INTENSIFICATION OF RICE CROPPING IN THE ASIA-PACIFIC REGION - PROBLEMS AND PROSPECTS

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ABSTRACT

Rice is the predominant food and source of employment and income for most of the people in the developing world. It provides about three-fourths of the calories and about one-third to one-half of the protein for the more than 2 billion people in Asia - about half of the world population.

The Asia-Pacific Region produces and consumes more than 90% of the world rice, hence adequate production of rice in the Region is closely linked with the Region's food, socio-economic and agro-ecological security.

Rice paddy production in the Asia-Pacific Region during 1975-85 increased at an average annual compound growth rate of 3.3% whereas the demand for rice grew annually by slightly more than 3%, of which about 2.1% per annum was due to population growth. During the same period, the gross area under rice paddy increased only by 0.2% per annum.

Considering that the demand for rice during the next decade or so is expected to grow at the trend level and there is negligible scope for expansion of net cultivated area in most of the rice-growing countries of the Region, future increase in rice production must accrue through increased per unit area production by increasing yield or cropping intensity or both.

Problems of intensification, especially soil health and disease and pest incidences, and strategies for and prospects of alleviating the constraints through development of high-yielding, disease and pest-resistant, cold-tolerant, period-bound and widely adapted varieties and appropriate management practices, including Integrated Pest Management, will be discussed.

Introduction

1 Definition of the Asia-Pacific Region

The Asia-Pacific Region encompasses the various 30 countries which fall within the jurisdiction of the FAO Regional Office for Asia and the Pacific (RAPA). These countries include Iran and Pakistan in the West and all countries of Asia geographically stretching eastward up to Japan. On the northern side, countries of China and Mongolia are included. In the South, the Region covers Australia, New Zealand and several South Pacific Island countries. Three of the countries, namely, Australia, Japan and New Zealand, are developed countries and the remaining 27 are classed as developing countries. Except Fiji, the Pacific Island countries, along with New Zealand, Maldives and Mongolia do not produce rice, hence are not included in the analysis. Iran, which is a rice-producing country, could not be included in the present analysis as it joined RAPA after the analysis was completed a few months ago.

2 Importance of rice paddy in the Region

Rice is the foremost food of the developing world. It provides about four-fifths of the calories for the more than two billion people in Asia and one-third the calorie intake of the nearly one billion people in Africa and Latin America. Rice is also a major source of protein for the masses of Asia. Rice occupies one-third of the area planted to cereals in the developing countries, which is about 50% more the area under wheat, the second most important crop. There are 36 countries with more than 100,000 ha of rice, and half of these countries fall in the

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lowest income group, with annual income less than US$300 per capita. More than 95% of the world's rice area is in the developing countries, mostly in Asia.

The Asia-Pacific Region produces and consumes more than 90% of the world's rice. In 1984, the Region produced 426 million tons of rice paddy, out of a total of 465 million tons produced in the world as a whole. Twenty of the 27 countries studied in the Asia-Pacific Region produced rice paddy. In these 20 countries taken together, rice paddy constituted 57% of the total cereals produced (Table 1), which in turn accounted for about 70% or more of the total agricultural output and about 85% to 90% of the daily food intake.

Table 1 Production of individual cereal crops to the total cereals produced in the Asia-Pacific Region, 1985

Crop	Production (million tons)	% of Total cereals
Rice paddy	435	57%
Wheat	165	22%
Coarse grains	157	21%
Total cereals	757	100%

The relative proportion of rice paddy to the total cereal production in the individual countries varied considerably. In, as many as nine countries, namely, Bangladesh, Burma, Dem. Kampuchea, Japan, Laos, Malaysia, Republic of Korea, Sri Lanka and Vietnam, rice paddy production accounted for 90% or more of the total cereals produced, while in three countries, Fiji, Indonesia and Thailand, its share ranged from between 70% and 90% and in five countries, i.e. China, DPR Korea, India, Nepal and the Philippines the proportion ranged from about 50% to 69%. In fact, in the majority of the countries of this region, food self-sufficiency and food security largely depend on rice self-sufficiency and rice security.

Beside being the major food source of the majority of the people in the world, rice is a major export crop of Thailand, Burma, and Pakistan, hence of paramount economic importance.

Rice paddy production

1 Rice paddy production in the Asia-Pacific Region

Rice paddy production, in absolute terms, in the Asia-Pacific Region as a whole reached an all-time high of 437 million tons in 1985, while it was only 325 million tons in 1975, an increase of 112 million tons in the annual level of production in the 10-year period (Table 2). During the same period, in the rest of the world the production increased only by five million tons, from 34 million tons to 39 million tons. China, producing 179 million tons, and India producing 93 million tons, together accounted for almost three-fifths of the world's rice paddy production.

During 1975-83, the average annual compound growth rate for production in the Asia-Pacific Region was 3.3%, against 1.4% in the rest of the world. In the more recent years, 1981-85, paddy production in the Region moved at a much faster annual growth rate of 4.4%, whereas in the rest of the world it had declined annually by 0.9%.

Rice paddy yield per hectare in the Region progressed satisfactorily. Between 1975 and 1985, it increased from 2,548 kg/ha to 3,315 kg/ha, an increase of 767 kg/ha. During the same

Table 2 Rice paddy production, yield and area in the Asia-Pacific Region and the rest of the world, 1975-1985

Geographic entity	1975	1982	1983	1984	1985	Average annual growth rate 1975-85	1981-85
			Production (million metric tons)				
Asia-Pacific Region	325	384	416	432	435	3.3%	4.4%
Rest of world	34	40	35	38	39	1.4	-0.9%
World	359	424	451	470	474	3.1%	3.9%
			Yield (kg/ha)				
Asia-Pacific Region	2548	3052	3227	3343	331	3.1%	3.7%
Rest of world	2330	2495	2389	2484	253	1.4%	1.4%
World	2525	2989	3142	3252	324	3.0%	3.6%
			Area (million ha)				
Asia-Pacific Region	127	126	129	129	131	0.2%	0.6%
Rest of world	15	14	14	15	15	0.0%	-2.3%
World	142	140	143	144	146	0.2%	0.3%

period, in the rest of the world, the average yield moved up only marginally by 263 kg/ha, increasing from 2,330 to 2,593 kg/ha. The Asia-Pacific Region, thus, attained an annual average growth rate of 3.1% in rice paddy yield, against only 1.4% in the rest of the world. In the more recent years, 1981-85, the increase in rice productivity in the Asia-Pacific Region got further accelerated, recording an average annual growth rate of 3.7%, while in the rest of the world it maintained the trend level.

The area under rice paddy increased only marginally from 127 million ha to 131 million ha, recording a low annual growth rate of 0.2%. In the rest of the world, it remained unchanged.

It is significant to note that during 1975-85, about 90% of the increase in rice paddy production occurred due to increase in productivity.

2 Rice paddy production in the individual countries of the Asia-Pacific Region

Rice paddy production, yield, and area for individual countries of the Asia-Pacific Region for the decade ending 1985 are given in Appendices I, II and III, respectively. During 1975-85, while the Region as a whole achieved an annual compound growth rate of 3.3% in paddy production, performances of the individual countries varied considerably. China, the foremost rice-producing country in the world, increased its rice paddy production by 50 million tons during the past 10 years from 129 million tons in 1975 to 179 million tons in 1985, with an annual growth rate of 3.8%. India, the second largest rice-producing country, also made rapid increases in its rice paddy production from 73 million tons in 1975 to 93 million tons in 1985, thus attaining an annual growth rate of 2.7%. Indonesia, the third major rice-producing country in the world, made phenomenal increases in its rice paddy production, from 22 million tons in 1975 to 39 million tons in 1984, with an impressive growth rate of 6.3% per annum. In terms of relative increases in the production during the past 10 years, Sri Lanka registered the highest average annual growth rate of 7.8%, closely followed by Australia, Indonesia, Burma and Laos with growth rates ranging from 5.7% to 6.5%. Among the other major rice-producing countries, besides China, Korea DPR, Thailand and Vietnam registered growth rates ranging from 3% to

APPENDIX I

Rice paddy: production

Unit: 1000 tons

Country	1975	1982	1983	1984	1985	Average annual growth rate 1975-85	Average annual growth rate 1981-85
						%	%
Developing countries							
Bangladesh	19143	21325	21751	21950	21700	1.9	1.5
Bhutan	51	59	60	61	62	2.0	2.4
Burma	9208	14373	14288	14588	14700	5.9	0.9
China	128827	164848	172184	181198	179000	3.8	5.0
Dem. Kampuchea	1500	1400	1700	1970	1900	1.4	14.2
DPR, Korea	3700	5000	5200	5400	5600	3.4	3.5
Fiji	23	20	16	22	22	0.0	6.3
India	73352	70772	89579	89300	92500	2.7	5.4
Indonesia	22340	33584	35237	37978	38970	6.3	4.8
Laos	910	1088	1002	1322	1400	5.7	6.0
Malaysia	1997	1832	1818	1755	1895	-0.4	-3.2
Maldives	-	-	-	-	-	-	-
Mongolia	-	-	-	-	-	-	-
Nepal	2605	1833	2757	2760	2800	1.1	6.1
Pakistan	3926	5167	5009	5186	5250	2.7	0.4
Papua New Guinea	2	-	-	-	-	-	-
Philippines	6160	8108	7731	8150	8470	2.9	1.9
Rep. of Korea	6485	7308	7608	7970	7868	0.6	2.8
Samoa, W	-	-	-	-	-	-	-
Sri Lanka	1154	2156	2484	2414	2600	7.8	4.3
Thailand	15300	16878	19549	19300	19600	3.0	3.4
Tonga	-	-	-	-	-	-	-
Vanuatu	-	-	-	-	-	-	-
Vietnam	10539	14169	14732	15600	15000	4.2	4.7
Sub-total	307222	369920	402705	416924	419337	3.5	4.4
Developed countries							
Australia	388	854	548	632	865	6.5	0.4
Japan	17097	12838	12958	14848	14600	-2.1	4.1
New Zealand	-	-	-	-	-	-	-
Sub-total	17485	13692	13506	15480	15465	-1.7	3.9
Asia-Pacific total	324707	383612	416211	432404	434802	3.3	4.4
Rest of world	34123	40306	34710	38441	38613	1.4	-0.9
World	358830	423918	450921	470845	473415	3.1	3.9

APPENDIX II

Rice paddy: yield

Unit: kg/ha

Country	1975	1982	1983	1984	1985	Average annual growth rate 1975-85	Average annual growth rate 1981-85
						%	%
Developing countries							
Bangladesh	1853	2014	2062	2242	1973	1.4	1.3
Bhutan	2000	2017	2000	2001	2000	0.0	-0.2
Burma	1831	3150	3067	3122	3128	6.6	1.1
China	3531	4889	5097	5366	5300	4.8	5.1
Dem. Kampuchea	1429	833	969	1159	1086	-2.8	8.3
DPR, Korea	5949	6173	6341	6506	6667	1.1	2.2
Fiji	2254	2125	1901	2016	2000	-0.7	-1.2
India	1858	1850	2185	2178	2250	2.3	4.5
Indonesia	2630	3736	3871	3921	3977	4.7	3.1
Laos	1338	1477	1494	2167	2333	5.6	13.0
Malaysia	2661	2674	2674	2659	2807	0.4	-2.8
Maldives	-	-	-	-	-	-	-
Mongolia	-	-	-	-	-	-	-
Nepal	2074	1449	2066	2067	2084	0.4	4.7
Pakistan	2296	2612	2507	2571	2586	1.3	-0.3
Papua New Guinea	2900	2200	2000	2000	2000	-4.4	-6.4
Philippines	1721	2362	2386	2470	2491	3.7	2.7
Rep. of Korea	5324	6151	6193	6475	6371	0.6	2.3
Samoa, W	-	-	-	-	-	-	-
Sri Lanka	1933	2890	3192	2725	2889	4.7	1.2
Thailand	1831	1893	2080	1990	1997	1.4	1.0
Tonga	-	-	-	-	-	-	-
Vanuatu	-	-	-	-	-	-	-
Vietnam	2133	2482	2630	2751	2632	3.1	4.6
Average	2465	3000	3180	3286	3258	3.3	3.7
Developed countries							
Australia	5135	6943	6459	5311	6811	2.0	-3.2
Japan	6186	5688	5701	6414	6266	0.2	3.4
New Zealand	-	-	-	-	-	-	-
Average	6157	5753	5728	6360	6294	0.3	3.1
Asia-Pacific average	2548	3052	3227	3343	3315	3.1	3.7
Rest of world	2330	2495	2389	2484	2593	1.4	1.4
World	2525	2989	3142	3252	3241	3.0	3.6

APPENDIX III

Rice paddy: area harvested

Unit: 1000 ha

Country	1975	1982	1983	1984	1985	Average annual growth rate 1975-85	1981-85
						%	%
Developing countries							
Bangladesh	10330	10586	10548	9790	11000	0.5	0.2
Bhutan	26	29	30	31	31	1.9	2.7
Burma	5030	4562	4659	4672	4700	-0.7	-0.2
China	36483	33715	33781	33766	33775	-1.0	-0.1
Dem. Kampuchea	1050	1680	1755	1700	1750	4.3	5.5
DPR, Korea	622	810	820	830	840	2.2	1.2
Fiji	10	10	9	11	11	1.3	7.6
India	39475	38262	40990	41000	41118	0.4	0.9
Indonesia	8495	8988	9102	9686	9800	1.5	1.6
Laos	680	7373	670	610	600	0.0	-6.2
Malaysia	750	685	680	660	675	-0.8	-0.4
Maldives	-	-	-	-	-	-	-
Mongolia	-	-	-	-	-	-	-
Nepal	1256	1265	1334	1335	1343	0.7	1.2
Pakistan	1710	1978	1999	2017	2030	1.4	0.7
Papua New Guinea	1	-	-	-	-	-	-
Philippines	3579	3433	3240	3300	3400	-0.8	-0.7
Rep. of Korea	1218	1188	1228	1231	1235	0.0	0.5
Samoa, W	-	-	-	-	-	-	-
Sri Lanka	597	746	778	886	900	3.0	3.1
Thailand	8357	8916	9400	9700	9816	1.6	2.4
Tonga	-	-	-	-	-	-	-
Vanuatu	-	-	-	-	-	-	-
Vietnam	4940	5709	5603	5670	5700	1.1	0.1
Sub-total	124609	123299	126626	126895	128724	0.2	0.6
Developed countries							
Australia	76	123	85	119	127	4.4	3.7
Japan	2764	2257	2273	2313	2330	-2.2	0.7
New Zealand	-	-	-	-	-	-	-
Sub-total	2840	2380	2358	2434	2457	-2.0	0.8
Asia-Pacific total	127449	125679	128984	129329	131181	0.2	0.6
Rest of world	14647	16152	14531	15474	14893	0.0	-2.3
World	142096	141831	143515	1444803	146074	0.2	0.3

4.2%. Two countries, namely, Japan and Malaysia, of the 20 rice-producing countries of the Region, showed a negative growth rate, while six countries, namely, Bangladesh, Bhutan, Dem. Kampuchea, Fiji, Nepal and Republic of Korea showed low growth rates ranging from 0% to 2%.

During the 1980s, as mentioned earlier, the overall growth rate of rice paddy production in the Region had further been accelerated. The top two producers, China and India, registered high growth rates of 5% to 5.4%, during 1981-85. During the same period Dem. Kampuchea rehabilitated its rice paddy production considerably, registering a growth rate of 14.2%. Nepal and Japan had accelerated their growth rates while it was considerably decelerated in case of Burma, Sri Lanka and Australia. The growth had considerably decelerated in case of Burma, Sri Lanka and Australia during the recent years.

The average rice paddy yields differed widely from country to country. Four countries, namely, Australia, DPR Korea, Japan and Republic of Korea recorded average yields between 6.2 and 6.7 tons per hectare. China, from a vast area of about 34 million ha under rice paddy registered a remarkably high yield of 5.3 t/ha. Next was Indonesia with an average yield of about 4 t/ha. The yields in Burma, Malaysia and Sri Lanka were about 3 t/ha, whereas the remaining 11 of the 20 rice paddy-producing countries had yields ranging from 1.1 t/ha (Dem. Kampuchea) to 6 t/ha (Vietnam). As regards the rate of increase in yield during the past 10 years, high growth rates were recorded by Burma, China, Indonesia, Laos and Sri Lanka, with average annual growth rates ranging from 4.7% to 6.6%. Two of these countries, China and Laos, along with India and Nepal further accelerated their growth rates of productivity during 1981-85. Burma and Sri Lanka showed a considerable slowdown.

Rice paddy area decreased in five countries, namely, Burma, China, Malaysia, Philippines and Japan, and remained stagnant in case of two countries, namely, Laos and Republic of Korea or increased annually by values ranging from 0.3% to 2% in case of 10 countries. In the remaining 13 countries it increased, the rates of growth being highest in case of Australia (4.4%), Dem. Kampuchea (4.3%) and Sri Lanka (3%). In absolute terms, India showed the highest increase of 1.6 million ha, followed by Thailand and Indonesia which showed increases of 1.5 and 1.3 million ha, respectively. On the other hand, China, the largest producer of rice paddy in the world, showed a decrease of 1.8 million ha between 1974 and 1984.

3 Rice paddy production vs population growth in the Asia-Pacific Region

Rates of growth of rice paddy production and population in 18 major rice-producing Asia-Pacific countries during 1973-83 are given in Appendix IV. It may be seen from the Appendix that the rice paddy production growth rate was higher than the population growth rate in 13 of the 18 countries. In five countries, namely, Bangladesh, Japan, Republic of Korea, Malaysia, and Nepal, however, the population growth outstripped the rice paddy production growth. In case of Japan, a highly developed country, cut back of the production was deliberate. As regards Malaysia, plantation crops like rubber and oil palm receive priority attention, and for rice paddy the country is aiming at about 60% to 70% self-sufficiency.

Republic of Korea is the other country where the rice paddy production growth rate has not kept pace with the population growth. Rice paddy yield in this country is already very high, but still there is a considerable gap between farmers' yields and demonstration plot yields. Government, through intensification of extension activities and improved soil, water, fertilizer, seed and pest management, is striving to bridge the yield gap. Further, there is considerable scope of increase in cropping intensity through further increase in irrigated area and development of suitable varieties and cropping patterns. Rice paddy area has remained constant during the past decade and there is limited scope for increase in net area. However, marineland reclamation is expected to increase rice paddy area by about 400,000 ha in the Republic of Korea by the year 2000 which will add considerably to the rice paddy production.

Moreover, Malaysia and the Republic of Korea are close to being classed as developed countries, hence are able to meet their food demands through imports. As such, the lag of

APPENDIX IV

Rice paddy production and population growth rates (%)

Country	Population 1973-83	Rice paddy 1973-83
	%	%
Australia	1.3	6.3
Bangladesh	2.4	2.2
Bhutan	1.9	2.0
Burma	2.0	3.0
China	1.5	5.0
India	2.3	3.1
Indonesia	2.3	8.0
Japan	0.9	-2.5
Korea DPR	2.5	3.9
Korea Rep. of	1.6	0.8
Laos	2.2	2.8
Malaysia	2.4	-0.6
Nepal	2.6	0.2
Pakistan	3.0	3.8
Philippines	2.7	3.7
Sri Lanka	1.7	6.9
Thailand	2.3	2.6
Vietnam	2.7	3.2

growth in rice production essentially in Bangladesh, and Nepal is a matter of concern. While all out effort should be made to decelerate population growth, there is a considerable scope for increasing the productivity and cropping intensity in these countries. Of late, these countries have accelerated the pace of paddy production and it is hoped that the gaps will be bridged considerably.

Agricultural production resources in Asia-Pacific Region

Most of the Asia-Pacific Region, especially the developing countries, fall within the tropical and sub-tropical rice belts. Under such climatological conditions year-round crop production is possible, ample solar radiation is available during the 12 months for satisfactory crop yield. In fact, the photosynthetic turnover in tropical and subtropical regions should be much higher than that in temperate regions. It is therefore paradoxical that despite high soil and climatic potentials for crop production, there is a high concentration of malnourished people in the tropical world. It is estimated that about three-fourths of an estimated 400 million malnourished people in the world live in the tropical and subtropical belts of the Asia-Pacific Region.

Table 3 presents the arable land area, population and irrigation intensity in the Asia-Pacific Region, rest of the world and the world as a whole. It may be seen from the table that in the Asia-Pacific Region the arable land and permanent crop area is estimated to be 438 million ha. These areas of arable lands and permanent crops constitute 30% of the total areas of these categories in the world. Of the 213.4 million ha of irrigated arable land area of the world, about 58% (123.1 million ha) exists in the Asia-Pacific Region. It must also be underlined that about 55% of the total human population lives in this Region. It may further be emphasized that about 70% of the farming households live in the Asia-Pacific Region, thus indicating the significance of agriculture as a means of livelihood.

Table 3 Agricultural production resources in Asia-Pacific Region, 1983

Resources	Asia-Pacific Region	Rest of the world	World
Total population (million)	2567	2103	4670
Total agricultural population (million)	1445	631	2076
Total land area (million ha)	2833	10559	13392
Arble land area (million ha)	438	1034	1472
Irrigated land (milliön ha)	123	90	213
Percentage irrigation	28.1%	8.7%	14.5%
Fertilizer use (1000 tons)	35	90	125

Only about 15.5% of the total land area in the Asia-Pacific Region is considered arable and under permanent crops. On an average, about 28.1% of the arable land and permanent crop land is irrigated. Of the 2.57 billion people in the Asia-Pacific Region, about 56% are engaged in agricultural activities. As such, there is an average agricultural population pressure of 3.3 persons per ha of arable land in the Asia-Pacific Region against an average pressure of 0.6 persons per ha in the rest of the world.

There is a wide variation in arable land and irrigation water resources among the countries of the Region (Appendix V). Tonga, Bangladesh and India have relatively much higher percentages of cultivated land area (57% to 81%). Bhutan, Laos, Mongolia, Papua New Guinea, Vanuatu, Australia and New Zealand have relatively much smaller percentages of cultivated land area (0.8% to 6.4%). Although China has a vast land area (933 million ha), only about 10.7% can be used for crop production. Western Samoa, Thailand, Philippines and Sri Lanka have relatively modest proportions for cultivated area percentage ranging from 34% to 43%. The rest of the countries had proportions ranging from 11% to 26%. Several of the countries of the Asia-Pacific Region, such as Malaysia, Indonesia, Sri Lanka, Burma, and India had 0.5 to 5.0 million ha under permanent crops.

About 70% of the arable land in the Asia-Pacific Region is cultivated under rainfed conditions. Often the monsoonal rains are adequate to grow one or two crops in most of the South and Southeast Asian countries but there are risks of monsoonal vagaries. The countries of the Region vary widely in their irrigation intensity (Appendix VI). For example, 71% of the arable land in Pakistan is irrigated, closely followed by 67% in Japan and 55% in Korea. Irrigation intensity in China, DPR Korea and New Zealand ranged from 45% to 50%. In Bangladesh, India, Indonesia, Sri Lanka and Vietnam, irrigation intensities ranged between 20% and 27%. Four countries, namely, Burma, Laos, Philippines and Thailand had irrigation intensities between 10% and 18%. The remaining countries, namely, Dem. Kampuchea, Fiji, Malaysia, Mongolia, Nepal and Australia had less than 10% irrigation intensity, Fiji having the lowest irrigation percentage of 0.4%.

The tropical and subtropical conditions of the rice belts in Asia-Pacific Region provide a wide and diverse crop base. A large number of plant species including cereals such as wheat, barley, maize, sorghum, millets, fiber crops especially cotton and jute, legumes, oil seeds, roots and tubers, fruits and vegetables and plantation crops are grown throughout the year as commercial crops, in addition to rice. Each one of these crops has different categories of varieties adapted to varying agro-ecological conditions and thus provides numerous permutations and combinations of crop sequences to be grown in the Region.

APPENDIX V

Mineral fertilizers: consumption per ha of arable land and perm. crops

Unit: 1000 kg/ha

Country	1973	1980	1981	1982	1983	Average annual growth rate 1973–83	Average annual growth rate 1980–83
						%	%
Developing countries							
Bangladesh	20.0	45.6	43.8	51.2	59.6	13.3	10.1
Bhutan	–	1.1	1.1	1.0	1.0	-2.0	-3.7
Burma	4.2	10.0	12.5	16.7	15.8	15.7	18.1
China	64.1	154.1	151.5	160.4	180.6	13.5	5.5
Dem. Kampuchea	0.7	2.7	6.2	3.6	1.6	36.5	-19.0
DPR, Korea	176.9	325.5	348.6	325.9	345.2	7.2	1.1
Fiji	36.0	69.5	79.7	58.5	46.2	3.5	-14.2
India	15.2	31.1	34.0	34.9	39.4	11.0	7.6
Indonesia	25.5	60.2	74.4	78.1	74.5	14.8	7.1
Laos	0.2	4.5	4.5	0.3	0.6	26.8	-58.3
Malaysia	65.2	105.1	92.3	102.1	111.5	7.2	2.8
Maldives	–	–	–	–	–	–	–
Mongolia	7.0	6.9	10.8	10.9	11.6	8.4	17.0
Nepal	5.5	9.2	9.4	13.8	13.7	10.4	17.1
Pakistan	20.8	53.2	53.1	60.9	58.6	12.1	4.4
Papua New Guinea	17.8	14.8	32.5	15.1	18.2	0.0	-1.5
Philippines	26.6	30.6	28.8	30.4	32.0	2.0	1.9
Rep. of Korea	337.8	365.7	351.3	281.7	331.1	-0.8	-5.1
Samoa, W	–	–	4.9	–	–	–	–
Sri Lanka	56.1	77.0	68.4	71.6	74.0	5.7	-0.7
Thailand	9.6	16.2	17.3	20.4	24.0	8.0	14.4
Tonga	–	–	–	1.9	1.9	0.0	0.0
Vanuatu	–	–	–	–	–	–	–
Vietnam	40.6	29.6	34.0	44.4	47.1	-2.7	18.1
Average	32.8	69.1	70.4	73.9	82.0	11.3	5.8
Developed countries							
Australia	38.0	26.3	26.5	24.2	24.2	0.1	-3.3
Japan	430.4	372.1	387.2	411.1	437.0	0.3	5.6
New Zealand	1702.6	1024.7	1015.1	1017.2	1146.8	-3.2	3.5
Average	96.5	69.5	71.9	69.2	72.6	-1.1	0.9
Asia-Pacific average	39.8	69.1	70.6	73.3	80.9	9.1	5.2
Rest of world	68.3	84.2	81.6	79.9	86.8	2.3	0.7
World	59.9	79.8	78.4	77.9	85.1	3.8	1.9

APPENDIX VI

Irrigation

Unit: 1000 ha

Country	1973	1980	1981	1982	1983	Average annual growth rate 1973-83	1980-83
						%	%
Developing countries							
Bangladesh	1299	1639	1726	1800	1848	3.7	4.1
Bhutan	-	-	-	-	-	-	-
Burma	890	999	1073	1044	1011	1.2	0.1
China	43500	45388	45074	44770	45144	0.5	-0.2
Dem. Kampuchea	89	89	89	89	89	0.0	0.0
DPR, Korea	700	1050	1050	1060	1060	3.5	0.4
Fiji	1	1	1	1	1	0.0	0.0
India	31840	39350	38805	40600	39500	2.5	0.6
Indonesia	4700	5418	5418	5450	5418	1.6	0.1
Laos	30	115	116	118	118	15.7	0.9
Malaysia	298	370	330	390	334	1.8	-1.4
Maldives	-	-	-	-	-	-	-
Mongolia	18	35	35	37	38	7.3	3.1
Nepal	117	230	230	230	230	5.3	0.0
Pakistan	13634	14680	14690	14700	14720	1.0	0.1
Papua New Guinea	-	-	-	-	-	-	-
Philippines	980	1300	1340	1370	1400	3.5	2.5
Rep. of Korea	1020	1150	1160	1170	1190	1.5	1.1
Samoa, W	-	-	-	-	-	-	-
Sri Lanka	427	525	548	519	538	2.0	0.2
Thailand	2300	3015	3171	3340	3472	4.4	4.9
Tonga	-	-	-	-	-	-	-
Vanuatu	-	-	-	-	-	-	-
Vietnam	980	1542	1650	1700	1730	6.7	3.8
Sub-total	102823	116896	116506	118388	117841	1.6	0.4
Developed countries							
Australia	1470	1500	1655	1700	1750	1.7	5.0
Japan	3295	3250	3200	3230	3240	-0.2	0.0
Nea Zealand	135	166	200	170	230	4.2	8.5
Sub-total	4900	4916	5055	5100	5220	0.5	1.9
Asia-Pacific total	107723	121812	121561	123488	123061	1.5	0.5
Rest of world	73722	88514	89344	89873	90315	2.2	0.7
World	181445	210326	210905	213361	213376	1.8	0.5

Pathways of intensification of rice cropping

There are only two major pathways for intensification of crop production. The first is the method of area expansion. In the Asia-Pacific Region, the contribution of expansion of net-cropped area to production is expected to be rather limited as the frontiers of cultivable land are almost closed in this Region. However, it is possible to increase gross-cropped area through multiple cropping wherever there is water, or where there is a wide bimodal or even distribution of rainfall so that it is possible to increase the number of crops.

The second pathway to intensification is yield improvement. As mentioned earlier, the Region as a whole has a paddy yield of about 3.3 t/ha. While some countries such as Australia, China, DPR Korea, Japan, and Republic of Korea have high yield levels ranging form 5.3 to 6.3 t, there are a number of countries in the Region whose yield levels are currently below the regional average by a significant margin. For instance, the yield level in India is only about 2.3 t/ha. In Bangladesh, it is even lower. In Pakistan and Sri Lanka, the yield levels are somewhat higher but even then they are only about 2.5 to 2.9 t/ha. Among the Southeast Asian countries, the only country which has a respectable yield level is Indonesia which produces about 4 tons of paddy per ha. Thailand with less than 2 t/ha has the lowest yield in the ASEAN sub-region. Philippines is around 2.5 tons and Malaysia 2.8 t/ha. There are similarly wide variations in yield levels of other corps usually grown in rotation with rice.

Considering the large area of paddy in different countries with rather low or medium yields, there is considerable scope for increased production through yield improvement and this warrants optimism. This will call for expanded use of high-yielding varieties, improvement in cultural practices, better water control and significantly larger use of mineral fertilizers. Given necessary efforts, it should be possible by 2000 A.D. that no country in the Region has a yield level below 3 t/ha and for most countries, the yield should be between 3-4 t/ha. It may be added that, in a large country like China where the current yield is already at a high level of 5 t/ha, the national authorities are contemplating the national yield to go up to a minimum of 6 t/ha.

Constraints to crop intensification

1 Physical (climatic) constraints

Aberrant water and temperature regimes are the most common physical constraints. Lack of control on water is the major cause of low and fluctuating rice yields in most of tropical Asia. Low temperature in high-elevation areas, temperate regions, or winter season limits rice production. Untimely cold weather, such as onset of early cold in Korea in 1980 reduced rice production by 40%. In the Asia-Pacific Region, high temperature is not much of a problem. While increasing the irrigation intensity will mitigate the drought conditions to a certain extent, there is little control on the environmental factors. Under rice-wheat rotation, high temperature during seedling growth of wheat will be a major constraint.

Development of varieties tolerant to drought, deepwater and flooding conditions and low temperature or high temperature regimes have and in future would continue to alleviate, at least partially, these constraints.

2 Soil constraints

The main soil constraints to rice productivity are nutrient deficiencies and soil toxicities. The major deficiencies are those of nitrogen, phosphorus, and zinc. The major toxicities are salinity, alkalinity, strong acidity, iron toxicity, and excess organic matter.

Nitrogen deficiency is the most common nutritional disorder of rice, and high yields are not possible without nitrogen added in the form of fertilizers or organic manures. But efficiency of fertilizer nitrogen may be as low as 30% because of incorrect timing or application method.

Phosphorus and zinc deficiency is also widespread, and can be corrected by addition of these elements or by growing varieties that make better use of them.

Toxic soils cover millions of hectares of current and potential rice lands in South and Southeast Asia. The most common and most extensive problem is salinity, which is a severe yield-limiting factor on about 60 million ha of arid and coastal lands. Many of those areas could be brought into rice production through varietal development. Varieties now grown in saline soils have salt tolerance but low yield potential because of poor plant type and susceptibility to diseases and insects. Varieties with acceptable levels of salt tolerance have been identified.

The largest area of sodic or alkali soils in Asia is on the Indo-Gangetic plain. These areas are mostly not in crop production, but the presence of groundwater makes their reclamation possible through application of gypsum and leaching. Rice is the ideal crop during reclamation. The foreseeable productivity is moderate, although high yields have been obtained with IR8 on reclaimed areas of the Indian Punjab. Because no crops are presently grown in these otherwise suitable areas, even moderate yields are a substantial improvement on current productivity.

Iron toxicity is a severe growth-limiting factor of wetland rice on some highly leached, acid soils, and acid sulfate soils. The total area of current and potential iron toxic lands is about 10 million ha. On peat soils which cover about 27 million ha in the humid tropics of South and Southeast Asia, the main constraints are nutrient deficiencies, toxicity of organic substances, access to the areas, and the lack of human settlement in such areas because of present low productivity.

For dryland rice the main growth-limiting factors associated with the soil are aluminum and manganese toxicities and phosphorus deficiency in acid soils, and iron deficiency in neutral and alkaline soils. Poor soil structure is often an accessory limiting factor, and erosion can be important in many upland areas.

3 Biological constraints

Diseases and pests, including weeds and rats, constitute the major biological constraints. Under intensive culture, these problems are aggravated, especially in the humid tropics. Although precise figures of losses due to different pests and diseases are not known, the losses could be colossal. In the Philippines, for example, tungro virus virtually destroyed 70,000 ha in 1971 and 40,000 ha in 1972, and the brown planthopper damaged at least 80,000 ha in 1973-74. An estimated 500,000 ha of rice in Indonesia were attacked by the brown planthopper and the virus diseases carried by it in 1976-77. Other examples of damaging pest epidemics include tungro virus infestations in Bangladesh, India, and Thailand, and brown planthopper outbreaks in India and Sri Lanka. More than 100 insect species damage rice, 20 being of major economic significance. Even if infestations are low, the damage by various insects may accumulate to cause 15-20% yield loss.

Chemical controls (pesticides and fungicides) are commonly used but have their own economic and environmental limitations. Development of resistant varieties, whether possessing vertical and/or horizontal resistance, has been extremely effective in combating the pests and pathogens. But, it is an ever-ending battle and judicious use of resistant germplasm in building up durable resistance to ever-mutating pests would be a continuing job. For certain diseases, such as sheath blight, no germplasm source possessing high level of resistance has been found. Thus for such cases while search for the desirable germplasm should continue, chemical and cultural controls would be the strategy of protection.

The complexity of the insect and disease problems and the general socio-economic conditions of rice farmers imply the need for an integrated method for practical, persistent control. Most of the progress on control has been through varietal resistance and use of chemicals. While improvement of these two aspects must be continued, it is important to intensify the work on other aspects related to insect and disease control, such as the basic ecology of the common pests, and possible biological and cultural control techniques.

4 Socio-economic constraints

Socio-economic factors, such as degree of market orientation, pricing of inputs and outputs, costs and returns from using a particular technology, institutional structures for credit, land tenure, etc., social factors, and government policies have a direct bearing on rice production and utilization.

The profitability of HYV technology has been proven under congenial rice-growing conditions with adequate control on water. But, for rainfed and marginal conditions, appropriate and profitable technologies are usually lacking. Technology may provide profitable opportunities for increasing rice farm production, but if the opportunities for profit are less attractive than alternatives, farmers act rationally in not using the technology. Alternatives open to farmers require an availability of information to allow farmers to judge their attractiveness. Further, risk is often considered a constraint.

Lack of appropriate marketing, transport, processing, price supports, and other market-related phenomena are important constraints to the adoption of new technologies. Table 4

Table 4 Fertilizer-paddy price ratio and nominal protection rate of urea and rice in selected Asian countries (average 1978–82)

	Fertilizer-paddy price ratio	Nominal protection rate (%) Urea	Rice
Bangladesh	1.89	-23	2
Thailand	4.46	43	-35
Burma	1.81	-74	-49
Philippines	3.67	21	-9
India	3.0	15	-21
Pakistan	2.46	-19	-35
Malaysia	1.44	-27	0
Sri Lanka	1.95	-37	-23
Indonesia	1.52	-44	0
South Korea	0.85	47	135
Taiwan	1.18	11	37
Japan	0.7	92	300

$$NPR = \frac{\text{Domestic price}}{\text{Border price}} - 1 \quad \times 100$$

Source: Government Policies and Farm Incentives in Asia Rice Economy. Notes for "Prosperity Through Rice", Orientation cum Training Program on Improving the Income and Employment Potential of Rice Farming Systems, 21–30 January 1985.

presents fertilizer-paddy price ratio and nominal protection rate of area and rice in selected Asian countries as an average for 1978–82. It may be seen from this table that government policies in several of the South and Southeast Asian countries generally undervalue rice price to protect consumers. Input subsidies have not been generally adequate to offset the disincentive effects of artificially low output price. It is seen that the rice farmers in Thailand are most unfavorably placed while the Indonesian rice farmers are most favored. This situation seems to have a significant effect on average rice paddy yield in the two countries: the Indonesian yield was double of that in Thailand. An approach to planning effective intervention into markets - providing price supports, encouraging cooperative arrangements, buyer contracts, and other measures are thus needed for the spread of production-increasing technologies.

Prospects of intensification of rice cropping

Table 5 gives contribution of rice to total calories intake in different countries of the Region. It may be seen from the table that in the Asian countries, which comprise about 55% of the world's population, rice on an average contributes about 40% of the total calories consumed per person per day. Therefore, adequate production and availability of rice will constitute the most important component of food security in the Asia-Pacific Region.

Table 5 Contribution of rice to total calories consumption, 1980-82

Country	Total calories consumed	Calories contributed by rice	% Contribution by rice
			%
Developing countries			
Bangladesh	1869	1397	74.7
Bhutan	-	-	-
Burma	2359	1811	76.8
China	2490	897	36.0
Dem. Kampuchea	1975	1493	75.6
DPR, Korea	3062	1373	44.8
Fiji	2889	424	14.7
India	2030	663	32.7
Indonesia	2376	1405	59.1
Law	1936	1396	72.1
Malaysia	2569	1106	43.1
Maldives	2039	543	26.6
Mongolia	2749	67	02.4
Nepal	1939	863	44.5
Pakistan	2232	232	10.4
Papua New guinea	2061	277	13.4
Philippines	2405	910	37.8
Rep. of Korea	2937	1515	51.5
Samoa, W	2530	101	04.0
Sri Lanka	2207	962	43.5
Thailand	2312	1462	63.2
Tonga	3126	9	00.3
Vanuatu	2116	295	13.9
Vietnam	2103	1371	65.2
Developed countries			
Australia	3112	45	01.4
Japan	2869	785	27.4
New Zealand	3492	24	00.7

Demand for rice or cereals or food grains as a whole in developing Asia-Pacific is expected to grow by about 3.2% to 3.5% per annum. Considering that during the past decade rice paddy production in the developing countries has been growing annually by 3.5% and cereal production by 4%, essentially through increases in yield, there is every reason to think that the trend will be maintained during the next decade or so.

Ever-increasing pressure on land, and scarce and ever-shrinking arable land resources, adequate farm labor and increasing demand for more and balanced food, will favor crop intensification throughout Asia.

Multiple cropping is not new in Asia. However, the extent of the intensification varies widely depending on several agro-ecological, technological and socio-economic factors. Table 6 presents the cropping intensity in selected countries of Asia. It may be seen from the table that Bangladesh, China, Indonesia and Malaysia had a cropping intensity exceeding 150%. On the other hand, in Burma, India, Japan, Nepal, and Pakistan, the cropping intensity ranged from 102% to 119%. Sri Lanka, Thailand and Philippines had a cropping intensity ranging from 120% to 136%. It is thus clear that there is ample scope for increasing the cropping intensity in the majority of the countries. The national averages often hide wide variations occurring in different agro-ecological zones in individual countries. For instance, in certain parts of China, a cropping intensity of 300% covering million of hectares of land is not uncommon. Similarly in Indian Punjab, a cropping intensity of more than 200% is usually achieved. With the increasing availability of "period-bound" rather than "season-bound" varieties of crops and accent on crop diversification, it is expected that the cropping intensity in several of the countries of the Region should increase. However, it will call for concerted research to develop appropriate multiple cropping patterns, water and fertilizer management, cultural practices, land preparation, and pest and weed management, as briefly enumerated below:

Table 6 Cropping intensity in selected countries of Asia

Country	Cropping intensity %	Source
Bangladesh	150	M. RAHMAN (1986)
Burma	117	SAING and colleagues (1978)
India	121	RAO (1986)
Indonesia	161	OLDEMAN and FRERE (1982)
Japan	102	SANDERSON (1978)
Malaysia	158	VAN (1975)
Nepal	113	Ministry of Food and Agriculture, Nepal (1972)
Pakistan	108	DALRYMPLE (1973)
Philippines	136	DALRYMPLE (1973)
South Korea	131	KIM (1980)
Sri Lanka	120	RANAWEERA (1981)
Thailand	129	SEETISARN (1975)

1 Land resources exploitation

The area of arable and permanently cropped land for the Region as a whole in 1983 was about 438 million ha, representing about 30% of the world's arable and permanently cropped land area. On the other hand, the Region accounted for about 70% of the world's agricultural population. while the area of the cultivable land is more or less fixed, the agricultural population in the Region has been growing annually by about 2.1% during the past 10 to 12 years. Therefore, the ratio of arable and permanently cropped land to agricultural population has been declining. Between 1973 and 1983, in the developing countries of the Region, the ratio declined from 0.282 to 0.270 ha, and in the rest of the world, the corresponding values were 1,664 and 1,638 ha. In other words, the pressure of agricultural population on the arable and permanently cropped land in the developing countries of the Asia-Pacific Region was more than six times when compared with the rest of the world.

The frontiers of cultivable lands are almost closed in the Asia-Pacific Region. Therefore, as mentioned earlier, the future increases in crop production must accrue primarily through increases in yield per unit area and through increase in cropping intensity to a certain extent. Further, with the increasing pressure on the land, the chances of degradation and fertility erosion would increase. An appreciation of the land capability and its population carrying capacity is necessary for future exploitation of this fundamental resource for agricultural production.

FAO study on potential population supporting capacities of lands in Southeast Asia (Bangladesh, Bhutan, Brunei, Burma, Democratic Kampuchea, India, Indonesia, Laos, Malaysia, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam revealed the following;

1) Eighty four percent of the land area is climatically suitable for rainfed crop production, the remaining 16% being either too dry or too cold.
2) Thirty six percent of the land area has no inherent soil fertility limitations, 25% has severe soil fertility limitations, while the remaining 39% has limitations of shallow depth, poor drainage or salinity.
3) Areas where both soil and climate are suitable for crops form the potential land base for rainfed crop production, but some of this will be used for irrigated crop production. By the year 2000, projections indicate that 34% of the total arable area of Southeast Asia will be equipped for irrigation which would account for no less than 73% of the potential population supporting capacity at low input level.
4) As population rises, a growing area will be taken up by non-agricultural uses. By allowing a standard area of 0.05 ha per person, projections for the year 2000 indicate that 11% of the land area would be under non-agricultural uses.
5) A much more serious threat to the potential land base for food production is land degradation. Here the study assessed the potential impact of land degradation due to wind and water erosion. In the Southeast Asia region the consequence of unchecked degradation (low input level) would be the loss of as much as 36% of potential cropland and much that remained would also lose fertility owing to loss of topsoil.
6) The Southeast Asia region, because of the sheer size of its population, has the largest absolute numbers of people affected by potentially critical land resources. Favorable climate and soil resources indicate that one-third of the region's total land area is suitable for rainfed crop growth. However, although some countries still have substantial reserves, 92 % of the potential land base for rainfed crop production was already in use in 1975.
7) Analysis of the potential population supporting capacity for 1975 indicated that six countries in the Region (Singapore, Vietnam, Sri Lanka, Bangladesh, India and Nepal) had insufficient land resources to feed their populations at the low input level. However, at intermediate and high input levels only Singapore remained critical and

this in the statistical sense only as Singapore is well able to finance its food imports. Also, as the region is, on an average, around half-way in achieving the intermediate level of inputs, all six critical countries were in fact achieving yields closer to intermediate than to low levels.

8) The results of the study were also analyzed according to the length of growing season zones within each country for 1975 to give an idea of the real extent, on the ground, of the imbalance between land resources and populations. For the Southeast Asia Region at the low input level, just over one-third of the total land area would have been unable to support its 1975 populations. These critical zones covered most of India and Pakistan, the highland areas of Nepal and Bhutan, the most populous areas of Sri Lanka, Vietnam, Indonesia (Java) and the Philippines. However, at the intermediate input level the critical zones shrink to 7% of the total land area, remaining extensive only in northern Pakistan, highland Nepal, western Bangladesh and Java. High inputs reduce the area further, even in Java.

9) Southeast Asia's population growth is the slowest of all developing regions. Year 2000 predictions (FAO, 1981) indicate that the population of the countries studied will have risen by 73% from 1,118 million to 1,937 million, averaging 2.2% a year. If the large projected increases in irrigation materialize, the potential supporting capacity will increase faster than this, enabling the Region's lands to support 27% more than the expected population, using low inputs. With high inputs, the region would be able to support three times its year 2000 population. At low input level six countries would be critical (Singapore, Vietnam, Bhutan, Sri Lanka, Bangladesh, and the Philippines). At the intermediate input level only Bangladesh would remain critical and even at the high input level, would only be able to support 16% more than its expected year 2000 population which is expected to grow by a further 50% by the year 2025.

The above deductions were, however, based on somewhat inadequate data, but do reflect the general trend. It would be useful to prepare land resource inventory at country levels in greater detail to reach a more reliable assessment. Based on the capacity analysis, selection of areas suitable for annual crops, pastures, tree crops and reafforestation and those that should remain untouched would be possible. This will need a multidisciplinary approach. Appropriate, low cost production technologies, including genetically tailored plants to adapt to given soil conditions, should be developed.

2 Increasing fertilizer use

Fertilizers constitute a vital input for increased and sustained production of crops. The total annual level of nutrient consumption of fertilizer in the Region between 1973 and 1983 had risen from about 17 million tons to 35 million tons. The fertilizer consumption has thus risen at an annual compound growth rate of 9.5%. This includes rather low or negative growth rates witnessed by three developed countries, namely, Australia, Japan and New Zealand whose overall growth rate was -0.1% which already had high levels of fertilizer use. As regards the developing countries of the Region as a whole they have witnessed a growth rate in fertilizer consumption of nearly 12%. The three largest developing countries in the Region, namely, China, India, and Indonesia, had a remarkable spurt in fertilizer consumption during this period. China's fertilizer consumption moved up from about 5.4 million tons of nutrients to 18.2 million tons involving an annual growth rate of 13.4% during the period 1973-83. In the same period India's nutrient consumption moved up from 2.5 million tons to 6.6 million tons implying a consumption rate of increase of 11%. Indonesia also did remarkably well and the fertilizer consumption moved up in terms of nutrients from about 0.48 million tons to 1.5 million tons implying a high growth rate of 15% (Appendix V).

The growth in fertilizer use throughout the period 1973-83 was not uniform. Developing countries of the region recorded average annual growth rates of total fertilizer consumption of

11.6%, 13.2% and 6.2% for the periods 1973-1983, 1973-1980, and 1980-1983, respectively. Again growth rates were appreciably higher than those recorded for the rest of the world and the world as a whole over the same periods. However, the most rapid growth took place during the period 1973-1980. During the period 1980-1983 average annual growth rate slowed down markedly to less than half that recorded over the previous seven years. This is rather an unhealthy trend which should be reversed in order to maintain the momentum in yield increases and to maintain soil fertility. Some studies have shown negative balances in soil nutrients in several countries of the Region (Appendix V).

Despite the rapid increase in fertilizer consumption in the developing countries of the Region, the average consumption of NPK per ha for the Region as a whole is only 81 kg. The absolute level of fertilizer use in eight of the developing countries was below 20 kg NPK per hectare, which is almost negligible. There is a serious imbalance in the use of the major nutrients (N, P and K) and lately the imbalance has been increasing. In order to increase the overall efficiency of fertilizer use, fertilizers should be applied in appropriate proportions according to soil requirements. Further, enrichment of micronutrients, especially where intensive cropping patterns are being followed, should be undertaken to ensure optimum response to the nutrients. It is expected that the past growth of fertilizer use in the developing countries will be maintained, even though there was a deceleration in the use during the past 3 to 4 years in the Region as a whole. Further, effort should be made to enrich the nitrogen status of soils through maximizing biological nitrogen fixation as well as to improve the general health of soil through organic recycling. The Chinese experience in harmonious use of organic and inorganic fertilizers is highly rewarding and should be shared by other countries in the Region.

3 Increasing and efficient irrigation and water use

In the Asia-Pacific Region, more than 28% of the arable land is irrigated. The total irrigated area in the Region increased from 108 million ha in 1973 to 123 million ha in 1980, an average annual increase of 1.5%. More than four-fifths of the total irrigated area of the Region fell in China (45 million ha), India (40 million ha) and Pakistan (15 million ha). The percentage of irrigated area in the individual countries of the Region varied remarkably. It was as high as 72% in Pakistan and as low as 0.4% in Fiji. Japan (67%), Republic of Korea (55%), DPR Korea (46%), and China (45%) were the other countries with high irrigation intensity. On the other hand, as many as 12 countries had less than one-fifth of their arable land irrigated (Appendix VI). Thus there is a great scope for expanding irrigated areas in most of the countries.

It must be recognized that the easily irrigated and well-drained areas have already been developed in most of the countries in the Region. Further projects to bring rainfed land under irrigation will be more costly and technically difficult. Nevertheless, several of the countries are giving high priority to irrigation development. India plans to add two million ha of irrigated area every up to the year 2000, thus bringing its total irrigated area to about 70 million ha by the end of this century - a laudable but difficult target. It is expected that an additional 30 million ha, if not more, will be brought under irrigation in the Region as a whole by the year 2000. This will add substantially to productivity per unit of area and to stability of production.

Irrigation in itself is important, but equally important is its efficient use. In several of the developing countries, the water use efficiency is low. Increase in efficiency of water use and management is bound to pay rich dividends, not only by increasing the productivity and reaping appropriate returns to the huge investments made in developing the irrigation systems, but would also minimize the adverse side effects of increase in salinity and water-logging. More than half of the Indus Basin Canal system in Pakistan, some eight million hectares, is water-logged and 40% is saline. Therefore, while the increase in the irrigation percentage is likely to increase productivity substantially, the efficient on- and off-farm management of irrigation systems and irrigation water should be an essential component of the strategy of improving and sustaining productivity through increased irrigation.

4 Use of quality seed

The coverage under modern varieties varies from region to region, country to country and from crop to crop. FAO study AT2000 indicated that by 1980 about 27% of the developing countries' annual seed consumption involved improved varieties. In Latin America 44% of the seeds included improved varieties, in the Near East the share was 32%, in the Far East (almost analogous to the Asia-Pacific Region) 32%, and in Africa only 9%.

Among the cereals, the highest coverage under modern varieties is for wheat. It is estimated that more than 70% of the wheat acreage in India, Pakistan and China, the major wheat-producing countries, is under modern varieties. The countries, like Bangladesh, which have taken to commercial wheat production only in the recent years, have almost entire areas under improved varieties.

The coverage under modern varieties of rice-the foremost cereal of the Region-varied widely from country to country and according to growing conditions. During 1982-83, it ranged from a low 13% in Thailand to over 70% in Sri Lanka, and the Philippines (Table 7). Of late, the rate of adoption of rice HYVs has increased considerably in Burma, as also reflected in the high growth rates of productivity and production in that country in the recent years. There is a high scope of expanding rice area under the HYVs in Thailand, Laos, Vietnam, Dem. Kampuchea and in most of the South Asian countries, although in Thailand the lag in adoption is partly due to the strong demand for high quality long grain rice and in Bangladesh partly due to the lack of appropriate modern varieties for deep water conditions and other unique agro-ecological settings. However, the farmers are quite responsive to the new improved varieties and have increasingly adopted them as and when these are released for cultivation.

The situation is less favorable in case of coarse grains which may partly be ascribed to the non-availability of strikingly superior varieties and partly to the difficulty in production and maintenance of quality of standard seeds through the supply line.

Table 7 Proportion (%) of total rice area planted to modern varieties

Country	1970-71	1982-83
Bangladesh	4.6	24.8
Burma	4.0	52.7
India	14.9	49.4
Indonesia	11.0	62.0
Korea Republic	-	32.9
Malaysia (West)	23.6	43.7[a]
Nepal	5.7	36.3
Pakistan	36.6	46.0
Philippines	50.0	85.0
Thailand	0.4	13.0[b]
Sri Lanka	10.2	71.0[c]

a relates to 1977.
b relates to 1981.
c relates to 1980.

Source: World Rice Statistics.

A FAO survey conducted in 1983 in selected South and Southeast Asian countries showed that the available quantity of certified seed was sufficient only for 4% of the rice paddy area, 6% of the wheat area, and 5% of the coarse grains' area. Further, considering that about 35% of the cereal area in these countries taken together is under improved varieties and all the certified seed produced pertains to improved varieties only, about 85% of the area under improved varieties is sown to uncertified seeds. Little is known of the yield differences between the certified and uncertified seeds of a given variety. Further, the quality of the uncertified seeds may vary greatly. Reliable data on yield superiority of certified seed over uncertified seed of the same variety should be collected for different crops, which will be helpful in the formulation of appropriate seed programs.

Adequate and timely availability of seeds is a forerunner for crop diversification, new cropping patterns, and contingency crop planning. Therefore, the seed program should be so geared as to produce and supply seeds of different species to suit to different agro-ecological conditions, including emergency situations. Most of the countries in the Asia-Pacific Region have been paying increasing attention to production and distribution of standard seed and it is hoped that the quality seed will play an even greater role in the years to come as an engine to promote the adoption of improved agricultural technology.

5 Integrated pest management

Under intensive agriculture in the tropical countries and with varietal uniformity and genetic vulnerability, the pest and pathogen populations have been rapidly multiplying and diversifying. To minimize the losses due to the pests, insecticidal treatments and development of resistant varieties were resorted to. An estimated about 30% yield losses are attributed to insects on Asian farms. One study had estimated losses caused by brown planthopper to be about US$300 million in 11 countries, US$100 million in Indonesia alone. Another study revealed that in 1980 to control the rice pests, an estimated US$563 million were spent worldwide.

The chemical protection and genetical resistance, mostly vertical (oligogenic), were often effective in obviating the losses due to pests and diseases. But this approach was soon confronted with several adverse effects as mentioned earlier. Moreover, in some of the cases, insecticide treatments were uneconomical. Studies by IRRI, based on multi-year and multi-location trials on efficacy of insecticides showed that Philippine rice production can be easily maintained at current levels with potentially *half* the insecticides now used if applied effectively.

On the other hand, unaided (without chemicals) non-chemical control methods have not been satisfactory, except for some plants bred for resistance and the manipulation of biological agents in China. There is a potential for novel natural chemical methods such as sex pheromones, feeding inhibitors, and insectistatic compounds. However, their application is still limited.

From the above it is thus clear that at least in the foreseeable future, complete elimination of insecticides is not possible. A compromise between the two extremes would have to be struck by developing a multipronged approach in which varietal resistance, biological and cultural control, and insecticides should be integrated to develop an economically and ecologically suitable means of control. This approach has come to be known as Integrated Pest Management (IPM) which is the selection, integration, and implementation of pest control based on predicted economic ecological and soiciological consequences.

One of the major objectives of most of the breeding programs in future would be breeding for disease and pest resistance. The battle between the breeder and the pest is ever-ending. Virulent biotypes/races keep appearing and breaking the resistances, hence the need for discovering newer and durable sources of resistance. Large scale adoption of vertically resistant cultivars puts high pressure on the pest, hence the virulent mutations, such as the BPH biotypes in rice, certain physiological races of rust in wheat, and of bacterial blight in cotton. Thus, the thrust should be to diversify and broaden the genetic base of resistance, both in terms of major and minor genes. All the available genetic resources should be screened for resistance genes and catalogued. Depending on the nature of genetic control of resistance reaction, suitable breeding techniques for pyramiding of major genes and concentration of polygenes to provide durable tolerance should be undertaken. The multiline concept should get increasing prominence to ward off the rapid ramification and multiplication of pest forms. Multiple resistance should be the aim of breeding programs. Further it is quite possible that a given variety may not be resistant/tolerant to all the major pests and diseases. Under such circumstances, complementary use of other methods of protection, including use of chemicals is recommended.

IPM calls for interdisciplinary action and research. There is a need to strengthen the research for developing multiple resistance; identification of most appropriate complementing measures; the identification and assessment of beneficial forms; the collection, assessment and use of insect pest pathogens; the specificity, dose and mode of application of pesticides; the establishment of realistic economic threshold values; and the study of population dynamics under various conditions. Furthermore, an effective extension system is a must for IPM to succeed. A continuous dialogue between farmers, extension workers, researchers and policy makers is necessary for close monitoring and execution of the agreed programs. Finally, international cooperation in identification of the different races and resistance sources, containment of epidemic forms within the affected areas and for sharing of known technology and material should be strengthened.

Summary and conclusion

Rice is the predominant food and source of employment and income for most of the people in the developing world. It provides about three-fourths of the calories and about one-third to one-half of the protein for the more than 2 billion people in Asia - about half of the world population.

The Asia-Pacific Region produces and consumes more than 90% of the world rice, hence adequate production of rice in the Region is closely linked with the Region's food, socio-economic and agro-ecological security.

Rice paddy production in the Asia-Pacific Region during 1975-85 increased at an average annual compound growth rate of 3.3% whereas the demand for rice grew annually by slightly more than 3%, of which about 2.1% per annum was due to population growth. During the same period, the gross area under rice paddy increased only by 0.2% per annum.

Considering that the demand for rice during the next decade or so is expected to grow at the trend level and there is negligible scope for expansion of net cultivated area in most of the rice-growing countries of the Region, future increase in rice production must accrue through increased per unit area production by increasing yield or cropping intensity or both.

Among the problems of intensification, soil health and disease and pest incidence are most common. Multidisciplinary research and development approach to develop and adopt high-yielding, "period-bound", disease- and pest-resistant, cold-tolerant under subtropical and temperate regions and widely adapted varieties and appropriate management practices, including Integrated Pest Management, seeding time and density, minimum tillage, fertilizer, soil and water management should be promoted. Optimum cropping intensity will vary from location to location. Weather, water, land, labor, energy and economics would determine cropping intensity at a given site and given time.

Discussion

Gour Chandra Munda (India): I would like to know whether in India it is preferable to promote the intensification of double cropping or to increase the yield per hectare from single cropping.

Answer: Both approaches, i.e. intensification through yield increase and multiple cropping should be applied. However the choice of the pathways to intensification will depend on the agro-ecological conditions, input resource availability, labor and market forces. For instance in the northern states of India such as Punjab or Haryana the rice-wheat pattern is most common and as there is only one crop of rice in a year, in that case, yield increase per hectare should be recommended. In the southern states, especially where irrigation facilities exist double cropping of rice with a legume crop in the rotation may be more productive. The soil factor, particularly the status of micronutrients will be the main constraint.