Omonrice 18: 97-103 (2011)

IMPROVING OF MAIZE YIELD AND PROFITABILITY THROUGH INTEGRATED CROP MANAGEMENT (ICM) WITH EMPHASIS ON SITE-SPECIFIC NUTRIENT MANAGEMENT (SSNM) AND PLANTING DENSITY IN HAU GIANG PROVINCE OF VIETNAM

Tran Thi Ngoc Huan[1], Trinh Quang Khuong[1] and Nguyen Van Ngau[2]

[1] Cuu Long Delta Rice Research Institute, Can Tho, Viet Nam (CLRRI)
[2]Department of Science and Technology of Haugiang Province, Vietnam

ABSTRACT

Maize is the second most important cereal crop after rice in Southeast Asian countries. 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. The on-farm experiments were conducted at Chauthanh A district, Haugiang Province, Vietnam in early wet season 2010 on rice-maize-rice cropping system. The 7 treatments were the combination of planting densities.They included as the regular density 67,000 plants ha^{-1} (75x20cm) of farmers practice (FP) and local extension recommendation (LER) and ICM with high plant density of 74,000 plants ha^{-1} (75x18cm), and 76,000 plants ha^{-1} (60x22 cm);and fertilizer application methods: FFP (farmer's fertilizer practice), Extension fertilizer practice (EFP), SSNM and the omission plots of N, P and K on six farmer fields in a randomized completed block design. The result revealed that the ICM treatment got higher grain yield by 0.20-0.63 t ha^{-1} and higher net benefit by VND 0.755 to 2.56 million / ha as compared to LER and FP. For fertilizer application method, SSNM got higher profit than those of EFP and FFP treatments by VND 0.486-1.71 million ha^{-1}. The improved planting densities of 76,000 plant ha^{-1} (60x22 cm) and 74,000 plant ha^{-1} (75x18 cm) got higher benefits than regular planting density of 67,000 plant ha^{-1} (75x20 cm) by 0.37 to 1.56 million VND/ha. The ICM-2 was the best treatment. It should be recommended and transferred to farmers in order to improve the yield and profitability of maize production in Haugiang.

Keywords: Agronomy efficiency of Nitrogen (AEN), Agronomy efficiency of Phosphorus (AEP), Agronomy efficiency of Potassium (AEK), farmer practices (FP), Extension's fertilizer Practice (EFP), farmer's fertilizer practice (FFP), grain yield (GY), Integrated Crop Management (ICM), Integrated Pest Management (IPM), Local extension recommendation (LER), Site-Specific Nutrient Management (SSNM).

INTRODUCTION

In Vietnam 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, but it get lower grain yield than that of other countries. Otherwise, the maize productivity of Vietnam as well as the Mekong Delta is very large, in which Angiang is the one of provinces has maize yield are fairly high with 8,900 ha in 2004 and the average maize yield of 7.4 t/ha and the productivity of 77,000 tons. The new crop management like Site-Specific Nutrient Management (SSNM) and improved planting density have been applied there for increasing further maize productivity but up to now those technologies still new with many regions. Hau giang is the one of places that has the potential in expanding maize for both areas and productivity. For getting the best goal, the approaches are

quickly expansion of growing areas of good maize varieties and combined with intensive crop managements. 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 (Dobermann et al. 2003; Witt et al. 2004). Therefore, the objectives of this research are to determine the effect of Integrated Crop Management with emphasis of Site-Specific Nutrient Management (SSNM) and improving planting density on grain yield and economic efficiency of hybrid maize production at Haugiang province.

MATERIALS AND METHODS

The experiments were conducted on six farmer fields at Nhon nghia A village, Chau thanh A district, Hau giang Province in 2010 Spring-Summer (S-S)/EWS crop. The experiment was comprised of seven treatments, which were the combination of planting densities, fertilizer application methods, and pest management. The planting densities were regular density (67,000 plants/ha) with spacing of 75x20 cm at farmer's and local recommendation, the improved planting densities with high plant density of ICM: 74,000 plants/ha with spacing of 75x18 cm and 76,000 plants/ha with spacing of 60x22 cm. The fertilizer application methods included of farmer's fertilizer practice (FFP), the extension fertilizer practice (EFP) and Site-Specific Nutrient Management (SSNM). The omission fertilizer plots were also included with +PK, +NK and +NP (Table 1).

The soil was a silty clay loam alluvium with the contents of 16% sand, 54% silt and 30% clay at 0-20 cm layer and 9% sand, 51% silt and 40% clay at 20-40 cm layer. The chemical soil properties were medium in organic C, total N, P, and K but low in Ca and Mg, no micro-nutrients deficiency and no soil toxicity.

The maize variety of DK888 with 95-100 days growth duration was used in all farmer fields.
Data of yield components and grain yield were collected and calculated the economic efficiency of ICM with emphasis on improved planting density and SSNM compared to FP and LER followed by the procedure of IRRI and IPNI (Fairhurst et al. 2005).

RESULTS AND DISCUSSIONS

1. Effect of planting densities and fertilizer application methods on yield and yield components of maize.

In S-S/EWS2010, the ears No/ha of maize DK888 among fertilizer treatments and planting densities and spacing varied from 62,894-69,942 ear/ha at ICM with spacing 60x22 cm. This treatment also got highest kernel No/ear (368 kernels/ear) and higher value than that of FP treatment. The difference on the kernel No/ear was clearly varied between the omission plots of each N, P and K. The averaged weight of 100 grains of DK888 varied from 27.2 to 27.5 g at the FP and the ICM treatments, but it only got from 21.5-26.5 g in the omission fertilizer treatments. However; spacing change did not significantly differ on the kernel No/ear and 1000-grain weight (Fig. 1).

Table 1. The seven treatments on the on-farm experiments in S-S 2010 at Chau thanh A, Hau giang

SITE 1 OF ONFARM EXPERIMENTS AT NHON NGHIA A – CHAU THANH A		**PK** *(-N)*: N omission plot, but applied P and K at the recommendation rate. It is used to calculate the indigenous N soil supply.	
NK *(-P):* P omission plot, but applied N and K at the recommendation rate. It is used to calculate the indigenous P soil supply.		**NP** *(-K)*: K omission plot, but applied N and P at the recommendation rate. It is used to calculate the indigenous K supply	
LER (Local Extension Recommendation) Plant density: 67,000 plants/ha (75x20 cm). NPK application followed by extension fertilizer (EFP) and their pest management practices		**FP (Farmer Practices/Control):** Plant density: 67,000 plants/ha (75x20 cm), Farmer's fertilizer (FFP) and their pest management Practices.	
ICM-1: Plant density: 74,000 plants/ha (75x18 cm). NPK application as SSNM. N was adjusted by LCC. Pest management as followed IPM and combined with bio-insecticides.		**ICM-2**: Plant density: 76,000 plants/ha (60x22 cm). NPK application as SSNM. N was adjusted by LCC Pest management as followed IPM and combined with bio-insecticides.	

The grain yield of DK888 got the highest value at ICM and improved planting densities, spacing (75x18cm and 60x22 cm). They got 6.74 and 6.87 ha^{-1}, respectively. These data indicated that the combined treatment of SSNM and high plant densities and integrated pest management (IPM) got higher grain yield than those of the FP and LER treatments by 0.50-0.63 ha^{-1} and by 0.20-0.33

ha^{-1} respectively. That also meant the grain yield of maize was increased 8-10.1% compared to FP treatment and 3.1-5.1% compared to LER treatment. No nitrogen fertilizer application, the grain yield was very low. It got only 3.45-3.51 t/ha in the S-S 2010. Without phosphorus, the grain yield got some low value (5.56-5.68 t/ha). No potassium fertilizer application, the grain yield was got higher than without phosphorus (5.94-6.05 t/ha). These data affirmed that hybrid maize need high dose of nitrogen and phosphorus nutrient. The SSNM method with higher applied-nutrients in high density of plant was essential; especially nitrogen that adequately responded the plant need and led to getting higher grain yield than those of FFP and EFP treatments with the NPK rate at the Table 2 that was manifested.

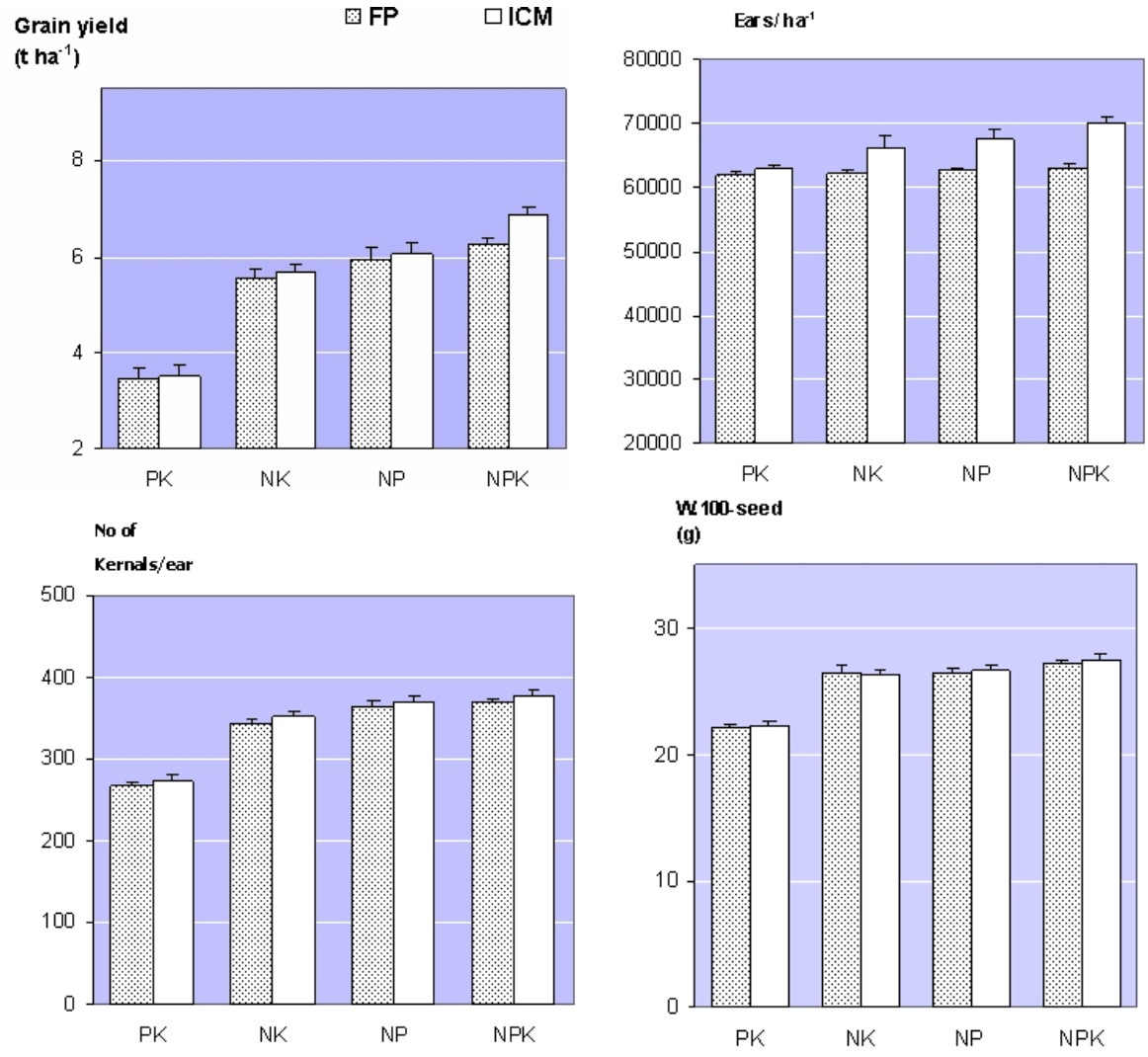

Fig 1. Effect of the planting density and fertilizer treatments on yield and yield components of Maize DK888 in Chauthanh A, Haugiang in EWS 2010.

2. Effect of planting densities and fertilizer application methods on the efficiency of fertilizer use

The difference of three fertilizers application methods on maize really differed on the fertilizer rates of them (Table 2) and especially on nitrogen and phosphorus nutrients. The SSNM of ICM treatments with high N and P than those of FFP and EFP treatments by 14-34 kg N/ha and 15-25 kg P_2O_5/ha, respectively. For potassium, SSNM was applied more than 10 kg K_2O/ha compared to EFP treatment. That clearly explained for the need of high nutrients of maize in such a high planting density of ICM with 74,000 and 76,000 plants/ha.

Table 2. Fertilizer rate of the treatments for Maize in 2010 S-S/EWS at Chau thanh A, Hau giang.

Treatments	NPK Rate (kg/ha)		
	N	**P_2O_5**	**K_2O**
FP (75x20 cm)	166	75	58
LER (75x20 cm)	180	100	50
ICM-1(75X18 cm) /SSNM	200	90	60
ICM-2(60X22 cm) /SSNM	200	90	60

On the other hand, the difference on the NPK rate among SSNM, EFP and FFP manifested on the fertilizer use efficiencies of every N, P and K nutrients. The SSNM treatment got higher AEP and AEK as compared to FFP and EFP, but AEN among treatments were not different because maize really needs much more nitrogen in the combination with high planting density at the ICM treatment (Table 3). This data also indicated that the higher dose of NPK should be applied for maize in a right way as followed with SSNM method to get higher grain yield (Witt 2004; Khuong et al. 2008; Khuong et al. 2010).

Table 3. Agronomic efficiency of N, P, K under different fertilizer management practices.

Treatment	AEN (kg of rice grain kg $^{-1}$ of N)	AEP (kg of rice grain kg $^{-1}$ of P)	AEK (kg of rice grain kg $^{-1}$ of K)
FFP (Control)	16.8	9.1	5.2
EFP	17.2 ns	9.8 ns	12.0 **
ICM-1/SSNM	16.2 ns	11.8 *	11.5 **
ICM-2/SSNM	16.8 ns	13.2**	13.7**

^{ns} non significant at 0.05; * significant at 0.05 and ** significant at 0.01

3. Effect of ICM with emphasis on planting density and fertilizer application methods on economy efficiency of maize production

ICM-2 gave the highest profits (Table 3). The increased profits of ICM-1 and ICM-2 treatments were VND 1.98 and 2.56 million /ha, respectively, as compared to FP treatment (11.4-14.7%). They also got the increased profits from VND 0.755 to 1.33 million /ha as compared to LER treatment.

Among three fertilizer application methods, SSNM got the highest profit than those of FFP and EFP treatments. The increased net benefit of SSNM was VND 1.13 to 1.71 million /ha as compared to FFP and from VND 0.486 to 1.064 million /ha compared to EFP, respectively.

Among three planting densities, the higher planting densities of 74,000 plant ha^{-1} (75x18 cm) and 76,000 plant ha^{-1} (60x22 cm) at ICM-1 and ICM-2 treatments got higher profits than those of regular planting density of 67,000 plant ha^{-1} (75x20cm) at FP and LER treatments. They increased the net benefit from VND 1.02 to 1.56 million /ha and from VND 0.37 to 0.91 million /ha, respectively as compared to FP and LER treatments.

Table 3. Economic analysis of ICM on maize at Chau thanh A, Hau giang in 2010 EWS.

Parameters	Treatments			
	FP	LER	ICM -1	ICM-2
Yield (t ha^{-1})	**6.24**	**6.54**	**6.74**	**6.87**
Price of corn (VND kg^{-1})	4,700	4,700	4,700	4,700
Gross benefit (VND ha^{-1})	**29,328,000**	**30,738,000**	**31,678,000**	**32,289,000**
Total fertilizer cost (VND ha^{-1})	**5,188,132**	**5,770,140**	**6,038,350**	**6,038,350**
Total seed cost (VND ha^{-1})	**1,121,580**	**1,121,580**	**1,238,760**	**1,272,240**
Total pesticides (VND ha^{-1})	**1,400,000**	**1,200,000**	**1,000,000**	**1,000,000**
Labor cost (VND ha-1)	**4,200,000**	**4,000,000**	**4,000,000**	**4,000,000**
Net benefit* (VND ha^{-1})	**17,418,288**	**18,646,280**	**19,400,890**	**19,978,410**
ICM Benefit vs FP (VND ha^{-1})	-	**1,227,992**	**1,982,602**	**2,560,122**
ICM Benefit vs LER (VND ha^{-1})		-	**754,610**	**1,332,130**
NPK benefit (VND ha^{-1}) SSNM vs FFP	-	**645,984**	**1,132,384**	**1,709,904**
NPK benefit (VND ha^{-1}) SSNM vs EFP		-	**486,400**	**1,063,920**
Planting density benefit (VND ha^{-1}) / High density vs regular density at FP	-	-	**1,015,204**	**1,559,244**
Planting density benefit (VND ha^{-1}) / High density vs regular density at LER		-	**369,220**	**913,260**

CONCLUSIONS

Maize yield of 6.5- 7.0 t ha^{-1} can be achieved in Chau thanh A district, Hau giang province. The highest yield was recorded at 6.87 t ha^{-1} on a silty clay loam alluvium soil in early wet season 2010. The yield increased of 0.50-0.63 t ha^{-1} (8-10%) by ICM with combination of SSNM (higher NPK rate and use LCC) and improved planting densities with 74,000 plants ha^{-1} (75x18 cm) and 76,000 plants ha^{-1} (60x22 cm).

ICM help to increase the profit of maize production. It was increased by VND 0.755 to 2.56 million ha^{-1} as compared to LER and FP.

For fertilizer application method, SSNM got higher profit than those of EFP and FFP treatments by VND 0.486 to 1.71 million ha^{-1}. The improved planting densities of 74,000 plant ha^{-1} (75x18 cm) and 76,000 plant ha^{-1} (60x22 cm) got higher benefits than regular planting density of 67,000 plant ha^{-1} (75x20 cm) by VND 0.37 to 1.56 million /ha.

The ICM-2 was the best treatment. It should be more expand recommended and transferred to farmers in order to improve the yield and profitability of maize production in Hau giang.

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Cải thiện năng suất và lợi nhuận của bắp lai thông qua biện pháp quản lý cây trồng tổng hợp (ICM) trong đó nhấn mạnh việc áp dụng quản lý dinh dưỡng theo vùng chuyên biệt (SSNM) và cải thiện mật độ cây ở Hậu Giang

Ở các nước Đông Nam Á, bắp là cây lương thực quan trọng đứng thứ hai sau lúa. Các ghi nhận gần đây cho thấy năng suất bắp trung bình so với tiềm năng suất của một giống trong điều kiện khí hậu nhất định có cơ hội gia tăng hơn nữa bằng biện pháp quản lý cây trồng và dinh dưỡng tổng hợp. Các thí nghiệm đồng ruộng được thực hiện trên ruộng nông dân ở huyện Châu Thành A, tỉnh Hậu Giang trong vụ Xuân Hè 2010 trên cơ cấu 3 vụ: lúa-bắp lai-lúa/năm. Thí nghiệm được bố trí theo khối hoàn toàn ngẫu nhiên với 7 nghiệm thức là sự kết hợp giữa mật độ cây: mật độ cây bình thường 67.000 cây/ha (75x20 cm) ở lô nông dân (FP) và lô khuyến cáo của khuyến nông địa phương (LER), mật độ cây cải tiến trong lô áp dụng quản lý cây trồng tổng hợp ICM: 74.000 cây/ha (75x18 cm) và 76.000 cây/ha (60x22 cm) và các phương pháp bón phân: bón phân theo nông dân-FFP; bón phân theo khuyến cáo của khuyến nông (EFP), bón phân theo địa điểm chuyên biệt-SSNM và các lô khuyết không bón phân N, P và K. Kết quả thu được cho thấy năng suất bắp lai ở nghiệm thức ICM đạt cao hơn từ 0,20 đến 0,63 tấn/ha và lợi nhuận cao hơn từ 0,755-2,56 triệu đồng/ha so với khuyến cáo của khuyến nông địa phương và kỹ thuật của nông dân áp dụng. Phương pháp bón phân theo tiểu vùng chuyên biệt gia tăng lợi nhuận cho nông dân trồng bắp lai được 0,486-1,71 triệu đồng/ha. Mật độ cây cải tiến: 76.000 cây/ha, khoảng cách 60x22 cm và 74.000 cây/ha, khoảng cách 75x18 cm đạt lợi nhuận cao hơn mật độ 67.000 cây/ha, khoảng cách 75x20 cm được 0,37 - 1,56 triệu đồng/ha. Quản lý cây trồng tổng hợp (ICM-2) bao gồm bón phân theo SSNM cho bắp lai, mật độ 76,000 cây/ha, khoảng cách 60x22 cm, áp dụng ICM và thuốc sinh học là nghiệm thức tốt nhất, nên được khuyến cáo mở rộng và chuyển giao áp dụng để gia tăng năng suất và lợi nhuận cho nông dân trồng bắp lai ở Hậu Giang.