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SHORT COMMUNICATION

INFLUENCE OF LONG TERM APPLICATION OF N, P, K FERTILIZER ON SOIL pH, ORGANIC MATTER, CEC, EXCHANGEABLE CATIONS AND SOME TRACE ELEMENTS

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ABSTRACT

Study the effects of long-term application of nitrogen (N), phosphorus (P) and potassium (K) in intensive rice mono-culture have been conducted since 1986 to 2003 wet season at the Cuu Long Delta Rice Research Institute (CLRRI), Cantho, Vietnam. It showed that pH (H_2O), pH (KCl), EC and organic matter decreased very strongly as compared to the beginning. After 34 rice seasons, CEC was not much changed and soil still can maintain and provide nutrients well for rice. Exchangeable cation Ca^{++} and Mg^{++} were high. The soil is still rich in exchangeable cation Ca^{++} and Mg^{++} for rice. Similar, Cu and Zn were not deficient in soil and still good for rice.

INTRODUCTION

Food security is one of important goals in rice production in the Mekong River Delta. However these goals cannot be achieved if farmers employed imbalanced fertilizer and ignored about important role of soil characteristics and trace elements. In fact, there is little known about the sustainability of the current production systems, particularly ones with double or triple cropping and minimum tillage. The current production systems may lead to soil depletion. Aside from soil pH, organic matter in soil can improve soil structure as well as major and trace elements. Study by Tuyen and Tan (2001) showed that returning organic matter as rice straw had improved soil fertility and increased exchangeable cations as Na^+, Ca^{++} and Mg^{++}. Man and et al. (2001) also reported the important role of organic matter in increasing rice yield and soil micro-organisms. Thus, the objective of this study is to assess soil pH, organic matter, unbuffer CEC, exchangeable cations and soil trace elements under long term mono-rice culture system with N, P, and K fertilizer application for 34 continuous rice seasons.

METHODS

The long-term fertility experiment on *isohyperthermic Fluvaquentic Humaquept* soil (Doberman and Olk 1995 Unpublished) with 57% clay (of which 40-50% kaolinite and 30% illite), 42.5% silt, 0.5% sand, with the rice- rice system was established at experimental field of Cuu Long Rice Research Institute. Rice was planted fromí986 wet season (June to August or He Thu) to 2003 wet season. Fertilizer sources were urea (46%N), super phosphate (18% P_2O_5) and muriate of potassium (60% K_2O). A randomized complete block design with 8 treatments of N, P, K with 4 replications were used. Two dosages of each N, P, K (0 and 80 kg Nha^{-1}, 0 and 17.5 kg Pha^{-1}, 0 and 25kg Kha^{-1}) were applied. Eight treatments were control (no fertilizer), N, K, NK, P, PK, NP, and NPK. Same doses of fertilizer were used in both wet and dry Seasons. In 1995 dry season, potassium rate come up to 75 kg K_2O ha^{-1}. After harvesting in dry seasons, rice stubbles were removed from the field. Land was prepared by hand hoeing and let it fallow from March to May. At beginning of dry Seasons, we pumped water out of the field, then rice straw and weeds were removed. In the experiment, nitrogen fertilizer was in three splits (each of 1/3 of N amount for basal application, top dressing at 20 days after transplanting, and at panicle initiation). Super phosphate and muriate of potassium were all used for basal application.

Soil samples were collected at end of 34th season. In each plot, soil samples were collected at 4 positions in the depth of 0-20cm and mixed to form 2 kg soil/plot. They were dried under air room temperature and then pulverized and through 2 mm sieve to determine pH (H_2O), pH (KCl), organic matter, unbuffer CEC, exchangeable cations, available Zn and Cu (extraction with 0.05 N HCl). The method for determining pH (H_2O) was 1:1 soil: water; pH (KCl) 1:1 soil: solution KCl 1N. Organic carbon was analyzed by method of Walkley and Black (1934). Unbuffer CEC is extracted by $BaCl_2$ 0,1M. Exchangeable cations (Na^+, Ca^{++}, Mg^{++}) by method $BaCl_2$ were measured by Atomic Absorption Spectrophotometer. Available Cu and Zn were extracted by HCl 0.05N and measured by Atomic Absorption Spectrophotometer

RESULTS AND DISCUSSIONS

1. pH (H_2O) in soil

In soil surface of all treatments, pH (H_2O) value decreased strongly after 34 rice seasons planting with high yielding rice. These pH (H_2O) values reacted acidity seriously. pH value reduced more than one unit in all treatments and this value changed to the lowest in control (no fertilizer) and N alone (pH=3.94). K and NK treatment exhibited the highest pH value (pH=4.18). Treatments supplied with P and K fertilizers have slightly decreased pH (Table 1). Rice roots produce organic acids leading low pH value. Moreover, single fertilizers as super phosphate and KCl with acidic property leaded to reducing pH dramatically.

2. pH (KCl) in soil

The value of pH (KCl) in soil was reduced stronger than pH (H_2O) after 34 rice seasons. pH (KCl) value in soil also dramatically decreased as compared to the initial pH value - pH (KCl)=4.08 and reacted acidity strongly. These pH values changed from 3.55 to 3.71, treatment N had the lowest pH value (KCl) (pH=3.55). In treatments supplied with K fertilizer or combined K with P, pH (KCl) decreased slower than other treatments.

Alluvial soil has low pH value because alluvial property is rich in SiO_2 and Al. When silts deposit, the process of leaching of Ca, Mg and accumulating SiO_2, Al, Fe happened; therefore, soil pH is low. Rice is highly adaptable to different conditions of environment, thus rice can grow and produces high yield in various soil pHs. However, Grantham (1917), Kamoshita (1932), and Thory and Giuxinop (1964) [cited by Lap, 1990] reported that the soil with pH<6.6 is the best condition for growing rice, and it can produce higher yield than neutral or alkaline soil.

Though soil at experimental site is not acid sulfate soil, its pH value is low. However, this pH value is within the range of good yield production.

3. EC (mS/cm) in soil

Soil surface with EC range from 0.20 to 0.26 mS/cm was evaluated as no salinity. EC values of all treatments were lower than initial EC value (0.74 mS/cm). This shows that after cultivating 2 seasons/year, water irrigation has decreased salt concentration and EC in soil was improved gradually. In control plot, EC was lower than those supplied with fertilizer. This indicates that fertilizer affects salt concentration in soil.

4. Organic matter (%)

Organic matter decreased strongly after 34 seasons as compared to initial status (6,13%). However, its content in soil is still high. Organic matter contents ranged from 4.48% to 4.92 % and were not statistically different among all treatments. Removing rice straw from field can help to assess the importance of providing organic matter into soil. IRRI claimed that the optimum organic matter content in irrigated rice area is 4% (Anh 2002). Ha (1999 cited by Anh 2002) shows that alluvial soil in Red River Delta with imbalance fertilizer application, humus decreases from 814 to 867 kg/ha per season, and soil fertility exhausted rapidly. The presence of organic matter is advantageous for good soil structure, strong activities of microorganism, and available nutrients and soil absorption ability. These are general soil characteristics in Mekong Delta, the high organic matter in soil surface tends to going down by long term rice cultivation (Tuyen 1997).

Table 1: Organic matter, pH (H_2O), pH (KCl) and EC of soil after 34 rice crops

Treatment	pH (H_2O)	pH (KCl)	EC (mS/cm)	Organic matter (%)
Initial	5.2	4.08	0.74	6.13
Control	3.94 a	3.63 ab	0.20 a	4.58 a
N	3.94 a	3.55 a	0.25 b	4.77 a
K	4.18 b	3.71 ab	0.24 b	4.53 a
NK	4.18 b	3.78 b	0.24 b	4.48 a
P	4.02 ab	3.59 ab	0.26 b	4.85 a
PK	4.11 ab	3.70 ab	0.24 b	4.67 a
NP	4.01 a	3.71 ab	0.26 b	4.92 a
NPK	4.11 ab	3.68 ab	0.25 b	4.74 a
CV (%)	3.5	9.8	23.7	7.5

5. Cation exchange capability (CEC) in soil (meq/100g)

CEC is an important criterion of soil fertility, reflecting maintenance capability and regulation of nutrient. This relates to suitable methods of fertilizer use. Soil rich in organic matter and high CEC can maintains nutrients for plants.

Soil CEC was high in all treatments and it ranged form 16.46 to 17.36 meq/100g were not significantly different (Table 2).

Table 2: Cation exchange capacity (CEC) (meq/100g) in soil after 34 rice seasons

Treatments	Unbuffer CEC
Control	17.357 a
N	16.582 a
K	16.943 a
NK	17.029 a
P	16.658 a
PK	16.750 a
NP	16.462 a
NPK	16.934 a
CV (%)	5.8

6. Exchangeable Na in soil (meq/100g)

Exchangeable Na in soil of all treatments ranged from 0.704 meq/100g to 1.107 meq/100g. Exchangeable Na was the lowest in NP treatment (0.704 meq/100g) and the highest in NPK treatment (1.107 meq/100g). This value in NP treatment was lower than those in K treatment and not different from other treatments (Table 3)

7. Exchangeable Ca in soil (meq/100g)

Exchangeable Ca in soil of all treatments varied from 9.822 meq/100g to 11.750 meq/100g. Exchangeable Ca was lowest in NK treatment (9.822 meq/100g) and highest in N treatment (11.690 meq/100g). Exchangeable Ca value in NK treatment was lower than those in N treatment and was not different from other treatments.

8. Exchangeable Mg in soil (meq/100g)

Exchangeable Mg in soil of all treatments was high and ranged from 9.304meq/100g to 10.433meq/100g. Exchangeable Mg was lowest in N treatment (9.304 meq/100g) and highest in K treatment (10.433 meq/100g). It was not statistically different among all treatments. In general, exchangeable Ca and Mg were high although the experiment was not supplied Ca and Mg fertilizer for 17 years.

Table 3: Exchangeable cation in soil (buffer pH 8.1) after 34th rice crop seasons

Treatments	Buffer pH 8.1		
	Na^+	Ca^{2+}	Mg^{2+}
Control	0.913 abc	11.297 ab	9.951 a
N	0.754 ab	11.690 b	9.304 a
K	1.070 bc	11.057 ab	10.433 a
NK	0.936 abc	9.822 a	10.187 a
P	0.847 abc	11.336 ab	9.945 a
PK	0.881 abc	11.024 ab	9.797 a
NP	0.704 a	10.750 ab	10.047 a
NPK	1.107 c	11.186 ab	10.160 a
CV (%)	22.3	10.0	10.3

9. Available Cu (mg/kg)

Available Cu in soil of all treatments was low and varied from 0.171 mg/kg to 0.204 mg/kg. Available Cu was lowest in K treatment (0.171 mg/kg) and highest in PK treatment (0.204 mg/kg). Available Cu was not statistically different among all treatments (Table 3)

10. Available Zn (mg/kg)

Available Zn in all treatments was high and ranged from 2.180 mg/kg to 2.904 mg/kg. Available Zn was lowest in NPK treatment (2.180 mg/kg) and highest in P treatment (2.904 mg/kg). Available of Zn in all of treatments were not statistically different. There was no shortage in micronutrient, particularly Cu and Zn. This indicates that the soil was rich in organic matter.

Table 3: Available Cu and Zn (mg/kg) in soil after 34 rice crops

Treatments	Cu	Zn
Control	0.200 a	2.714 a
N	0.193 a	2.500 abc
K	0.171 a	2.410 abc
NK	0.176 a	2.275 ab
P	0.182 a	2.904 c
PK	0.204 a	2.699 abc
NP	0.196 a	2.793 bc
NPK	0.199 a	2.180 a
CV (%)	16.5	14.1

CONCLUSIONS

Soil analyses after 34 rice seasons in the long term experiment conducted in intensive rice mono-culture indicated that pH (H_2O), pH (KCl), and EC decreased very strongly.

Removal of rice straw has decreased organic matter dramatically. Thus, returning back rice straw to the field plays an important role to soil fertility. After 34 rice seasons, CEC was not much changed. CEC values expressed soil capacity in providing nutrients for crops. This means that after 34 seasons, soil still maintained and provided nutrients well for rice. Exchangeable cation Na^+ was not much changed meanwhile exchangeable cation Ca^{++} and Mg^{++} were high. The soil is still rich in exchangeable cation Ca^{++} and Mg^{++} for rice. Similarly, Cu and Zn were not deficient in soil.

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Ảnh hưởng của bón phân N,P,K dài hạn đến pH đất, chất hữu cơ, khả năng trao đổi cation, và một số nguyên tố vi lượng sau 34 vụ lúa

Nghiên cứu ảnh hưởng của bón phân N,P,K dài hạn trên vùng lúa thâm canh bắt đầu từ vụ Hè Thu 1986 đến Hè Thu 2003 tại ruộng thí nghiệm Viện Lúa ĐBSCL cho thấy pH (H_2O), pH (KCl), EC và chất hữu cơ giảm mạnh so với ban đầu. Sau 34 vụ lúa, CEC không thay đổi nhiều và đất còn có thể duy trì và cung cấp tốt dưỡng chất cho cây lúa. Ca^{++} và Mg^{++} trao đổi cao và vẫn còn giàu trong đất. Tương tự, Cu và Zn không thiếu trong đất sau một thời gian dài canh tác lúa.