

CONVERTING LAND FOR PLANTING 3 RICE CROPS/YEAR WITH LOW EFFICIENCY TO A RICE-MAIZE-RICE STRUCTURE

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ABSTRACT

The models were designed as on-farm trials in 3 villages of Tan Hoa, Nhon Nghia and Truong Long Tay, Chau Thanh A district, Hau Giang province with 2 treatments: Farmer Farming (FF) and Integrated Crop Management (ICM) with the purpose of increasing income for rice farmers in the region 3 rice crops per year. Growing 3 rice crops/year in the absence of irrigation water in the Summer-autumn crop, the economic efficiency is not high, and farmers often break even or suffer capital losses. Rotating 2 rice crops with upland crops to change crop structure (maize has high yield potential), increasing income for low-efficiency rice farmers has been improved by the application of ICM in maize production. The results from the ICM model based on improved nutrient management and plant density in the Summer-autumn crop of 2021 showed that maize yield increased by 0.28 tons/ha and achieved a net profit of 1,931.8 million VND/ha compared to FF. Converting from rice to maize production (with ICM) in the Summer-autumn crop compared with FF (Summer-autumn) yielded a difference of 1.93 tons/ha and a net profit of VND 3,885.7 million VND/ha.

Keywords: Potential yield, grain yield (GY), maize production, farmer Farming (FF), Integrated Crop Management (ICM).

INTRODUCTION

In Viet Nam as well as in many Southeast Asia countries, maize is the second most important cereal crop after rice. Although the maize area and yield continuously increased in recent years, it gets lower grain yield than that of other countries. Otherwise, the maize productivity of Viet Nam as well as the Mekong Delta is very large, in which An Giang is the one of provinces that has a maize yield fairly high with 8,900 ha in 2016 and an average maize yield of 7.5 tons/ha and the productivity of 78,000 tons. To get the best goal, the approaches are quickly expanded of growing areas of good maize varieties and combined with intensive crop management. Moreover, currently recorded average maize yields compared with the yield potential for a given variety and climate indicate significant opportunities to further increase maize

productivity through site-specific, integrated nutrient and crop management (Witt et al. 2005). Every year, Viet Nam has to import more than 7 million tons of maize to meet the demand for livestock, while production of Summer-autumn rice in the Mekong Delta is not effective with low productivity that is only about 4.5-5.5 tons/ha and brings no profit for rice farmers. Meanwhile, the water needs for rice are very high. Therefore, it is necessary to convert a part of the Summer-autumn inefficient rice cultivation area into maize cultivation in order to increase income for farmers and reduce irrigation water for rice. According to the MARD, it is expected that by 2020, the production conversion area is over 204,000ha, of which maize alone accounts for 26% or 53,000 ha (www.mard.gov.vn). Over the past time, Cuu Long Delta Rice Research Institute (CLRRI) has

researched and developed models of application of technical advances in maize cultivation in the Mekong Delta, in which typical research in Chau Thanh A district, Hau Giang province in 2021 that achieved good results.

MATERIALS AND METHODS

Materials

The models were done at 3 villages of Tan Hoa, Nhon Nghia and Truong Long Tay, Chau Thanh A district, Hau Giang province on a loamy alluvium soil with the contents of 38% sand, 52% silt and 10% clay at 0-20cm layer and 37% sand, 50% silt and 13% clay at 20-50cm layer. The chemical soil properties were low in

organic C and total N, medium-high in P. P available *Bray No.2* analysis method is suitable for acidic soil (**Table 1**). Varieties: OM54541, OM 18, OM7347, Nang Hoa 9... These are high-yield rice varieties, with a growth duration of 90-100 days, good resistance to pests and diseases. The maize variety of DK9901 with a growth duration of 95-100 days was used in the Summer-autumn season. This variety evaluated that has high yielding and suitable for many ecological regions of the Mekong Delta. Fertilizers: Urea (46% N), Super Phosphorus (16% P₂O₅), Potassium (60% K₂O), DAP (18% N, 16% P₂O₅), NPK (20-20-15; 16-16-8 N - P₂O₅- K₂O).

Table 1. Characteristic of surface soil in 2021 of Chau Thanh A, Hau Giang province.

Soil depth (cm)	pH	EC mS/ cm	N total (% N)	Carbon (% C)	P available <i>Bray No.2</i> (mg P kg ⁻¹)
0-20	4.6	2.11	0.27	3.27	1.7
20-50	4.8	2.21	0.21	2.17	1.5

Methods

The Models were designed as On-farm trials in with 2 treatments as followed:

- Farmer Farming (FF): Cultivation measures such as plant density, fertilizer, watering, and plant protection were completely applied according to farmers' practices.
- Integrated Crop Management (ICM): Application of ICM consisted of adjusting plant density at 70,000 plants/ha with proper plant spacing and application of N, P and K at recommended rate (average N amount is 160 kg N/ha, the average P is 80 kg P₂O₅/ha, the average K is 80 kg K₂O /ha) and applied the IPM.

Sampling and data processing methods

Data on the annual production of triple rice crop and double rice crop - upland crop in FF were gathered from a sample of 50 farmers who cultivated an area of over 25 hectares. The data collection was conducted using the Participatory

Rural Appraisal (PRA) approach, as prescribed by the National Environment Secretariat (1991).

Data was collected on maize output from 50 farmers in an Integrated Crop Management (ICM) system covering an area of 25 hectares. The collection of this data was conducted using the Participatory Rural Appraisal (PRA) method (National Environment Secretariat, 1991), as guided by technical staff. The information gathered focused on several aspects of maize production, including fertilizer usage, plant density, irrigation practices, and pest management.

Data on the application of NPK fertilizer was collected from a sample of 50 farmers in FF and another sample of 50 farmers in ICM. The yield of rice and maize was collected and processed according to the procedures of IRRI (1994) and Witt et al. (2006).

Data were processed statistically by SPSS 10.05 and the T_{test}.

RESULTS AND DISCUSSION

Comparison of applied fertilizer amount between Integrated Crop Management and Farmer Farming of Summer-autumn season of 2021

There is a great difference in fertilizer application methods among farmers in ICM and FF treatments. The results of data collecting from 50 farmers in FF showed that the lowest fertilizer nitrogen was 88 kg N/ha and the highest was 214 kg N/ha with an average of 154 kg N/ha. The amount of phosphate fertilizer

ranged from 53-84 kg P₂O₅/ha and averaged at 72 kg P₂O₅/ha. The amount of potassium fertilizer applied ranged from 44-72 kg K₂O/ha and averaged at 63 kg K₂O/ha. The average amount of applied fertilizers of 50 farmers in FF were less than 6.0 kg N/ha, 8.0 kg P₂O₅/ha and 17.0 kg K₂O/ha compared to ICM (**Table 2**). The previous research indicated that maize has a high demand for N, P and K nutrients, thus increasing the applied fertilizer rate is needed to increase maize productivity (Tan and Khuong 2007; Trinh Quang Khuong et al. 2010).

Table 2. Average applied-fertilizer amount in Integrated Crop Management and Farmer Farming of Summer-autumn season of 2021 in Chau Thanh A, Hau Giang.

Season	Treatment	N (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
Summer-autumn 2021	ICM	160	80	80
	FF	154	72	63
T _{test}		ns	**	**

Comparison of plant density between Integrated Crop Management and Farmer Farming of Summer-autumn season of 2021 in Chau Thanh A, Hau Giang

There is a great difference in the adjustment of plant density between ICM and FF treatments. Compared to ICM which applied the plant density of 65-75 thousand plants/ha (averaged at 70,000 plants) the FF applied at the lower density of 56-65 thousand plants/ha. Otherwise, with the above plant density in ICM, the plant spacing of 70 x 20cm or 75 x 18cm was applied whereas the spacing of 80 x 25cm or 75 x 30cm in FF was applied. Sometimes, farmers still keep 2 plants

per hole with a density of 56-61 thousand plants/ha. This feature resulted from the sowing of two seeds in a hole, then 10-15 days after sowing they decided to cut off a weak plant or remained of 2 plants in their fields (**Table 3**). So that these higher plant densities helped to improve the maize yields in ICM. Recently, the results from research in improving productivity through Site Specific Nutrient Management - SSNM and plant density firmly confirmed the efficacy of ICM in maize production in other ecological zones of the Mekong Delta (Trinh Quang Khuong et al. 2010).

Table 3. Plant density in Integrated Crop Management and Farmer farming of Summer-autumn season of 2021 in Chau Thanh A, Hau Giang.

Unit: 1,000 plants/ha

Season	Treatment	Tan Hoa	Nhon Nghia	Truong Long Tay
Summer-autumn 2021	ICM	65-75	65-75	65-75
	FF	55-63	56-61	55-64
T _{test}		*	**	**

Effect of application of Integrated Crop Management in maize production on yield and economic efficiency

The result in **Table 4** showed the application of ICM in maize production that combined the improved planting densities and spacing with balanced NPK fertilization in FF helped to increase the grain yield compared to those of FF. The grain maize yield of ICM was 6.99 tons/ha compared to 6.71 tons/ha of FF and increased by 0.28 tons/ha. However, application of ICM, the seed and fertilizer costs increased which

increased higher than 106.4 thousand VND/ha for seed and 187.8 thousand VND/ha for fertilizers compared to FF. Besides, the pesticide cost decreased by 350 thousand VND/ha from the thoughtful care of extension workers towards ICM. Although the average total costs of 50 farmers in ICM got higher than 50 farmers in FF by 55.8 thousand VND/ha but with higher grain yield attained; consequently, the net benefit of ICM got higher than those of 1,931.8 thousand VND/ha compared to FF, equivalent increased 14.0%, Trinh Quang Khuong et al. (2016).

Table 4. Comparison of yield and economic efficiency of maize production in Integrated Crop Management and Farmer farming of Summer-autumn season of 2021, (Average of 100 farmers).

Parameters	ICM (Maize)	FF (Maize)	Difference (1) – (2)
	Summer- autumn (1)	Summer-autumn (2)	
Grain yield (kg ha ⁻¹)	6,990	6,710	280
Total income (1,000 VND ha ⁻¹)*	46,833	44,957	1,876
Seed cost (1,000 VND ha ⁻¹)	1,574	1,467.6	106.4
Fertilizer cost (1,000 VND ha ⁻¹)	10,084.8	9,897	187.8
Pesticide cost (1,000 VND ha ⁻¹)	2,400	2,750	- 350
Labor cost (1,000 VND ha ⁻¹)	12,400	12,400	-
Labor in handling stem, leave, root (1,000VND ha ⁻¹)	4,600	4,600	-
Total Cost (1,000 VND ha ⁻¹)	31,058.8	31,114.6	- 55.8
Net benefit (1,000 VND ha ⁻¹)	15,774.2	13,842.4	1,931.8

Maize price: 6,700 VND/kg, Rice price 6,725 VND/kg on 2021, June.

Effectiveness of application of Integrated Crop Management on maize in increasing efficiency on low-efficient rice land in Summer-autumn crop in 2021

The results in **Table 5** showed that when farmers in FF shifted from rice to maize cultivation in the Summer-autumn crop they had to spend more costs than rice cultivation including fertilizer, and labor costs from land preparation until harvesting and postharvest treatment. They got the higher cost difference of

3.884,8 million VND/ha for fertilizer and 4.70 million VND/ha for labor cost in production and 3.71 million VND/ha for by-product treatment. But the cost of seeds and pesticides for maize production was lower than those for rice production. They reduced from 276 thousand VND/ha for seeds and 2,100 thousand VND/ha for pesticides, respectively.

The difference in the total cost of maize production in FF was higher 8.0918,8 million VND/ ha compared to rice cultivation.

However, the maize yield got higher than that of 1.93 tons/ha compared to the rice yield. So, the net benefit of maize production in FF still attained higher than 3.885,7 million VND/ha compared to rice production, an equivalent increase of 33.8%, Trinh Quang Khuong et al. (2019), (Table 5).

Table 5. Effectiveness of application of Integrated Crop Management on maize in increasing efficiency on low-efficient rice land in Summer-autumn crop.

Parameters	ICM (Maize)	FF (Rice)	Difference (1) - (2)
	Summer-autumn (1)	Summer-autumn (2)	
Grain yield (kg ha ⁻¹)	6,990	5,060	1,930
Total income (1,000 VND ha ⁻¹)*	46,833	34,028.5	12,804.5
Seed cost (1,000 VND ha ⁻¹)	1,574	1,850	- 276
Fertilizer cost (1,000 VND ha ⁻¹)	10,084.8	6,200	3,884.8
Pesticide cost (1,000 VND ha ⁻¹)	2,400	4,900	- 2,100
Labor cost (1,000 VND ha ⁻¹)	12,400	8,700	3,700
Labor in handling stem, leave, root (1,000 VND ha ⁻¹)	4,600	890	3,710
Total Cost (1,000 VND ha ⁻¹)	31,058.8	22,540	8,918.8
Net benefit (1,000 VND ha ⁻¹)	15,774.2	11,488.5	3,885.7

Maize price: 6,700 VND/kg, Rice price 6,725 VND/kg on 2021, June.

Comparing the efficiency of maize and rice growing on inefficient rice land in the summer-autumn crop.

The rotation of upland crops in the rice cropping system is not only saving water but also increasing income for farmers. Besides, the

Summer-autumn rice crop after the Spring-summer upland crop will get a higher yield than that in the triple rice system (Witt and Dobermann 2006; Pham Sy Tan and Trinh Quang Khuong 2007).

Table 6. Comparing the efficiency of maize and rice growing on inefficient rice land in the Summer-autumn crop in Chau Thanh A district, Hau Giang.

Parameters	FF (Maize)	FF (Rice)	Difference (1) - (2)
	Summer-autumn (1)	Summer-autumn (2)	
Grain yield (kg ha ⁻¹)	6,710	5,060	1,650
Total income (1,000VND ha ⁻¹)*	44,957	34,028.5	10,928.5
Seed cost (1,000 VND ha ⁻¹)	1,467.6	1,850	- 382.4
Fertilizer cost (1,000 VND ha ⁻¹)	9,897	6,200	3,697
Pesticide cost (1,000 VND ha ⁻¹)	2,750	4,900	- 2,150
Labor cost (1,000 VND ha ⁻¹)	12,400	8,700	3,700
Labor in handling stem, leave, root	4,600	890	3,710

(1,000 VND ha⁻¹)

Total Cost (1,000 VND ha ⁻¹)	31,114.6	22,540	8,574.6
Net benefit (1,000 VND ha ⁻¹)	13,842.4	11,488.5	2,353.9

Maize price: 6,700 VND/kg, Rice price: 6,725 VND/kg on 2021, June.

The results in **Table 6** showed that when farmers in FF shifted from rice to maize cultivation in the Summer-autumn crop they had to spend more costs than rice cultivation including fertilizer, and labor costs from land preparation until harvesting and postharvest treatment. They got the higher cost difference of 3.697 million VND/ha for fertilizer and 3.700 million VND/ha for labor cost in production and 3.710 million VND/ha for by-product treatment. But the cost of seeds and pesticides for maize production was lower than those for rice production. They reduced from 382.4 thousand VND/ha for seeds and 2,150 thousand VND/ha for pesticides, respectively.

The difference in the total cost of maize production in FF was higher at 8.547,6 million VND/ ha compared to rice cultivation. However, the maize yield got higher than that of 1.650 tons/ ha compared to rice yield. So, the net benefit of maize production in FF still attained higher than 2.353,9 million VND/ ha compared to rice production (**Table 6**).

CONCLUSIONS

Application of ICM helped to increase the yield and profitability of maize production on low-efficient rice-growing land and remarkably promoted for shifting of the cropping system in the Mekong Delta of Viet Nam.

The application of proper fertilizer rate in ICM increased the amount of 6.0 kg N/ha, 8.0 kg P₂O₅/ha and 17.0 kg K₂O/ha and improved plant density from 65-75 thousand plants/ha that have resulted in an increase of 0.28 tons/ha and 1,931.8 thousand VND/ha compared to FF in maize production.

Shifting from paddy rice to maize production in the Summer-autumn crop followed by Farmer

farming got the difference in yield of 1.93 t/ha and the net benefit of 3,885.7 million VND/ha.

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CHUYỂN ĐỔI ĐẤT TRỒNG 3 VỤ LÚA/NĂM HIỆU QUẢ THẤP SANG CƠ CẤU LÚA-BẮP-LÚA

Trồng 3 vụ lúa/năm trong điều kiện thiếu nước tưới vụ Hè Thu hiệu quả kinh tế không cao, nông dân thường hòa vốn hoặc lỗ vốn. Luân canh 2 vụ lúa với cây trồng cạn để chuyển đổi cơ cấu cây trồng (trồng bắp có tiềm năng năng suất cao), nâng cao thu nhập cho nông dân trồng lúa ở vụ Hè Thu có hiệu quả kinh tế thấp đã được cải thiện nhờ ứng dụng Quản lý cây trồng tổng hợp (ICM) trong sản xuất bắp. Mô hình được bố trí theo kiểu thử nghiệm trên ruộng nông dân (On-farm trial) tại 3 xã Tân Hoa, Nhơn Nghĩa và Trường Long, huyện Châu Thành A, tỉnh Hậu Giang trên diện tích 50 ha. Ruộng nông dân (ND): Biện pháp canh tác như: mật độ, phân bón, tưới nước, biện pháp bảo vệ thực vật hoàn toàn theo tập quán của nông dân. Ruộng mô hình (MH): Ứng dụng các biện pháp kỹ thuật canh tác tổng hợp (điều chỉnh mật độ cây, khoảng cách cây từ 75.000 cây/ha, bón phân đạm; lân và kali theo khuyến cáo (lượng đạm trung bình là 169,4 kg N/ha; lượng lân trung bình là 80,9 kg P₂O₅/ha; lượng kali trung bình là 70,7 kg K₂O/ha) và biện pháp quản lý nước, phòng trừ sâu bệnh tổng hợp (IPM)). Thu thập các thông tin về sản xuất 3 vụ lúa/năm, 2 vụ lúa - 1 vụ bắp/năm canh tác của nông dân (FF). Kết quả từ mô hình ICM dựa trên cải thiện quản lý dinh dưỡng và mật độ cây trồng trong vụ Hè Thu 2021 tại huyện Châu Thành A, tỉnh Hậu Giang cho thấy, năng suất bắp tăng 0,28 tấn/ha và đạt lợi nhuận ròng là 1.931,8 triệu đồng/ha so với FF. Chuyển đổi từ canh tác lúa sang sản xuất bắp (ứng dụng ICM) trong vụ Hè Thu cho năng suất chênh lệch 1,93 tấn/ha và lãi ròng 3.885,7 triệu đồng/ha.

Từ khóa: *tiềm năng năng suất, năng suất (GY), sản xuất bắp, canh tác của nông dân (FF), quản lý cây trồng tổng hợp (ICM).*