Developments in Rice Production in Southeast Asia

By Ernst Mutert and T.H. Fairhurst

While some countries of Southeast Asia have increased productivity of rice in recent years, yields have stagnated in other countries of the region. The correlation to fertilizer nutrient use is clear, and there is great potential for increased production.

Because of its political, economic, and social significance in the eight agricultural countries of the Association of Southeast Asian Nations (ASEAN), rice remains the most important crop grown in Southeast Asia (SE Asia). The greatest levels of productivity are found in irrigated rice, where more than one crop is grown per year and yields are high (**Table 1**). Productivity is poor in upland systems where yields are small and only one crop is grown per year. Upland rice is usually grown without mineral fertilizer, and a long fallow period of at least eight years under secondary forest is required to generate soil fertility. Due to increased population pressure, such lengthy fallow periods are no longer feasible and upland rice is thus a major cause of land degradation and nutrient mining in many parts of the region.

Table 1. A comparison of the productivity of four different rice systems.

System	Yield, t/ha	Crops/yr	Fallow period, yr	Productivity, t/ha/yr
Irrigated rice	5.0	2.5	0	12.5
Rainfed rice	2.5	1	0	2.5
Deep water rice	1.0	1	0	1.0
Upland rice[1]	1.0	1	8	0.12

[1]Grown in slash-and-burn systems, usually on sloping land.

Irrigated and lowland rainfed systems account for more than 95 percent of rice production, so small productivity gains have a profound effect on total production. The significance of upland and deepwater rice systems lies in their contribution to food security and their impact on the environment in localities within the region.

Approximately 42 million (M) ha or 45 percent of SE Asia's cropped land is planted to rice in irrigated (18 M ha), rainfed (18 M ha), deep water (3 M ha), and upland (3 M ha) cropping systems. The largest area under irrigated rice is found in Indonesia, followed by Vietnam, the Philippines, and Thailand (**Table 2**). The largest

Table 2. Area under irrigated, rainfed lowland (RLLR), upland, and other rice cropping systems in SE Asia, 1995 (IRRI Rice Facts, 2002).

Country	Irrigated	RLLR	Upland	Flood prone	Total area
	- - - - - - - -	- - - - - - - -	'000 ha	- - - - - - - -	- - - - - - - -
Cambodia	154	1,124	33	614	1,924
Indonesia	6,154	4,015	1,247	23	11,439
Laos	40	319	201	—	560
Malaysia	445	152	84	—	681
Myanmar	1,124	4,166	252	602	6,144
Philippines	2,334	1,304	120	—	3,759
Thailand	2,075	6,792	36	117	9,020
Vietnam	3,687	1,955	345	778	6,766
Total	16,015	19,827	2,318	2,134	40,293

area under RLLR is found in Thailand, but there are also large areas in Indonesia and Myanmar. The largest area under upland rice is found in Indonesia, and significant amounts of land are planted in flood-prone areas in Cambodia, Vietnam, and Myanmar.

Table 3. Estimated population, rice production, and per capita rice consumption in SE Asia.

	Year		
	2000	2020	2050
Population, millions	520	650	780
Rice production, million tonnes	150	160	180
Per capita consumption, kg	270	250	230

At present, SE Asia produces 150 M tonnes (t) of paddy per year (25 percent of world production), of which 95 percent is consumed within the region. While per capita demand is expected to decrease in the future, total demand for rice in SE Asia is expected to increase to more than 160 M t per year by 2020 due to population growth (**Table 3**).

The area under the most productive and fertile irrigated rice lands, located in areas of high population density, is expected to decrease due to the effects of rapid urbanization and industrialization. Thus, productivity in rice systems must increase from the current average of 3.4 t/ha to at least 4 t/ha if food security and export potential of SE Asia are to be maintained.

In Indonesia and Vietnam, where more than 50 percent of the planted area is under irrigated rice, productivity increased from 3.3 t/ha to 4.3 t/ha within one decade during the recent past. This is attributed to an expansion in the area under irrigation and the increased use of modern varieties (**Table 4**) and fertilizer nutrients (**Table 5**).

Table 4. Rice area harvested and planted to modern varieties, 1999 (IRRI Agri Facts, 2002).

	Area harvested, '000 ha	Yield, t/ha	Area planted to modern varieties, %	'000 ha
Cambodia	1,961	1.94	11	216
Indonesia	11,624	4.25	77	8,951
Laos	718	2.93	2	14
Malaysia	674	2.94	68[1]	458[1]
Myanmar	5,458	3.24	72	3,930
Philippines	3,978	2.95	89	4,858
Thailand	10,000	2.33	68	6,800
Vietnam	7,648	4.11	80	6,118
SE Asia	42,061	3.48	75	31,345

[1] PPI/PPIC ESEAP estimate, 2002

The national average yield in the Philippines, however, is only 3 t/ha (**Table 4**), in spite of the greater use of modern varieties and a greater proportion of total rice land under irrigation. This is partly due to smaller inputs of fertilizer nutrients (**Table 5**).

National average yields for Cambodia, Laos, Myanmar, and Thailand are also small. The main contributing factors are: 1) the lower yield

Table 5. Growth rates for rice yields, fertilizer consumption, and rice imports in SE Asia.

	Increase in rice yield, % per year		Increase in fertilizer consumption, % (1990-99)			Rice imports, '000 t		
Country	1967-90	1990-99	N	P_2O_5	K_2O	1980-89	1990-99	Change
Cambodia	0.7	2.5	22.6	3.4	0	946	472	-474
Indonesia	4.0	0	4.6	-5.4	-1.0	4,915	13,784	+8,869
Laos	4.4	2.0	26.5	15.8	10.4	157	167	+10
Malaysia	1.6	0.5	3.7	4.7	6.5	3,150	4,409	+1,259
Myanmar	2.5	0.9	12.2	11.7	-2.3	0	0	0
Philippines	3.4	-0.4	0.3	1.8	2.1	1,044	5,898	+4,854
Thailand	0.5	1.5	6.2	4.7	9.6	0	2	+2
Vietnam	2.2	2.1	15.1	16.4	37.2	2,272	28	-2,244

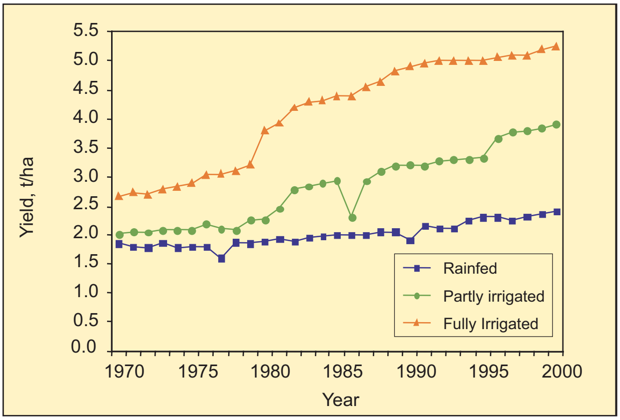


Figure 1. Rice yields in major cropping systems in SE Asia.

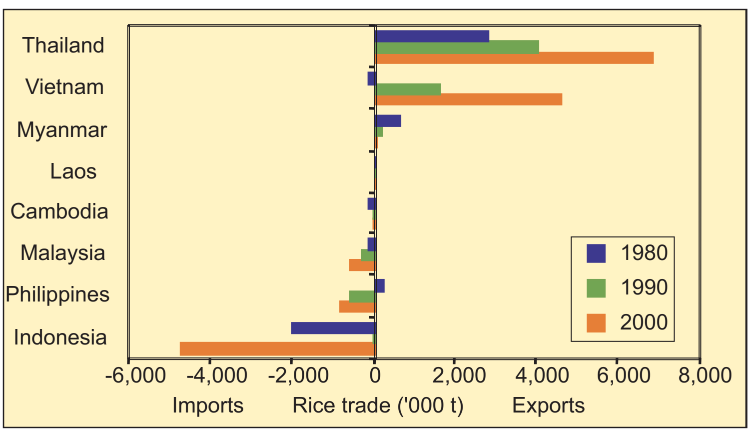
potential of the dominant rainfed systems, 2) greater use of traditional varieties instead of modern varieties, and 3) less efficient management of water and nutrients.

Achieving the required average yield of 4.5 t/ha in SE Asia will likely mean further increases in the area under rice, a larger proportion of rice systems under irrigation, and greater use of adapted modern varieties. Adequate nitrogen (N), phosphorus (P), and potassium (K) are also important. It is estimated that average application rates of 73 kg N/ha, 24 kg P_2O_5/ha, and 33 kg K_2O/ha will be needed to meet the levels of production required in the next 10 years.

Between 1980 and 2000, the harvested area of rice in SE Asia increased by 8.4 M ha to 43.4 M ha, the proportion irrigated increased by almost 4 M ha, and the use of modern varieties increased to 75 percent of the total area planted to rice. Impressive yield gains of up to 2 t/ha have been achieved over the period 1980–2000 in the irrigated and partly irrigated rice systems in SE Asia, but there has been little progress in the rainfed systems (**Figure 1**). There was a consistent decline in the rate of increase in rice yields compared with the 20-year period following the introduction of modern varieties in the early 1960s. During the last decade, average rice yields increased by about 1 t/ha.

Over the past three decades, Thailand has maintained its position as the region's major rice exporter (**Figure 2**). Vietnam was a rice importer in the 1980s, but began to export rice during the 1990s, and in 2000 exported more than 4 M t. Increased production in both Thailand and Vietnam is clearly correlated to the increased use of NPK fertilizers during the past 20 years.

Figure 2. Trade deficits in rice in SE Asia.



In contrast, rice productivity growth rates in Indonesia, Malaysia, and the Philippines decreased during the 1990s, and rice imports grew to almost 6.5 M t in 2000 (**Figure 2**). Rice imports for these three countries totalled 24 M t in the period 1990–1999, an increase of about 15 M t over the total import for 1980–1989 (**Table 5**). Growth rates for the consumption of NPK fertilizer nutrients were small or negative in Indonesia and the Philippines during the 1990s, particularly following the economic crisis in 1997. This has further increased their dependence on rice imports.

To maintain regional self-sufficiency in rice, the irrigated and rainfed rice systems must achieve yields of 6 t/ha and 3 t/ha, respectively, over the next two decades. Major constraints to improving productivity include low soil fertility, pest and disease damage, competition from weeds, drought in rainfed systems, flooding, soil acidity, poor infrastructure, land fragmentation, and land losses due to urbanization, poor availability and high cost of inputs, low and fluctuating rice prices, land degradation due to salinization, and poor extension services. Constraints are presented in more detail in **Table 6**.

On-farm research conducted by the International Rice Research Institute (IRRI) and the National Agriculture Research and Extension Stations (NARES) on 118 farms in four SE Asia countries has shown that the improved techniques of site-specific nutrient management (SSNM) can contribute to productivity increases of 10 to 15 percent, with an average increase in net farm income of about US$50/ha/crop or US$100/ha/yr in double cropped systems. Yield and income gains were much larger, however, in well-managed farms (Dobermann et al., 2002). Successful implementation of SSNM, however, requires complementary and comprehensive crop management techniques, including pest and disease management, and the use of high quality seed. The research showed that the impact of SSNM on yield and profitability were much greater where farmers achieved high standards of general crop care. This underlines the importance of "knowledge-based" approaches to extension where farmers learn to integrate different techniques by following prescriptive and piecemeal recommendations.

The average annual fertilizer NPK consumption in rice systems of SE Asia is estimated at 4.1 M t/yr (about 100 kg/ha) or about 50 percent of total fertilizer NPK consumption in the region (**Table 7**). Nutrient consumption appears to be unbalanced with an $N:P_2O_5:K_2O$ ratio of about 8:2:1.

One consequence of unbalanced fertilizer use in the region is the extent to which the K reserves in soils are being depleted. It is estimated that at least 1 M t of K is mined each year from SE Asia's rice soils, and calculations based on research in intensified rice systems in Indonesia, Thailand, the Philippines and Vietnam show negative balances for K of 40 to 60 kg K ha/yr (Sheldick et al., 2002; Syers et al., 2001). However, when combined with improved N management techniques (i.e., more precise timing and splitting of N fertilizer, use of a leaf color chart), increased applications of K resulted in average yield increases of about 0.5 t/ha.

Table 6. Main production constraints for rice in SE Asia (modified after IRRI Rice Facts, 2002). White background indicates that a constraint exists in country indicated.

	Cambodia	Indonesia	Laos	Malaysia	Myanmar	Philippines	Thailand	Vietnam	Total*
Low soil fertility			Sandy soils			50% problem soils	>75% rice lands		5
Soil acidity							Acid sulfate soils		2
Salinity				Intrusion of seawater			NE and S coast	Coastal areas	4
Drought				Rainfed rice systems					8
Flooding	Low lying areas		Mekong River			Typhoons	In RLLR	Rainfed areas	5
Low temperatures							Upland rice in N. Irrigated in N and NE.	N Vietnam	2
Pests and diseases	Stem borer, gall midge	BPH, stem borer, BLB, blast, RTV		BPH, stem borer, blast, GLV, RTV		RTV, BLB, Blast, GLH, stem borer	BLB, blast, BPH, stem borer	BPH, stem borer, leaf roller, blast, BLB, brown spot	8
Weeds				Weeds in direct seeded rice		Direct seeded rice	Direct seeded rice	Weeds in direct seeded rice	6
Land fragmentation			Small farm size					Small farm size	3
Land security	Land mines								1
Rural poverty									2
Labour scarcity		In agriculture production areas							2
High input cost					Fertilizer				1
Input scarcity	Infrastructure, credit, seed fertilizers, agrochemicals	Lack of quality fertilizers	Infrastructure, credit, seed fertilizers, agrochemicals		Infrastructure, credit, seed fertilizers, agrochemicals			Infrastructure, credit, seed fertilizers, agrochemicals	4
Rice price policy			Low price	Low price		Price policy			5
Ineffective extension									2
Water management									2
Land loss		Urban sprawl	Erosion						2
Others		New technology required	Preference for glutinous rice		Limited market opportunity	Lack of clear policy			4
Total*	10	10	12	6	10	7	8	12	

*Total number of incidences where production constraints have been detected

Table 7. Fertilizer NPK use by rice in major agro-economics of SE Asia 2001 (PPI-PPIC ESEAP estimates, 2002).

Country	Area '000 ha	N Fertilized %	N Rate kg/ha	P_2O_5 Fertilized %	P_2O_5 Rate kg/ha	K_2O Fertilized %	K_2O Rate kg/ha	Consumption N ('000 t)	Consumption P_2O_5 ('000 t)	Consumption K_2O ('000 t)	Total	Ratio
Cambodia	1,873	30	15	20	14	5	3	8.4	5.2	0.3	13.9	28.0: 17.3 :1.0
Indonesia	11,523	90	105	70	22	40	14	1,192.6	177.5	64.5	1,434.6	18.4:2.8:1.0
Laos	690	30	55	20	15	5	5	11.4	3.1	0.2	14.7	57.0:15.5:1.0
Malaysia	692	90	95	90	40	70	35	59.2	24.9	17.0	101.1	3.5:1.5:1.0
Myanmar	6,000	60	35	50	12	10	4	126.0	36.0	2.4	164.4	52.5:15.0:1.0
Philippines	4,037	85	51	85	15	75	11	175.0	51.5	33.3	259.8	5.3:1.5:1.0
Thailand	10,048	90	62	90	33	60	17	560.7	298.4	102.5	961.6	5.5:2.9:1.0
Vietnam	7,655	90	108	80	45	50	40	744.1	275.6	153.1	1,172.8	4.9:1.8:1.0
Total:	42,518							2,877.4	872.2	373.3	4,122.9	
							Ratio	8:	2:	1		

The stagnation in rice yields and the consequent increase in rice imports in Indonesia, Malaysia, and the Philippines are clearly related to the low fertilizer K application rates averaging less than 10 kg K_2O/ha in these countries. An estimated 1.3 M t K_2O/yr and 1 M t P_2O_5/yr are required to support the levels of rice productivity that will be needed to maintain self-sufficiency in the region (Greenland, 1997).

The challenge in rice systems in SE Asia is to achieve regional food security and increase farm incomes using site-specific integrated crop management techniques. This will require much greater investments in research and extension over the next two decades. **BCI**

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