by N, the predictive power of the first sampling was better compared to the second sampling for both GY (r^2= 0.50 vs 0.31) and PNU (r^2= 0.25 vs 0.15).

DISCUSSION

Optimal timing and rates of applied N to irrigated rice could be based on accurate estimates of the INS. Hence, the primary objective of this study was to identify simple laboratory tests that reasonably approximate the INS in farmers' fields when defined as the differences in PNU or GY in the -F plots and the +NK plots as well as the SSNM plots .

In all three cropping periods, the results provided insights into the behavior of the tested soil N availability indices. Soil N availability parameters had mostly positive correlations with each other. First, related soil N availability analyses appeared to measure related soil properties or pools of soil N, as demonstrated by the much higher proportion of parameter cross-correlations that were significant within the parameter groupings used here than between all parameters. A second insight was that several groupings tended to be better correlated with certain other groupings than with all groupings. The conventional soil N availability indices—the salt extractions and the oxidative, hydrolytic, and autoclaving indices—tended to be significantly correlated with each other more than with other parameters. These parameters dominated the multiple regression equations for the INS. A second highly cross-correlated bloc consisted of the anaerobic incubation, MHA, and light absorption indices. These indices were the most common N availability indices in the multiple regression equations for GY and PNU responses, and they also appeared in the NET63 equations. A final insight was that some analyses were well correlated with many other soil measurement; of the 65 possible correlations each parameter had with all other parameters in the 1997 WS and 1998 DS, those indices with at least half of their correlations being significant were TAUTO (40), TPB (36), AUTO (35), PB (35), TN (34), and MHA-N (33).

The conventional N availability indices contributed more to prediction of GY and PNU in the -F plots than did several experimental parameters, such as the light absorption and MHA indices. These results do not provide any evidence that significant relationships between anaerobic incubation and MHA indices previously reported by Nguyen Bao Ve (1996) have any application to field conditions. Given the generally weak predictions of the INS found here, however, some relationship of MHA properties to field N availability cannot yet be excluded.

The N availability indices also varied considerably in their sensitivity, simplicity and reproducibility, as measured through laboratory soil replicates. Those indices that varied the most proportionately among all farmers were K2, PBB, MHA-C, MHA-N, and $NaHCO_3$, and those that varied the least proportionately were MHA-CN, $KMnO_4$, and ACID. Those indices that were the easiest to conduct were Light UV, TUV, NM260, NaOH, and $NaHCO_3$, and the most difficult ones were anaerobic incubation, MHA extraction, and phosphate buffer extraction. Those that required the most specialized equipment were the anaerobic incubation (incubator, N_2 gas, centrifuge), MHA extraction (N_2 gas, centrifuge), and autoclaving. The N availability indices that gave the most precise laboratory replication were NaOH and $NaHCO_3$ extractions, and those that gave the least precise replication were phosphate borate buffer and 2 M KCl extractions (data not shown).

The results presented here place into question the conclusions of studies such as Gianello and Bremner (1986a, 1986b, 1988), Mary and Recous (1994) and Wilson et al. (1994a, 1994b), which presumed that PNU and GY could be proxied by mineralizable N measured in incubations. Our closest estimate of mineralizable N, NET63, could be precisely predicted via other N availability indices and soil properties for both seasons in which it was measured, as shown by the high coefficients of determination achieved through multiple regression analysis. Yet NET63 itself was poorly correlated with crop performance. Further those properties identified by multiple regression analysis as significant predictors of GY or PNU were poorly correlated with NET63.

Given the difficulties in correlating GY and PNU in unfertilized plots with soil N availability indices and intrinsic soil properties, the poor and inconsistent multiple regression correlations with crop response to N fertilizer application were to be expected. The quality of SOM may well affect movement of N fertilizer through the soil and into the crop, but several other crop management practices can have primary effects on N fertilizer use efficiency, such as the schedule of fertilizer splits and split sizes. Any effect of soil properties on fertilizer use efficiency might be most easily identified in on-station experiments conducted under better controlled conditions for extended numbers of years. One observation on the multiple regression equations for GY and PNU response is that parameters occurring in more than equation seldom appeared in the multiple regression equations for prediction of GY and PNU in the unfertilized plots, but most of them also appeared in the multiple regression equations for NET63. These parameters include ACID, $NaHCO_3$, NET63, SAND, pH, LIGHT, and MHA-CN. Conversely, the parameters that were most common for prediction of the INS were not common in the GY and PNU response equations.

Analyses conducted on the first soil sampling (0-10 DAS) of the 1998 WS appeared to give slightly better predictions of the INS than did analyses of the second soil sampling (25-40 DAS). All soils still shared some properties, e.g. modest SOM levels and moderate pH. In the 1998 WS, soil N availability indices decreased from the first sampling to the second sampling. Similar to GY and PNU, each soil N index and soil property was generally poorly or moderately correlated with itself across seasons. Soil N availability indices had lower correlation coefficients between seasons than did soil properties. Then results suggest that soil N availability is a transient property and changes throughout the growing season. This finding runs counter to expectations, since the time of maximum crop N uptake is mid-season at the second sampling. However, this finding might be compatible with a general finding from upland cropping systems that the best predictor of GY is pre-plant NO_3 (Bundy and Meisinger 1994). Although NO_3 would not be common for more than a few days in irrigated rice soils, the point is that if this study were to be repeated, one sampling time should be as soon as possible after sowing/transplanting.

This study identified several obstacles to basing fertilizer recommendations on rapid laboratory analyses. Grain yield and PNU in the -F plots as well as GY or PNU response were not consistent for each farmer across all three cropping periods: lodging, bacterial leaf blight and drought limited crop growth in many of the -F plots, and no single laboratory analysis provided an extremely strong correlation with GY or PNU in all cropping periods. Soil N availability appeared to be transient property that changed markedly between seasons and during one season.

REFERENCES

Anh TTN, DC Olk. 2000. Prediction of crop nitrogen uptake by soil nitrgen availability tests for irrigated lowland rice. OMonRice 8: 74-85.

Bundy LG, and JJ Meisinger. 1994. Nitrogen availability indices. In A. L. Page et al. (ed.) Methods of Soil Analysis, Part 2 Microbiological and Biochemical Properties, American Society of Agronomy, Madison, WI. pp. 951-984.

Cassman KG, A Dobermann, PC Sta Cruz, MI Samson, JP Descalsota, JM Alcantara, MA Dizon, and DC Olk. 1996a. Soil organic matter and the indigenous nitrogen supply of intensive irrigated rice systems in the tropics. Plant and Soil 182:267-278.

Cassman KG, and PL Pingali. 1995. Intensification of irrigated rice systems: Learning from the past to meet future challenges. Geojournal 35:299-305.

Cassman KG, GC Gines, MA Dizon, MI Samson, and JM Alcantara. 1996b. Nitrogen-use efficiency in tropical lowland rice systems: contributions from indigenous and applied nitrogen. Fields Crops Res. 47:1-12.

Cassman KG, MJ Kropff, and Y Zhen-De. 1994. A conceptual framework for nitrogen management of irrigated rice in high-yield environments. In S. S. Virmani (ed). Hybrid rice technology: new development and future prospects. Int. Rice Res. Inst. Philippines. pp. 81-96.

Gianello C and JM Bremner. 1988. A rapid steam distillation method of assessing potentially available organic nitrogen in soil. Commun. Soil Sci. Plant Anal. 19:1551-1568.

Gianello C, and JM Bremner. 1986a. A simple chemical method of assessing potentially available organic nitrogen in soil. Commun. Soil Sci. Plant Anal. 17:195-214.

Gianello C, and JM Bremner. 1986b. Comparison of chemical methods of assessing potentially available organic nitrogen in soil. Commun. Soil Sci. Plant Anal. 17:215-236.

Grunes DL, HR Haise, F Turner, JR and J Alessi. 1963. Relationship between yield response to applied fertilizers and laboratory measures of nitrogen and phosphorus availability. Soil Sci. Soc. Am. Proc. 27, 675-679.

Janssen BH, FCT Guiking, D Van Der Eijk, EMA Smaling, J. Wolf, and H. Van Reuler. 1990. A system for Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS). Geoderma 46:299-318.

Mary B and S Recous. 1994. Measurement of nitrogen mineralization and immobilization fluxes in soil as a means of predicting net mineralization. Eur. J. Agronomy 3:291-300.

Miura K, RB Badayos, and AM Briones. 1995. Pedological characterization of lowland areas in the Philippines. Department of Soil Science, College of Agriculture, University of the Philippines, Los Baños.

Nguyen Bao Ve. 1996. Characterization of two humic acid fractions and their contribution to soil nitrogen supplying capacity of tropical lowland rice soils. (Ph.D. thesis, University of the Philippines, Los Banos).

Philippine Bureau Of Soils. 1957. Soil map of Nueva Ecija at the 1:125,000 Scale. Philippine Dept. Agric., Quezon City.

Schepers JS, and JJ Meisinger. 1994. Field indicators of nitrogen mineralization. Soil Sci. Soc. Am, 677 S. Segoe Rd., Madison, WI 53711, USA.

Stumpe JM, CB Christianson, and RJ Buresh. 1985. An aluminum block digestion procedure for determination of total N in soil containing ^{15}N. Commun. Soil Sci. Plant Anal. 16:1-14.

Walkley A, and IA Black. 1934. An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 37:29-38.

Wilson CE, RJ Norman, and BR Wells. 1994a. Chemical estimation of nitrogen mineralization in paddy rice soils: I. Comparision to laboratory indices. Commun. Soil Sci. Plant Anal. 25:573-590.

Wilson CE, RJ Norman, BR Wells, and MD Correl. 1994b. Chemical estimation of nitrogen mineralization in paddy rice soils: II. Comparison to greenhouse availability indices. Commun. Soil Sci. Plant Anal. 25:591-604.

SUMMARY IN VIETNAMESE

Mối quan hệ giữa hàm lượng đạm hấp thu trong cây lúa phản ứng với phân đạm hoặc năng suất lúa phản ứng với phân đạm và lượng đạm dễ tiêu trong đất lúa tưới bằng các phương pháp phân tích đạm dễ tiêu và ưu khuyết điểm của các phương pháp phân tích đạm

Thạch Thị Ngọc Ánh, Daniel C. Olk

Trong điều kiện lúa có nước tưới, hiệu quả phân đạm có thể được nâng lên nếu như lượng phân N khuyến cáo được tính toán dựa vào độ phì của đất, hay còn gọi là đạm có sẵn trong đất (INS). Ở nghiên cứu nầy, INS được thể hiện bởi năng suất lúa hay là lượng N hấp thu trong cây lúa tại những nơi không có bón phân N (-F), trong khi đó ở những nơi có bón phân N và K (+NK) và những nơi có bón phân theo mức khuyến cáo của các nhà nghiên cứu theo từng vùng đất riêng biệt để nâng cao hiệu quả sử dụng phân bón (SSNM). Sự khác biệt năng suất lúa (GYresponse) hay là sự khác biệt hàm lượng hấp thu phân N trong cây lúa (PNU response) giữa lô -F và các lô +NK, SSNM được sử dụng để phân tích mối tương quan của chúng với 26 phương pháp phân tích N dễ tiêu trong đất lúa tưới. Các chỉ tiêu N dễ tiêu và các đặc tính lý-hóa của đất đều hầu hết không cho mối tương quan với GY response/PNU response ở phương trình đơn tuyến. Ở phương trình hồi quy đa biến cho mối tương quan giữa các chỉ số N dễ tiêu và các chỉ số đặc tính đất với GY response/PNU response dao động từ 14-77%. Hầu hết các chỉ tiêu N dễ tiêu cho mối tương quan với NET63, đây là một chỉ tiêu trong phương pháp ủ đất ở điều kiện yếm khí, thì chúng lại không có mối tương quan với năng suất và đạm hấp thu trong cây lúa ở lô -F, nhưng các chỉ tiêu nầy lại có tương quan với GY response/PNU response. Kết quả của nghiên cứu nầy đi ngược lại với nghiên cứu trước đây đã cho rằng các chỉ tiêu đánh giá đạm dễ tiêu trong đất lúa ở phương pháp ủ chiếm ưu thế nhất để dự đoán INS. Các chỉ tiêu đạm trong phương pháp ủ đất, phương pháp mobile humic acid và phương pháp hấp thụ trong ánh sáng thì thường xuyên xuất hiện trong phương trình đa tuyến phân tích sự tương quan giữa chúng với GYresponse/PNU response và chúng cũng xuất hiện trong phương trình đa tuyến phân tích sự tương quan giữa chúng với NET63. Các chỉ tiêu phân tích đạm từ các phương pháp khác nhau đã thể hiện độ nhạy, tính đơn giản và tính chuẩn xác trong suốt quá trình đánh giá trong phòng thí nghiệm qua các lần lập lại.