EFFECTS OF N, P, K FERTILIZERS ON SOWING RICE YIELD IN THE TWO-RICE CROPPING SYSTEM ON ALLUVIAL SOIL OF THE MEKONG DELTA

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ABSTRACT

The long-term experiment to evaluate the effects of nitrogen (N), phosphorus (P) and potassium (K) in intensive rice monoculture has been conducted at Cuu Long Delta Rice Research Institute from 1986 to 2021. The experiments were laid out in a split-plot design with 4 replications in the Dry season (DS) and Wet season (WS); the main plots consisted of two varieties (OM1490 and IR64 in the DS2020-2021 and WS2021), the subplots consisted of six treatments (1) Control (-F); (2) PK (-N); (3) N (-PK); (4) NK (-P); (5) NP(-K); (6) NPK. N was applied at 100 kgN/ha (DS), 80 kgN/ha (WS) 7-10 DAS, 20-22 DAS and panicle initiation (PI) stage. P was applied at 40-60 kg P_2O_5/ha (DS and WS) at the time of final puddling. K was applied at 30 kg K_2O/ha at 7-8 DAS and PI stages. The results showed that N is a great factor contribute to the rice yield. The treatments with single N or the combined application of NP, NK, and NPK all increased yield from 1.63-1.85 tons/ha, respectively (IR64) from 1.35-1.62 tons/ha (OM1490) in DS2020-2021 and from 1.01-1.39 tons/ha (IR64) from 0.83-1.16 tons/ha (OM1490) compared with (-F) in WS2021.

Keywords: Long term, Nitrogen (N), Phosphorus (P) Potassium (K), grain yield (GY).

INTRODUCTION

Nitrogen (N), Phosphorus (P) and Potassium (K) are three macro-element nutrients in rice cultivation, N fertilizer contributes to an increase in yield by about 40-45%, P fertilizer contributes about 20-30% and K fertilizer contributes about 5-10% (Pham Sy Tan 2008). However, nutrition managment and investment efficiency depend on many factors such as soil conditions, climate and weather, crops of each region, varieties, and cultivation level of farmers. In conventional method, farmers usually apply a tremendous amount of N fertilizer while paying little attention to P and K fertilizer or not paying attention to K fertilizer. In addition, the long-term application of N, P, and K fertilizers will increase soil compaction to lead the rice yield will decrease gradually over time of cultivation.

A balanced applied fertilizer and fertilizing method according to the rice nutrition demand is the best way to achieve high productivity, and high economic efficiency and protect the environment. Therefore, we conducted the research on fertilizing according to the plant demand base on the ability to supply nutrients from the source in the soil which has been carried out precisely through the application of the vacant lot technique (Dobermann and Witt 2004).

MATERIALS AND METHODS

Materials

Two high yield rice varieties (OM1490 and IR64), with a growth duration of 90-100 days, good resistance to pests and diseases were supplied by Cuu Long Delta Rice Research Institute used in this research. The experiences were conducted in two consecutive seasons

(Dry Season 2020 (DS2020) and West Season 2021(WS2021)). The fertilizer source was used from popular synthetic fertilizer in Vietnam; Urea (46% N), Super Phosphorus (16% P_2O_5), Potassium (60% K_2O).

Methods

The experiments were laid out in a split-plot with 2 factors:

- Factor A (Main-plots): Seed factor, including 2 varieties OM1490 and IR64 (DS 2020-2021 and WS 2021).

- Factor B (Sub-plots): Fertilizer factor, including the following levels of fertilizer: (1) Control (-F); (2) PK (-N); (3) N (-PK); (4) NK (-P); (5) NP (-K); (6) NPK with 4 reps.

Table 1. Description of the experimental treatments.

No.	Treatments	Description
T1	Control	Do not fertilizers (-F)
T2	PK	Full application of phosphorus, potassium, Nitrogen omission
T3	N	Full application of nitrogen, Potassium and phosporus omission
T4	NK	Full application of nitrogen, potassium, Phosphorus omission
T5	NP	Full application of nitrogen, phosphorus, Potassium omission
T6	NPK	Full application of nitrogen, phosphorus, potassium

The cultivation practices

The main plots area is $80m^2$, the sub plots area is $40m^2$. After each crop, the rice straw is cut close to the root and removed from the field. Seasonally, the soil preparation was conducted by hand for undisturbed beside plots.

The formula of fertilizer in DS and WS crops was applied by the following dosage:

- DS: 100-40-30 (N; P: P_2O_5; K: K_2O); WS: 80-60-30 (N; P: P_2O_5; K: K_2O).

- N: Divided into 3 applications, the 1^{st} time from 7-10 days after sowing (DAS) with 30%; the second time applied at rice from 20-22DAS with 40%; the 37-42 DAS with the remaining 30%.

- P: Apply 50% at 7-10 DAS and the remaining 50% at 18-22 DAS.

- K: Apply at 7-10 DAS is 50% and the remaining 50% apply rice at 37-42 DAS.

Sowing method: Seed broadcast in rate 100kg/ha in DS, 80kg of seed/ha in WS.

The chemical properties of the soil were a loamy alluvium with the contents of 40% sand, 51% silt and 9% clay at 0-20cm layer and 40% sand, 49% silt and 11% clay at 20-40cm layer. The properties of soil were low in organic C and total N, medium-high in P, and low-medium in K.

Data collection

Data of yield components and GY were collected and calculated followed by IRRI (1995). Yield and yield components were collected when the grains reach 80% of maturity.

- Grain yield: Grain will be harvested at maturity from the inner $5m^2$ sampling area with five replications and be threshed using a small portable thresher to determine the final paddy grain weight. The final yield data will be presented on a per-hectare basis at 14% moisture content, kg/ha.

- Grains per panicle: These shall be composed of total counts and weights of grains in 25 sample superior panicles and 25 sample inferior panicles at random.

- Filled and unfilled grain: From the total counts and total weights of grains in 25 sample superior panicles and 25 sample inferior

panicles further separations into filled and unfilled grains for each panicle sample will be done and recorded.

- One thousand grain weight: The 25 sample superior panicles and 25 inferior panicles per plot will be manually hand-threshed and weighed using an electronic weighing balance.

Data analysis

The data relating to each character will be analyzed statistically by applying the technique of Analysis of Variance with the help of SAS and SPSS software.

RESULTS AND DISCUSSION

Long-term effect of N, P, K fertilizers on number of panicles/m^2 on 2 rice varieties of Dry season 2020-2021 and Wet season 2021

The **Table 2** showed the number of panicles/m^2 in two seasons of IR64 and OM1490. In control (-F) treatment, the average number of panicles/m^2 in DS2020-2021 and in PK treatment was 318 panicles/m^2 and 323 panicles/m^2, consecutively which were significantly lower at 5% compared with other treatments such as (N, NK, NP, NPK). The number of panicles/m^2 of these varieties in WS 2021 was similar to the trend in the DS 2020-2021. The lowest number of panicles/m^2 was recorded in control and PK treatments. The number of panicles/m^2 of the supplied N (NK, NP and NPK) treatments was the highest in both rice varieties in two consecutive seasons (**Table 2**). The result shows that nitrogen deficiency has a positive effect on the number of panicles/m^2 in both rice varieties and in both DS and WS crops.

Table 2. Effect of N, P, K fertilizers on the number of panicles/m^2 on 2 rice varieties.

Treatment	DS 2020-2021		Mean (B)	WS 2021		Mean (B)
	IR64	OM1490		IR64	OM1490	
Control	327^b	310^b	318^b	358^b	338^b	348^c
PK	327^b	320^b	323^b	360^b	340^b	350^c
N	376^a	370^a	373^a	384^b	405^a	395^b
NK	378^a	373^a	375^a	445^a	407^a	426^{ab}
NP	384^a	380^a	382^a	466^a	402^a	434^{ab}
NPK	390^a	382^a	386^a	467^a	411^a	439^a
Mean (A)	363	356		413	384	
F (A)	ns	CV%	14.2	ns	CV%	14.7
F (B)	*	CV%	5.8	*	CV%	9.8
F (A*B)	ns			ns		

In the same column, numbers with the same letter followed do not differ at 5% significance through the Duncan test; ns: Differences are not statistically significant; *: 5% difference in significance.

Long-term effect of N, P, K fertilizers on number of filled grains/ panicle on 2 rice varieties of Dry season 2020-2021 and Wet season 2021

The results of **Table 3** showed the number of filled grains/panicle in two consecutive season. The lowest number of filled grains/panicles was recorded in the control and PK treatment in both 2 rice varieties (IR64 and OM1490) of 2 crops (DS 2020-2021 and WS 2021). The filled

grains/panicle was 40-43 and 31-33 filled grains/panicle in the DS and in the WS, consecutively which differed significantly from the supplied N treatments (N, NK, NP, NPK). These results showed that N fertilizer has an effect on the formation of filled grains/panicle in two varieties and in two crops of 2020 and 2021. In the DS 2020-2021, N treatment, the number of filled grains/panicles reached 52 filled grains) was not significantly different from the supplied P, K treatments. But in the WS 2021, when applied N, but without P, K fertilizer, the number of filled grains/panicle obtained 37 filled grains which was significantly different compared with the supplied P and K treatments.

Table 3. Effect of N, P, K fertilizers on the number of filled grain/panicle.

Treatment	DS2020-2021		Mean (B)	WS2021		Mean (B)
	IR64	OM1490		IR64	OM1490	
Control	39^{b}	42^{b}	40^{b}	27^{b}	35^{b}	31^{c}
PK	41^{b}	43^{b}	42^{b}	30^{b}	36^{b}	33^{c}
N	51^{a}	52^{a}	52^{a}	31^{b}	42^{a}	37^{b}
NK	56^{a}	57^{a}	56^{a}	37^{a}	44^{a}	40^{ab}
NP	53^{a}	54^{a}	54^{a}	37^{a}	45^{a}	41^{a}
NPK	56^{a}	59^{a}	57^{a}	37^{a}	45^{a}	41^{a}
Mean (A)	49	51		33^{b}	41^{a}	
F (A)	ns	CV%	10.1	*	CV%	9.1
F (B)	*	CV%	9.4	*	CV%	8.9
F (A*B)	ns			ns		

In the same column, numbers with the same letter followed do not differ at 5% significance through the Duncan test; ns: Differences are not statistically significant; *: 5% difference in significance.

Long-term effect of N, P, and K fertilizers on the percentage of unfilled grain on 2 rice varieties in Dry Season 2020-2021 and Wet Season 2021

According to the report of Nguyen Nhu Ha (2006), the lack of nitrogen causes the poor tillering, small tillers, poor flowering ability, low number of filled grains/panicles and lead to yield loss. Excess nitrogen causes large leaves, long leaves, ineffective tillers, late flowering, high plant, and collapse which adversely affects the grain yield and quality. Thus, the absence of N fertilizer in control treatment greatly affected the percentage of unfilled grain in two rice varieties (IR64 and OM1490) in the two rice crops (DS2020-2021 and WS2021). The percentage of unfilled grain gradually increased in the order of the fertilizer formula as follows: NPK < NP < NK < N < PK < -F (in DS2020-2021) and NPK < NK < NP < N < PK < -F (WS 2021), (**Table 4**).

Table 4. Effect of N, P, K fertilizers on the percentage of unfilled grain on 2 rice varieties.

Treatment	DS2020-2021		Mean	WS2021		Mean
	IR64	OM1490	(B)	IR64	OM1490	(B)
Control	17.9^{a}	18.0^{a}	18.0^{a}	34.6^{a}	28.8^{a}	31.7^{a}
PK	16.2^{a}	17.5^{a}	16.9^{ab}	33.9^{a}	27.0^{ab}	30.4^{ab}
N	14.6^{ab}	16.0^{ab}	15.3^{bc}	32.5^{ab}	24.7^{bc}	28.6^{bc}
NK	12.2^{bc}	15.7^{ab}	13.9^{cd}	28.6^{c}	22.1^{c}	25.3^{d}
NP	11.3^{bc}	13.7^{b}	12.5^{d}	29.4^{bc}	23.9^{bc}	26.7^{cd}
NPK	10.6^{c}	12.9^{b}	11.7^{d}	26.1^{c}	23.0^{c}	24.6^{d}
Mean (A)	13.8	15.6		30.9^{a}	24.9^{b}	
F (A)	ns	CV%	25.5	*	CV%	9.3
F (B)	*	CV%	16.4	*	CV%	8.1
F (A*B)	ns			ns		

In the same column, numbers with the same letter followed do not differ at 5% significance through the Duncan test; ns: Differences are not statistically significant; *: 5% difference in significance.

Long-term effects of N, P, K fertilizers on 1,000 grain weight of 2 rice varieties Dry season 2020-2021 and Wet season 2021

The results of **Table 5** demonstrated the effect of N, P, and K fertilizers on 1,000 grains weight in two rice varieties in two consecutive crops (DS2020-2021 and WS2021). Among treatments, there was no significant difference in the weight of 1,000 grains at the 5% level, the weight ranges from 25.4-26.4 gr in IR64 and ranged from 24.4-25.3 gr in OM1490 in both two crop seasons.

Table 5. Effect of N, P, K fertilizers on weight of 1,000 grains (gr) on 2 rice varieties.

Treatment	DS2020-2021		Mean	WS2021		Mean
	IR64	OM1490	(B)	IR64	OM1490	(B)
Control	26.0	25.1	25.6^{ab}	26.3	25.0	25.6
PK	26.0	25.1	25.6^{ab}	25.7	25.0	25.3
N	25.5	25.2	25.3^{abc}	26.4	24.7	25.5
NK	25.5	25.0	25.3^{abc}	25.8	24.4	25.1
NP	25.4	24.6	25.0^{bc}	25.7	25.3	25.5
NPK	26.1	25.2	25.7^{a}	25.7	24.6	25.2
Mean (A)	25.8	25.0		25.9^{a}	24.8^{b}	
F (A)	ns	CV%	3.3	*	CV%	1.1
F (B)	*	CV%	2.1	ns	CV%	1.7
F (A*B)	ns			ns		

In the same column, numbers with the same letter followed do not differ at 5% significance through the Duncan test; ns: Differences are not statistically significant; *: 5% difference in significance.

Long-term effect of N, P, K fertilizers on yield of 2 rice varieties Dry season 2020-2021 and Wet season 2021

Table 6 showed the average grain yield of two varieties in two consecutives. In the DS 2020-2021, both IR64 and OM1490 variety in - F and PK (without N) treament gave the lowest grain yields (3.03 and 3.14 tons ha^{-1}, respectively) which were significant different compared with the other treatments (N, NK, NP, NPK with rice yield ranging from 4.52-4.76 tons ha^{-1}).

In the WS 2021 crop, the results were similar to the DS2020-2021 crop. In the - F and PK treatments, the yield obtained (2.3 and 2.7 tons ha^{-1}, respectively) significantly lower compared with treatments with applied N fertilizer (N, NK, NP, NPK) ranged from 3.22-3.58 tons ha^{-1}. These results showed that the absence of fertilizer and the absence of N fertilizer is the main factors that affected rice yield in both two varieties.

The results of two crop seasons demonstrated that rice grain yield was boosted in applied nitrogen element (N, NP, NK, NPK) treatments. Rice grain yield increased 1.63-1.85 tons ha^{-1} and 1.35-1.62 tons ha^{-1} in IR64 and OM1490, respectively in DS2020-2021. In WS2021 crop yield increased 1.01-1.39 tons ha^{-1} in IR64 and 0.83-1.16 tons ha^{-1} in OM1490) compared with treatment (- F).

Table 6. Effect of N, P, K fertilizers on grain yield (tons ha^{-1}) on 2 rice varieties.

Treatment	DS2020-2021		Mean	WS2021		Mean
	IR64	OM1490	(B)	IR64	OM1490	(B)
Control	3.02^{b}	3.04^{b}	3.03^{b}	2.16^{b}	2.44^{b}	2.30^{c}
PK	3.17^{b}	3.11^{b}	3.14^{b}	2.66^{b}	2.74^{b}	2.70^{b}
N	4.65^{a}	4.39^{a}	4.52^{a}	3.17^{a}	3.27^{a}	3.22^{a}
NK	4.71^{a}	4.50^{a}	4.60^{a}	3.34^{a}	3.47^{a}	3.41^{a}
NP	4.80^{a}	4.59^{a}	4.70^{a}	3.43^{a}	3.53^{a}	3.48^{a}
NPK	4.87^{a}	4.66^{a}	4.76^{a}	3.55^{a}	3.60^{a}	3.58^{a}
Mean (A)	4.20^{a}	4.05^{b}		3.05	3.18	
F (A)	*	CV%	3.6	*	CV%	12.5
F (B)	*	CV%	6.7	ns	CV%	11.3
F (A*B)	ns			ns		

In the same column, numbers with the same letter followed do not differ at 5% significance through the Duncan test; ns: Differences are not statistically significant; *: 5% difference in significance.

These results clearly showed that the nitrogen element is the main factor that increases grain yield, while the P and K factors do not play a role in increasing the yield significantly. But applying a full combination of P and K fertilizers with N obtained the optimal yield. And the results in this experiment are similar to the findings of Pham Sy Tan (2008), in rice intensive cultivation in the Mekong Delta, nitrogen fertilizer contributes to an increase in grain yield by about 40-45%, phosphate fertilizer contributes about 20-30% and potash fertilizers contribute about 5-10%.

CONCLUSION

The results of the rice crop experiments DS 2020-2021 and WS 2021 draw the following conclusions: The grain yield in applied nitrogen (N, NP, NK, NPK) in both consecutive crops was higher compared to the control (- F). These

results confirmed again the role of nitrogen element to decide grain yield in rice cultivation. There was no statistical significance between applied nitrogen treatment. However, the grain yield increased in supplied adequate N, P, K elements. Thus, achieving the highest rice grain yield, it is necessary to combine all N, P, K elements in rice nutrient management.

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ẢNH HƯỞNG DÀI HẠN CỦA N, P, K TRÊN NĂNG SUẤT LÚA SẠ TRONG CƠ CẤU 2 VỤ LÚA/NĂM Ở VÙNG PHÙ SA Ở ĐỒNG BẰNG SÔNG CỬU LONG

Thí nghiệm nghiên cứu ảnh hưởng của phân đạm (N), lân (P) và kali (K) dài hạn trên đất phù sa thâm canh lúa 2 vụ lúa/ năm được thực hiện tại Viện Lúa ĐBSCL từ năm 1986 đến năm 2021. Thí nghiệm được bố trí theo thể thức lô phụ với 4 lần lặp lại vào vụ Đông Xuân (ĐX) và vụ Hè Thu (HT). Giống lúa thuộc lô chính bao gồm 2 giống (OM1490 và IR64 trong vụ ĐX2020-2021 và HT2021) với mật độ sạ 100 kg lúa giống/ha. Lô phụ gồm 6 nghiệm thức (1) Đối chứng (-F); (2) PK (-N); (3) N (-PK); (4) NK (-P); (5) NP (-K); (6) NPK. Phân N bón 100 kgN/ha (vụ ĐX), 80 kgN/ha (vụ HT) ở giai đoạn 7- 10 ngày sau sạ (NSS), 20-22 NSS và giai đoạn bắt đầu tượng khối sơ khởi (PI). Phân P được bón ở mức 40-60 kg P_2O_5/ha (ĐX và HT) ở giai đoạn 7-10 NSS. Phân K được bón ở mức 30 kg K_2O/ha ở 7-10 NSS và giai đoạn (PI). Từ kết quả thí nghiệm cho thấy phân N là yếu tố tăng năng suất lúa cao nhất, các nghiệm thức bón N (-PK) hay bón kết hợp NP, NK, NPK đều cho năng suất lúa tăng từ 1,63-1,85 tấn ha^{-1}, tương ứng với giống lúa (IR64) từ 1,35-1,62 tấn ha^{-1} (OM1490) trong ĐX2020-2021 và từ 1,01-1,39 tấn ha^{-1} (IR64) từ 0,83-1,16 tấn ha^{-1} (OM1490) so với nghiệm thức (-F) trong vụ HT 2021.

Từ khóa: *Thí nghiệm Dài hạn, Đạm (N), Lân (P) Kali (K), năng suất (GY).*