Omonrice 14 92-96 (2006)

INFLUENCE OF LONG TERM APPLICATION OF N, P, K FERTILIZER ON MAJOR SOIL ELEMENTS

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ABSTRACT

A long-term fertility experiment to study effects of nitrogen (N), phosphorus (P) and potassium (K) in intensive rice mono-culture has been conducted at Cuu Long Delta Rice Research Institute (CLRRI), Cantho, Vietnam from 1986 to 2003. This showed that total soil nitrogen content increased in NK, P, PK, and NP treatments and was slightly increased in NPK treatment. Total N was not changed in N treatment and decreased in control and K treatments. Total P content increased in treatments with P fertilizer as P alone or PK and NP. Available P was high in the treatments supplied phosphorus. Total K was still high in both plots with and without fertilizer. Total P was not affected by long term N, P, K fertilizer application. Exchangeable K was high in the plots supplied potassium.

INTRODUCTION

Rice production in Mekong Delta is an important factor for food security in Vietnam and rice exports. However, we have little known about the sustainability of the current production systems, particularly systems with double or triple cropping and minimum tillage. Intensive rice mono-culture may lead to increase weed, diseases, and insects. Poor seed quality, low N-use efficiency, deteriorating soil fertility, and stagning or declining rice productivity are other majors concerns (Tan et al. 1995; Tan 1997; Lai and Tuan 1997; Hoa et al. 1998; and Phung et al. 1998). Further, rapidly citization rate lead to ennarrow rice production area.

Rice yield and farmers' benefit depend on soil fertility. Soil fertility depends on the status of soil nutrients such as total amount of N, P, K, …, their capacity to produce nutrients in the form for easily up-taking by the crops (available N, P, K, …), toxic substances, soil erosion, being washed out and other ways of lost. Soil fertility can be reduced, especially under humid tropical conditions in less developed and developing countries because of deduction of nutrients from soil stock and less returns back to the soil (Lieu 1997). During the past 25 years, the fluxes of nutrients within a typical irrigated rice field have increased 5 to 7 folds and cannot be met by nature sources such as sediments provided by the Mekong river alone. Mineral fertilizer inputs have dorminent factors of the overall nutrient balance, but their use is often imbalance and their efficiency remains below optimum levels. Managing the variability in soil nutrient supply that has resulted from intensive rice cropping is one of the major challenges to sustaining and increasing rice yields in the Mekong Delta (Doberman et al. 1996).

The objective of this study is to assess the major soil elements after long term mono-rice culture with N, P, P fertilizer application for 34 rice crops.

MATERIALS & METHODS

The long-term fertility experiment with the rice- rice system was established at experimental field of Cuu Long Rice Research Institute, Co Do District, Can Tho city. Its location is at $10^0$07'50" N latitude, $105^0$34'80" E longitude, 3 m above sea level. The soil was classified as *isohyperthermic Fluvaquentic Humaquepts* (Doberman and Olk 1995 Unpublished). This is heavy clay soil with 57% clay (of which 40-50% kaolinite and 30% illite), 42.5% silt, 0.5% sand, slowly being wet, holding water capacity is high and mudding easily. Soil texture is not varied along the soil depth. The 105 days-duration rice variety (IR64) was planted from wet season 1986 (June to August or He Thu crop) to 2000 dry season (November to February or Dong Xuan crop). The 90-day genotype OMCS2000 was used in later seasons. 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 included 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 ha^{-1}. After harvesting dry crops, the stubles were removed from the field. Land was prepared by hand hoeing and let it fallow from March to May. At beginning of dry seasons, water was pumped out of the field, then rice straw and weeds were removed.

Method of crop establishment was transplanting with spacing of 20 cm x 15 cm, with seedlings of 22-25 days old of IR64, 18-20 days old of OMCS2000. Two and three seedlings / hill were transplanted. 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. Water depth was maintained at 5-10 cm since planting until 10 days before harvest. Pest care was taken and hand weeding was applied before each time of fertilizer application.

Soil samples were collected at end of 34^{th} crop season in the long–term experiment of N, P, K fertilizer applications with 8 treatments in 4 replications.

In each plot, soil samples were collected at 4 positions within the depth of 0-20cm, after that 4 samples were mixed to have 2 kg soil/plot. They were dried under air room temperature and then pulverized and sieved through 2 mm sieve for analysis of total N, P, K, available N in NH_4^+ and NO_3^-, available P (Bray-2), total K and exchangeable K^+. Total N was analyzed by Kjeldahl (Bremner et al. 1982); available N-NH_4^+ by Nessler (Peech et al. 1947). For total P, samples were undergone digestion by $HClO_4$ and color developing after Dickman and Bray (1940); available P by method of Bray-2 (NH_4F 0,03N + HCl 0,1N). For Total K, samples were undergone digestion by H_2SO_4 and $HClO_4$ and measured by Atomic Absorption Spectrophotometter (Tiem and Tau 1983); exchangeable cation K^+ by method $BaCl_2$ were measured by Atomic Absorption Spectrophotometer.

Statistical analysis tool by IRRISTAT software was employed to summarize the data and examined the effect of long term fertilizer application.

RESULTS AND DISCUSSIONS

1. Total N (%N) in soil

Nitrogen is a major nutrient element determining crop yield. The differences of nitrogen contents in soil are depended on soil organic matter content. Plenty of humus in soil is a plenty of nitrogen (Anh 2002)

After 34 rice crops, total N in all treatments ranged from 0.248% to 0.303%N (Table 1). Total N in control treatment (0.248%N) was lower than at the initial status (0.26%N). Total N in treatments supplied only K fertilizer was not different from control and lower than other treatments: NK (0.284%N), P (0.297%N), PK (0.289%N), NP (0.303%N), and NPK (0.278% N).

Soil tillage before growing rice also significantly affected to the soil structure in regulating nutrients, air, and water in soil.

The system of mono-culture is disadvantageous because plant can take up selected nutrient. This causes shortage of certain nutrients and excess of other ones for the need of the crop. Therefore, rotational cultivation improves soil fertility and plant residues from previous season will supply for the next season. For example, residues from legume in previous season play role as fertilizer for rice crop in the following season (Tuyen 1997).

2. Available N as NH_4^+ form (mg/kg)

Available N as NH_4^+ form varied from 23.78 to 32.04 mg/kg. These amounts were not significantly different among treatments. This showed that nitrogen element was not accumulated in soils.

Table 1: Total nitrogen and available N in soil after 34 rice crops

Treatments	Total N (%)	$N\text{-}NH_4^+$ (mg/kg)	$N\text{-}NO_3^-$(mg/kg)
Initial	**0.260**		
Control	0.248 a	26.04 a	4.39 ab
N	0.266 ab	29.29 a	8.77 b
K	0.249 a	23.78 a	5.82 ab
NK	0.284 bc	32.04 a	6.42 ab
P	0.297 bc	27.81 a	2.80 a
PK	0.289 bc	30.82 a	4.43 ab
NP	0.303 c	28.18 a	8.15 b
NPK	0.278 abc	25.24 a	8.33 b
CV (%)	7.5	17.8	46.3

3. Total P_2O_5 (% P_2O_5) in soil

According to Anh (2002), P is the first element limiting crop yield, especially rice plant. Serious P shortage in Vietnam soil nowadays has lead to P fertilizer use as important strategy in agriculture production. This investigation shows that total P_2O_5 in all treatments ranged from 0.037 to 0.060 % P_2O_5. This indicates that P_2O_5 in soil is poor. The total P_2O_5 in all treatments were noticed in P treatment as 0,060 %P_2O_5, PK (0,056 %P_2O_5), NP (0,053%P_2O_5), NPK (0,045 %P_2O_5)]. They were equivalent or higher than initial P value (0,05% %P_2O_5). Treatments without P were lower than initial value [control (0.037 %P_2O_5); N (0.038 %P_2O_5); K (0.037 %P_2O_5); NK (0.039 %P_2O_5)] (Table 2). P rich soil is high fertility, and high fertility soil is rich in phosphate (Detrunk 1931 cited by Anh 2002).

4. Available P_2O_5 (mg P_2O_5/kg) in soil

Available P by Bray-2 (NH_4F 0.03N +hl 0.1N) shows that control treatment is the lowest available P (0.254 mg P_2O_5/kg) and treatment supplied P is the highest available P (0.784 mg P_2O_5/kg). The values in all other treatments were higher than control.

Table 2: Total P (% P_2O_5) and available P (mg P_2O_5/100g) in soil after 34 seasons

Treatments	Total P (%P_2O_5)	P-Bray-2 (mgP_2O_5/100g)
Beginning	0.05	
Control	0.037 a	0.254 a
N	0.038 a	0.275 ab
K	0.037 a	0.281 ab
NK	0.039 a	0.309 ab
P	0.060 c	0.784 c
PK	0.056 c	0.473 ab
NP	0.053 bc	0.526 b
NPK	0.045 ab	0.498 ab
CV (%)	13.6	36.8

5. Total K (%K_2O)

K is the third important element for plant after N and P. Hoa (1998) reported that total K in Mekong delta soil varied from 1.41 to 1.91 % K_2O. Exchangeable K quantity in alluvial soil was evaluated from medium to high, limiting at 0.21 cmol/kg. Thai (1994) studied on clay mineral components and showed that soil was rich in hydromica mineral. Clay minerals rich in hydromica, vermiculite and illite have absorbed K strongly. Exchangeable K and available K are major nutrient sources for the crops.

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

Although the soil has high in total K, exchangeable K was shortage. Exchangeable

K in all treatments varied from 0.105 to 0.249 meq/100g. Exchangeable K was highest in K treatment (0.249 meq/100g), followed by NK treatment (0.236 meq/100g). Exchangeable K was not significantly different among control, N, P, NP, and NPK treatments and they were lower than other treatments. It was the highest value in K treatment. The value in K treatment was as well as in NK treatment and higher than other treatments (Table 3).

Table 3: Total K (%K_2O) and exchangeable K cation in soil after 34 seasons

Treatments	Total K (%K_2O)	K^+ (meq/100g)
Control	1.95a	0.126 a
N	1.94a	0.134 a
K	1.99a	0.249 c
NK	1.99a	0.236 bc
P	1.93a	0.136 a
PK	1.96a	0.193 b
NP	1.95a	0.105 a
NPK	1.96a	0.111 a
CV (%)	2.5	18.9

CONCLUSIONS

The soil analyses after 34 seasons in the long term experiment conducted in intensive rice mono-culture indicated that between 1st and 34th season; total nitrogen has increased in NK, P, PK, and NP treatments. Total nitrogen was slightly increased in NPK treatment. Total nitrogen in N treatment was not changed from 1st to the 34th season; meanwhile it was decreased in K and control treatments.

Total P has increased in P, PK, and NP treatments. Total P in NPK treatment did not change. Total P in control, N, K, and NK treatments were decreased after 34th season. Available P in P treatments was higher than the others. The available P in other treatments (PK, NP, and NPK), which were supplied with P fertilizer was higher than the treatments without P (Control, N, K, and NK).

Total K was very abundant, but in immobilization form that plant cannot up take. Exchangeable K is an important nutrient source for plant. Exchangeable K in the treatments K and NK were high. This was low in the rest treatments (Control, N, P, PK, NP, and NPK treatments) possibly due to fixation phenomenon.

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Ảnh hưởng của bón phân N, P, K dài hạn đến N, P, K trong đất sau 34 vụ lúa cao sản

Nghiên cứu ảnh hưởng của bón phân đạm (N),lân (P) và kali (K) dài hạn trên vùng thâm canh lúa tại Viện lúa ĐBSCL, Cần Thơ từ 1986 đến 2003 cho thấy đạm tổng số tăng ở các lô có bón NK, P, PK, và NP và tăng nhẹ ở lô bón NPK. Đạm tổng số không thay đổi ở nghiệm thức có bón N và giảm ở nghiệm thức không bón phân hoặc chỉ bón kali. Lân tổng số tăng ở các nghiệm thức bón lân hoặc lân kết hợp với Kali. Lân dễ tiêu cao ở các nghiệm thức có lân. Kali tổng số cao ở cả hai nghiệm thức có bón phân và không bón phân. Tuy nhiên, kali trao đổi chỉ cao ở lô có bón Kali.