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Hybrid Rice Technology for Food Security in the Tropics: Can the Chinese Miracle be Replicated in the Southeast Asia?

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1 Introduction

Rice is the life-line for the Southeast Asians because it is not only a dominant food crop, but also plays an important role in their national economy. It accounts for a major share of cereal consumption ranging from 67% in the Philippines to 97% in Myanmar. Rice contributes about 30-76% to total daily calorie intake in the region (Table 1). Therefore, boosting the rice production and making it available to the consumers at the affordable prices is always on the top political agenda for any national government in the region.

The Green Revolution-led high-yielding modern varieties (MVs) of rice and associated improved crop management practices since the late 1960s contributed significantly to achieving the food security in Asia (Barker and Herdt, 1985; Pingali et al, 1997 and Pingali and Hossain, 1999). Rice production (unmilled) in Southeast Asia rose from about 50 million tons during 1966 to about 140 million tons by 1999 with the annual growth rate of 3.2%, surpassing the population growth of 2.1% per annum. Yield improvements from the technological progress, largely in the favourable irrigated environments have contributed 78% of rice production growth between 1966 and 1986; and however the share of yield increases to total rice production has dropped to nearly 50% after 1986 (Fig. 1). The growth in rice production and yield has slowed down in many countries of the region, except in Vietnam that has catch up after 1985, between periods 1966-1985 and 1985-1999 (Table 2 and Fig. 2). Diminishing growth rate of the rice yields in the most intensive irrigated environments where farm-level yields have already reached about 5.0-6.0 t ha⁻¹ (Fig. 3) is a primary source of slowed down in the growth of rice production after 1985. On the other hand, demand

for rice in the region is expected to rise substantially in the years to come in order to meet the food needs of the growing population and urbanization (Hossain, 1999). Therefore, the sense of complacency in the demand-supply balance of food has begun disappearing in the Southeast Asia region since the early 1990s.

Inspired by the miraculous success of hybrid rice technology in the Chinese rice sector in the 1970s and 80s, policymakers and research managers across tropical Asia considered this technology in the late 1980s as a potential option to sustain the food security by shifting upward the yield frontier in the irrigated environments.

1.1 Objectives

The principal goal of the paper is to explore the possibilities on whether the Chinese miracle of hybrid rice success can be replicated in other countries with special reference to Southeast Asian countries for sustaining food security in the region. Specific objectives of the study are: (i) to understand the ‘socio-economic and institutional factors’ that were responsible for the large-scale adoption of hybrid rice in China; (ii) to evaluate the recent farmers’ experiences with hybrid rice in outside China; and (iii) to sensitize the potential demand for the deployment of hybrid rice technology within the framework of socio-economic conditions of the Southeast Asia.

1.2 Methodology

All relevant studies on hybrid rice adoption in China were critically reviewed to understand the factors responsible for its success in this country. Farm level data on input, output, farmers' perceptions, etc. on hybrid rice adoption were generated for a larger study *Socioeconomic Evaluation of Hybrid Rice Technology in Asia* at the International Rice Research Institute (IRRI), the Philippines in collaboration with the concerned national agricultural research systems (NARSs). Data collected from 391 sample farmers in Vietnam (2000 dry season) and from 120 farmers in the Philippines (2000-01 dry seasons). Most of the sample farmers surveyed were those supported by the government under hybrid rice promotion programs, but not voluntarily adopters of hybrid rice in these countries. Among the sample farmers surveyed, area coverage under hybrid rice was higher for small and marginal farmers compared to large farmers in Vietnam. Area planted to hybrid rice per sample household during the survey seasons was only 0.19 and 1.92 ha in Vietnam and the Philippines respectively.

In order to supplement the farmers’ experiences, secondary data (country-level) on wages, prices, farm labour, irrigation, etc, were obtained and used for carrying out

the sensitivity analysis on whether current socio-economic environment of rice production system in the Southeast Asia would be congenial for hybrid rice deployment.

2 Results and Discussion

2.1 Lessons from the Chinese Experiences

The Chinese hybrid rice program was initiated in Hunan Province in 1964. The first rice hybrid with a marked yield potential was developed in 1974 and released to the farmers in 1976 after on-farm testing across the regions. Hybrid rice in China has spread into farmers' fields rapidly in the 1970s and 80s. About 58% of total rice harvested area was planted to hybrid rice by 1992 that has contributed about 15-18 million tons of additional rice (unmilled) in this country (Lin, 1994, Virmani, et al 1998 and Virmani, 1999). In China, hybrid rice had a 15% yield gain in the farmers' fields, but was facing lower price in the market because of its poor grain quality as compared with inbred varieties (conventional MVs). Thus, hybrid rice was not higher profitable than the popular MVs (He et al., 1987). It was hypothesised that the direct intervention of the government through political pressure in the 1970s and 1980s was a primary factor for the large-scale adoption of hybrid rice in China (Barker and Herdt, 1985). Later on, it was found that political pressure from government was the major factor that contributed to rapid adoption of hybrid rice in this country especially during the initial stage-pre-reform period (Lin, 1991). Often farmers were instructed to plant varieties/hybrids that the government considered good for the country, and the local government agencies ensured that the farmers implemented the decision. It was not unusual in China, when it was a centrally planned economy to promote certain technologies without considering relative profitability (Lin, 1991). Government agencies produced and supplied hybrid rice seeds for free to farmers supported with subsidies on fertilizers and plant protection chemicals (Lin, 1991). The Chinese objective of promoting hybrid rice with direct policy intervention was to increase the domestic rice production to feed the huge rural and urban masses. As supply of hybrid seed and the procurement of the final produce were in the hands of the state, grain quality and hybrid seed cost were not constraints to large-scale adoption of this technology. In addition to distinct political set up, other socio-economic factors also favored for rapid adoption of hybrid rice in China. Almost 100% rice area is under irrigation where transplantation of rice seedlings is a common practice in about 97% of rice area in this country. Further, average size of operational land holding is very small

in China where rice production at household level is mainly for family consumption. Availability of labour is not a limiting factor in rural China to adopt any labour-intensive technology like hybrid rice, which in fact helped to increased labour earnings of small and marginal households. Therefore, it was the nature of the political economy and other socio-economic and institutional factors that were behind the miraculous success of hybrid rice in China, not the inherent economic superiority of hybrid rice over the existing MVs. The Chinese experience *in toto* may not be replicated in other Asian countries whose political economy and socio-economic conditions are different from China under a democratic social system with free operation of the market forces (except to some extent for Vietnam).

The socio-economic and political facets of China have been changing rapidly with onset of reform process since the early 1990s. It may be mentioned here that in 1990s after the introduction of liberalized food production and distribution system the expansion of the area under hybrid rice has halted, and in some of the prosperous southeastern provinces the area has been declining (Fig. 4). Further, income elasticity for hybrid rice grain was negative because of its inferior grain quality, implying that consumer demand for hybrid rice grain has been declining as income levels increases after the reform process (Huang, 1994). With the onset of economic liberalization, farmers and rice consumers in China have started expressing their own preferences. Quality enhancement therefore has become the primary breeding objective for hybrid rice research in China to improve the price competitiveness in the market.

2.2 Inspiration from the Chinese success

The miraculous success of hybrid rice technology in China triggered an interest to initiate rigorous research efforts in some tropical countries in Asia in the late 80s and the early 90s. The efforts of the NARSs in collaboration with IRRI, Philippines over the past decade led to the development and release of a few promising rice hybrids in India, Bangladesh, Vietnam and the Philippines (Table 2). The private seed sector also participated in a big way in the 1990s in these countries (except in Vietnam) both in research, seed production and marketing, and seed imports expecting a huge and guaranteed seed business in view of rice being a widely cultivated crop in the region.

The initial studies on hybrid rice adoption in India, a democratic set up where producers and consumers have free option to choose whatever they prefer, reported on an average yield gain of 12-16% over the current inbred varieties with additional input cost of 15-20%. But the grain of hybrid rice faced about 10-12% lower price in the

market compared with inbred varieties (existing MVs) due to lack of consumer demand because of inferior grain quality. Therefore, the net return to hybrid rice production was lower than that of inbred rice. As a result, hybrid rice has not been adopting continuously for more than one crop season by the farmers in India. Area covered under hybrid rice even 8 years after released, is very meager i.e. less than 0.3% of total rice area in India (Janaiah 1995, 1997, ;Janaiah and Hossain, 2001). Similar findings were also reported from Bangladesh based on the evaluation of farmers' experiences with hybrid rice adoption during 1999 boro season (Husain et al., 2001).

2.3 Farm-Level Experiences in the Southeast Asia

The farmers' decision to adopt a new variety or hybrid in a market economy, such as in many Asian countries (other than China) is primarily determined by the relative economic incentives from the new technologies as compared to the existing technologies. Therefore, the product value and relative profitability are the ultimate factors that would determine farmers' decision in the reallocation of ricelands from existing MVs to hybrids. The role of profitability is much more crucial in the adoption of any new variety/hybrid by the commercial farmers in the irrigated rice environments where rice is produced commercially mainly for market in the Southeast Asia region unlike in China.

Hybrid rice out-yielded the existing inbred varieties (conventional MVs) by averaged at 21 and 17% in the farmers' fields in Vietnam and the Philippines respectively (Table 4). However, this yield gain of hybrid rice was associated with increased input costs and lower price for hybrid rice grain. Total cost is higher for hybrid rice than for inbred varieties by 14% in Vietnam and 34% in the Philippines. (Table 4). Thus, hybrid rice has not generated additional net return in the Philippines where many sample respondents were commercial rice farmers.

On contrary, hybrid rice was higher profitable than existing MVs in Vietnam. The reported price of hybrid rice grain, unlike in the Philippines, was mainly based on farmers' perception in Vietnam, but not real price they received in the market, because most of the small and marginal farmers in this country produces rice mainly for household consumption like in China. Therefore small and marginal farmers in North and Central Vietnam have shown more interest than the large commercial farmers in hybrid rice as they are interested in additional production that they can get from the limited land holdings with higher capacity utilization of under-utilized family

resources. Similar findings were also reported from the early experiences of farmers with hybrid rice in eastern India and Bangladesh, where majority of small and marginal farmers cultivate rice primarily for household consumption (Janaiah and Hossain, 2000, Hussain et al., 2001). Thus, small and marginal farmers (subsistence farmers) are likely to be the potential adopters and beneficiaries of hybrid rice technology compared to the commercial and progressive farmers, if quality seed of hybrid rice is made available at low prices after technological refinement of current hybrids.

2.4 Seed Production: a Key to Success of Hybrid Rice

The availability of quality hybrid seed at a reasonable price is crucial to the success of hybrid technology in any crop. Further, farmers will have to purchase hybrid rice seed every crop season unlike for conventional MVs in which farmers uses their own harvest as a seed in the next season. The Chinese success in the large-scale adoption of hybrid rice may also be attributed to the efficient and economical hybrid seed production and distribution by the state-owned seed industry.

Hybrid rice seed production may be considered a highly labour, capital and knowledge-intensive process, besides one with heavy risks from poor synchronization of parental lines, weather changes, etc. Thus, farmers would not be motivated to engage in hybrid rice seed production, if labour is not available at a reasonable wages; and unless it is shown to be more profitable than the alternative of cultivating inbred varieties (MV).

Total costs for hybrid rice seed production were US \$ 540 ha⁻¹, of which labour alone accounted for about 49% in the Philippines (2001 dry season) because of additional requirement. Yield of hybrid rice seed was only about 675 kg ha⁻¹ in the Philippines due to imperfect technologies for seed production at present. Thus, average cost of producing hybrid seed was US\$ 0.80 kg⁻¹. At the seed price of US\$ 2.3 kg⁻¹ (as reported by the seed growers during 2001 dry season), net profit from hybrid rice seed was about US \$ 993 ha⁻¹ (excluding by-product value) which is 72% more profitable than alternative economic activity i.e. inbred rice cultivation. Therefore, production of hybrid seed would not be a problem to either by public or private sector in the future in Southeast Asia, once demand for hybrid seed is created among commercial farmers. However, growing labour shortage, which in turn, rising wages are likely to constrain the large-scale adoption of any labour-intensive technologies such as hybrid rice unless labour saving methods and devices developed as complementary technologies.

2.5 Potential Demand for Hybrid Rice Deployment: Sensitivity Analysis

Hybrid rice R&D program was primarily aimed at breaking the yield frontier in the favourable irrigated environments where rice production is commercialized. Lin and Pingali (1994) projected based on Chinese experiences that countries with higher proportion of irrigated area and with a higher land-man ratio would find more potential demand for hybrid rice adoption. The countries, identified based on this assessment are India, Indonesia, the Philippines, Sri Lanka and Vietnam. Two key factors i.e., irrigation and labour were considered in this assessment. However, there are other equally important socio-economic factors such as average size of operational land holding, wages, paddy prices, etc. were not taken into account by Lin and Pingali while suggesting potential areas for hybrid rice adoption.

A critical evaluation of Chinese miraculous success and recent farmers' experiences with hybrid rice adoption in outside China, as discussed above, facilitated to identify five important factors that would sensitize the potential demand for hybrid rice adoption in the Southeast Asia under democratic set up where market forces operates freely. **Firstly**, irrigation is obviously a crucial input for hybrid rice cultivation. **Secondly**, purpose of rice farming i.e. commercial or subsistence. The currently available hybrid rice is not attractive to the commercial farmers in irrigated systems in spite of about 15-20% yield gains, mainly due to lower market price. However it was noted from Bangladesh and Vietnam experiences that small and marginal farmers who produce rice mainly for household consumption have shown interest in hybrid rice. But non-suitability of hybrid rice grain for home consumption due to inferior quality would also constrain its adoption by small and marginal farmers. **Third** factor is availability of labour for farm sector. Hybrid rice seed production is highly labour-intensive which requires about 100-150 additional persondays of labour per a hectare. A labour-intensive technology will have less probability of success in irrigated environments where labour is becoming a serious constraint for farm sector. Further, wage rates are increasing at a faster rate than paddy prices due to growing non-farm employment opportunities as experienced in Japan and South Korea and same is now happening in Thailand, the Philippines, Sri Lanka and also in some parts of India. Higher wage rates associated with lower paddy prices would further deteriorate profitability and also increase seed production cost of hybrid rice. Therefore, **fourth** factor is the ratio of farm wage- paddy price that is likely to inversely associate with the adoption rate of labour-intensive technology such as hybrid rice. **Another** very crucial factor is the method of crop establishment, which

decide on how much seed is required for sowing in a hectare (seed rate). Rice crop is usually grown under irrigated conditions either by transplanting of 3-4 week old seedlings from nursery (Transplanted rice) or by direct seeding of soaked/sprouted seeds (Direct seeded rice). The seed rate in direct seeded rice is much higher (3-4 times) than for transplanted rice. Since cost of hybrid rice seed is about 8-12 times to that of MVs, irrigated ricelands where direct seeding method is widely practiced will have less probability for success of hybrid rice technology; because the use of more costly seed of hybrid rice for direct seeding would not be profitable. All these five variables were cross-matched in the selected countries to sensitize the most potential demand for the deployment of rice hybrids in these countries.

Tables 5-6 reports the basic information on rice area, coverage of rice area under irrigation, MVs and direct seeded rice, rice yields, farm labour-arable land ratio, farm wage-paddy price ratio and size of operational land holding in selected countries of the Southeast Asia. Cross-factor matches in the selected countries were presented in table 7. These countries are classified in to three groups based on cross-factor match among the five basic factors as mentioned above.

Group-1: Countries with (a) higher proportion of irrigated area and with a less coverage under direct seeded rice; (b) more concentration of small and marginal operational holdings and with more labour availability per unit arable land and (c) lower farm wage -paddy price ratio. These countries are likely to have the highest potential demand for hybrid rice technology According to the maximum matches among favourable factors, Vietnam is the most potential country for the deployment of hybrid rice technology at present. Further, socio-economic and political set up in Vietnam, which is closely similar to the Chinese system, allowed to promote hybrid rice with direct intervention by the government (providing subsidy on hybrid rice seeds, fertilizers, etc.) in the recent years. About 4% (0.30 million ha) of total rice harvested area was planted to hybrid rice in this country during 2000-01 crop year, although it not spreading as expected. Vietnam, being a major rice-exporting country with surplus rice production by about 4 million tons, may no longer be interested in expansion of hybrid rice on a large-scale due to inferior grain quality that would not find demand in the export market.

Countries falling under group-2, the Philippines and Indonesia are not likely to find demand for hybrid rice technology immediately. Hybrids with improved grain quality are needed with labour saving methods and devices for seed production in these countries to fetch competitive market price thereby generating profitability.

Hybrids suitable for direct seeding are required for creating demand for hybrid rice in those areas such as in South Vietnam.

In other countries (**Group-3**) such as Thailand and Myanmar, hybrid rice would not find demand due to reasons as shown in table 8.

3 Concluding Remarks

The distinct political economy and other socio-economic factors were the driving forces behind the Chinese miracle of hybrid rice success, but not inherent economic superiority of this technology. Although hybrid rice had a yield gain of about 17-21% over the existing MVs in the farmers' fields, present rice hybrids are not acceptable to the farmers and consumers because of higher input cost and lower market price due to inferior grain quality in outside China except in Vietnam. Our study suggests that small and marginal farmers in Vietnam have shown more interest in hybrid rice. However, higher seed cost and its regular replacement, and inferior grain quality may constrain hybrid rice adoption by small and marginal farmers unless seed cost is brought down and grain quality is improved through technological refinements.

Vietnam (north and central region) and India (central and eastern region) is likely to find potential demand for deployment of rice hybrids at present. Countries such as the Philippines and Indonesia are not likely to find demand for hybrid rice technology immediately, unless new miraculous rice hybrids are developed which are highly price competitive and cost-effective, and suitable for pest-endemic areas. Hybrid rice technology would not find demand in Thailand and Myanmar.

Hybrid rice would show desired impact at the household food security, only if hybrid rice R&D is re-focused in the direction of: (a) quality improvement, (b) perfection of seed production practices, (c) development of labour-saving methods and devices, (d) and proper deployment planning based on a micro-level analysis of socio-economic factors. We conclude with the statement that *the current set up of political system and other socio-economic environments in other Asia countries where market forces operate freely (except Vietnam in some aspects) are not congenial for replicating the Chinese model of hybrid rice research and development strategy in toto.*

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Table 1 Share of rice in the national economy and food security in selected countries, Southeast Asia

Country	Gross value of rice (as % of agril-GDP)	Per capita daily calorie intake	Share of rice (%) in	
			Cereal consumption	Calorie intake
Indonesia	33	2609	83	54
Thailand	25	2365	93	53
Vietnam	84	2303	94	68
Myanmar	NA	2620	97	76
Philippines	15	2371	67	37
Malaysia	4	2782	70	31

Source: World Bank (1998), FAO (1996)

Table 2 Trends in the population growth and rice production in selected countries, Southeast Asia, 1965-2000.

Country	Rice harvested area (m ha)	Population growth (%/year)		Growth in rice production (%/year)	
		1965-85	1985-2000	1965-85	1985-2000
Indonesia	11.6	2.3	1.6	5.3	1.8
Thailand	10.0	2.6	1.2	2.7	1.5
Vietnam	7.7	2.3	1.9	2.7	5.2
Myanmar	6.0	2.2	1.2	3.9	2.7
Philippines	3.9	2.8	2.2	3.8	1.8
Malaysia	0.7	2.5	2.4	1.7	1.0

Source: FAO, FAOSTAT database, 2000.

Table 3 Basic information on current status of hybrid rice R&D and adoption in selected countries in tropical Asia.

Country	Year of research initiated ^{a/}	Year of first hybrid released	Number of hybrids released ^{d/}	Level of seed production infrastructure ^{e/}	Area planted to hybrid rice cultivation 1999 (000 ha)
India	1990	1994 DS	20	strong	120 ^{f/}
Bangladesh ^{b/}	1997	1999 DS ^{b/}	4 ^{b/}	weak	50
Vietnam ^{b/}	1992	1992 WS ^{b/}	7 ^{b/}	moderate	220
Philippines	1995	1993 WS ^{e/}	3	weak	5
Indonesia	...	...	...	weak	...
Sri Lanka	1996	...	...	weak	...
Thailand	...	...	...	weak	...
Myanmar	1997	...	...	weak	...

Note

^{a/} - year of mission-mode R&D initiated

^{b/} Imported from China and India in Bangladesh and from China in Vietnam.

^{c/} first rice hybrid released in the Philippines was developed at IRRI where hybrid rice research was initiated in 1979.

^{d/} Includes imported hybrid seed in case of Bangladesh and Vietnam. Also includes both hybrids released by public and private seed research institutions in India by year 1999 (Source: DRR- Directorate of Rice Research, Progress reports of hybrid rice projects and AICRIP, 1996-99 (Various issues), DRR, Hyderabad, India, 1999.

^{e/} Source: Virmani (1999)

Table 4 Farm level profitability for the production of hybrids and inbred varieties of rice in selected countries, Southeast Asia.

Cost/Return	(US \$ ha ⁻¹)					
	Vietnam, dry season 2000 (n=391)			Philippines, dry seasons 2000-01 (n=120)		
	Hybrids	Inbreds	% Difference	Hybrids	Inbreds	% Difference
COSTS						
Seed: Qty: (kg ha ⁻¹)	39	109	-64.2	34	90	-62.2
Cost (US \$ kg ⁻¹)	47	24	96	75	18	316.7
Manures and Fertilizers	139	118	17.8	46	35	31.4
Labour cost	204	183	11.5	169	162	4.3
Irrigation	31	31	0	19	15	26.7
Plant protection	26	29	-10.3	33	27	22.2
Machinery use	37	38	-2.6	20	14	42.8
Miscellaneous	11	10	10	9	5	80
Total costs	495	433	14.3	371	276	34.4
RETURN						
Grain yield (t ha ⁻¹)	6.33	5.25	20.6	5.41	4.62	17
Grain price (US \$ t ⁻¹)	124.6	128.8	-3.3	173	181	-4.4
Gross return	789	676	16.7	936	836	12
Net return	294	243	21	565	560	1.0
Cost of production (US \$ t ⁻¹)	78.2	82.5	-5.2			

Source: Survey data (2000 and 2001), Social Sciences Division, IRRI, The Philippines

Table 5 Coverage of irrigation, MVs, direct seeding method and rice yields, selected countries, Southeast Asia

Country	Rice Area m ha	% share of cropped area	Irrigation Coverage %	HYV Coverage %	Coverage under seeding method (%)	Rice yield ^{a/} Ton/ha
Philippines	4.0	34.0	65 (1998)	92 (1998)	38.0	2.86
Vietnam	7.6	70.8	84 (1999)	91 (1999)	34 – 42	4.10
Indonesia	11.6	45.8	72 (1991)	79 (1996)	8.0	4.3
Myanmar	5.5	51.0	28 (1997)	72 (1996)	9.0	3.1
Thailand	10.0	66.6	20 (1996)	16 (1997)	31.0	2.3

Note

^{a/}Related to 1999. Bracketed figures are year of corresponding data.

^{b/}Area under direct seeded as % of total irrigated plus rainfed lowland.

Source: Pandey, S, 'Economics of direct seeding in Asia: pattern of adoption and research priorities', International Rice Research News, Vol. 24 (2), 1999, pp.6-11)

Table 6 Farm labour-arable land ratio, farm wages-paddy price ration and average size of operational holding, selected countries, Southeast Asia.

Country	Farm labor-arable land ratio ^{a/}	Farm wage-paddy price ratio	Average size of operational holding (ha)
Philippines	1.15	7.7 (1997)	2.17 (1991)
Vietnam	2.60	8.2 (1999)	0.41 (1999)
Indonesia	1.86	6.2 (1993)	1.05 (1983)
Myanmar	1.74	26.4 (1997)	2.35 (1993)
Thailand	1.40	13.6 (1997)	1.83 (1988)

^{a/} Related to Year 1998

Bracketed figures are corresponding year of data.

Source: IRRRI Database 2000

Table 7 Classification of countries for hybrid rice development in Southeast Asia.

Factors		Irrigation coverage		Farm labor-arable land ratio	
		Low (<50% or <2.0 m ha)	High (>50% or >2 m ha)	Low <2.0	High >2.0
Operational land holding	Low (<1.0 ha)		Vietnam ¹ , Indonesia ²	Indonesia ²	Vietnam ¹
	High (>1.0 ha)	Myanmar ³ , Thailand ³	Philippines ²	Philippines ² , Myanmar ³ , Thailand ³	-
Farm wage, paddy price, opportunity cost	Low (<10.0)		Philippines ² , Vietnam ¹ , Indonesia ²	Philippines ² , Indonesia ²	Vietnam ¹
	High (>10.0 ha)	Myanmar ³	Thailand ³	Thailand ³ , Myanmar ³	
% rice area under direct seeded method	Low (<30%)	Myanmar ³	Indonesia ²	Indonesia ² , Myanmar ³ , Philippines ²	
	High (>30%)	Philippines ² , Vietnam ¹ , Thailand ³	Philippines ² , Vietnam ¹ , Thailand ³	Thailand ³	Vietnam ¹

- 1- Highest potential countries for the hybrid rice technology (group 1).
- 2- Less potential countries for hybrid rice (group 2).
- 3- Not potential countries for hybrid rice (group 3).

Figure 1 Sources of growth in rice production I SE Asia in percent per year

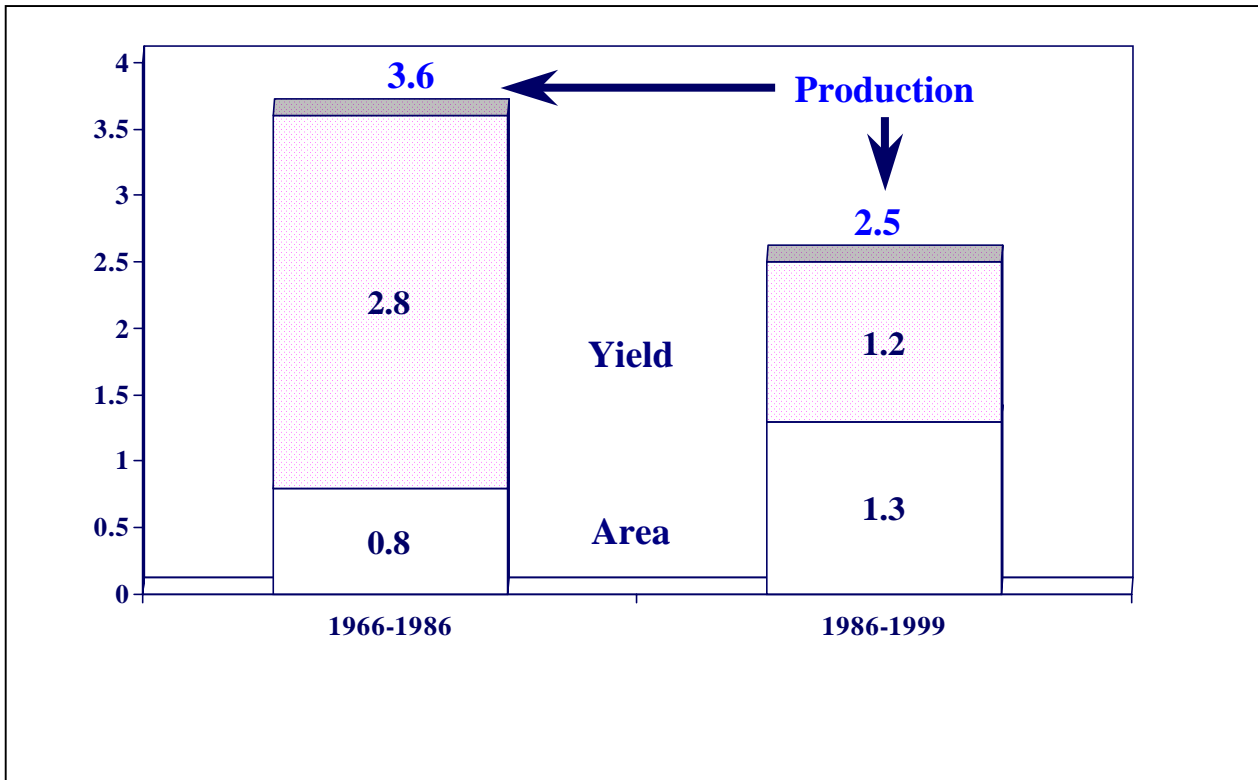


Figure 2 Growth in yield by countries in the Southeast Asia

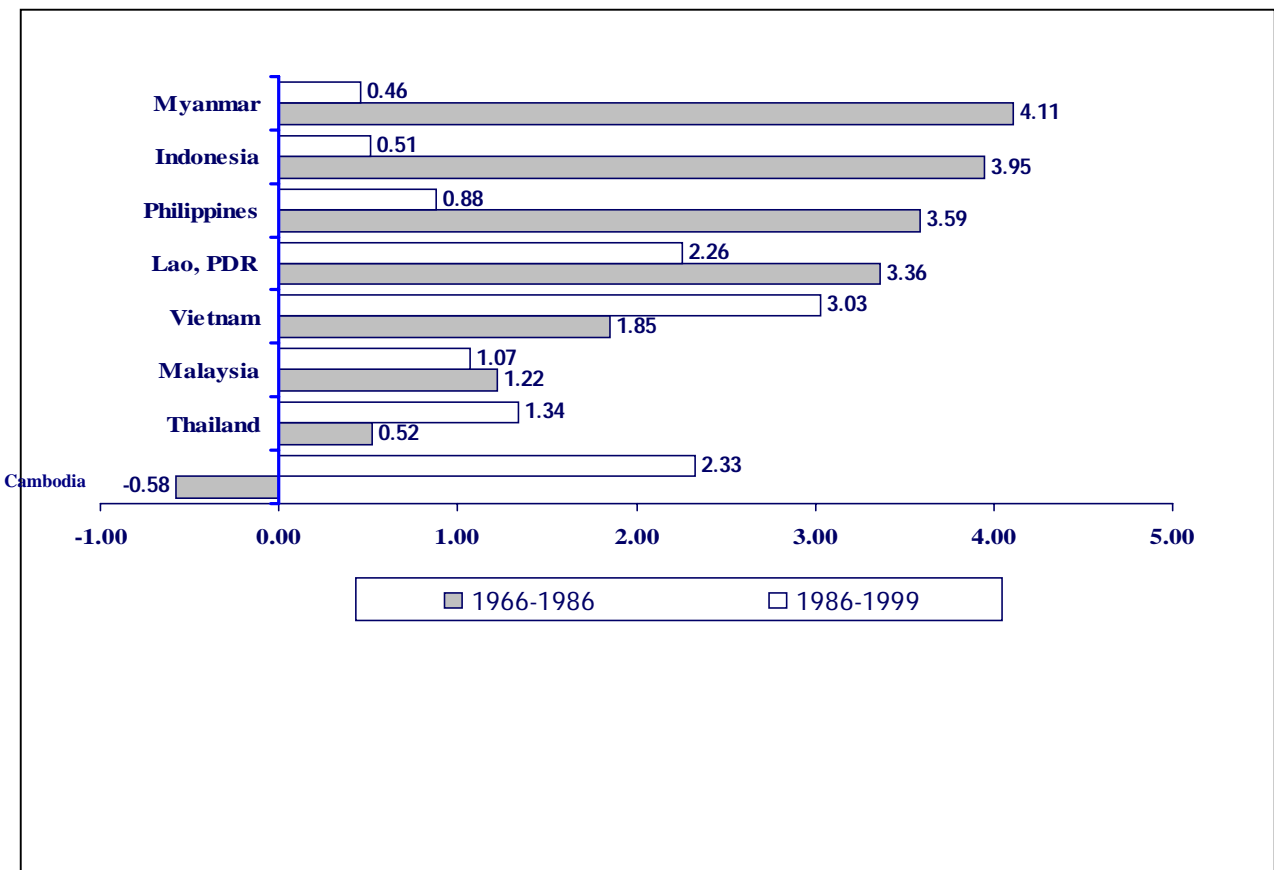


Figure 3 Trends in Rice yield for irrigated and rainfed ecosystems, South east Asia, 1970 - 97

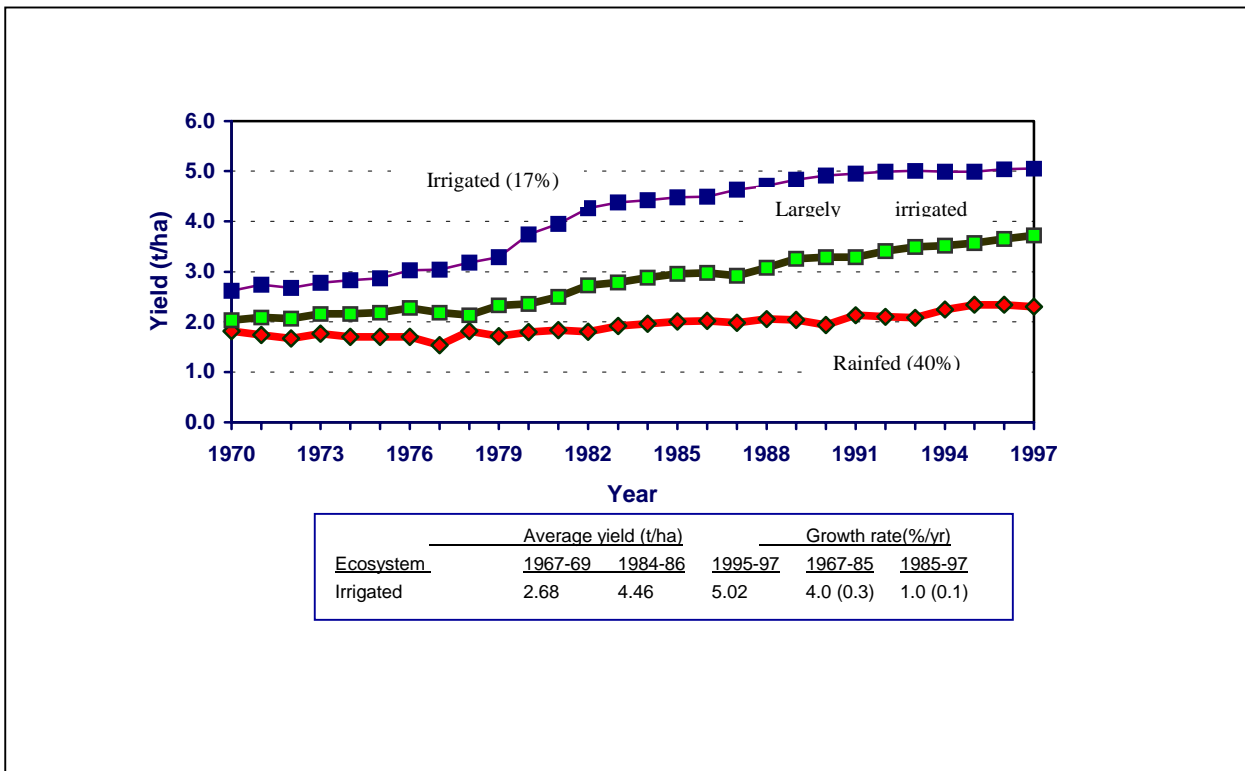


Figure 4 Trend in the adoption of hybrid rice in China, 1978-2000

