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RICE AND CORN TECHNOLOGY AND POLICY IN THE PHILIPPINES

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ABSTRACT

Rice and corn are the main staple food in the Philippines. Around 55% of total agricultural land was planted to these crops in 1984. Increase in rice yields came from increase in productivity but that in corn mainly from expansion in production area. Modern varieties, fertilizers and irrigation contributed to rice productivity in irrigated areas involving resource-rich farmers.

The government goal is to achieve and maintain self-sufficiency in these staple foods. The universal concern and challenge is how resource-poor farmers can produce and earn more. Since the adverse environments inhabited by resource-poor farmers are very diverse, packages of technologies have to be tested and tailored to specific locations. Soil fertility surveys of rice and corn regions by the Bureau of Soils have to be completed to insure the effectivity of NPK fertilizer recommendations. Technology transfer methods involving greater farmer participation in decision making should be evaluated and adapted to insure their effective adoption by resource-poor farmers. Rice and corn breeders are developing varieties with greater adaptability to adverse environments, in addition to pest and disease resistance and improved grain milling and eating qualities. To further encourage production, the farmers should be provided low-tax fertilizer and pesticide prices, adequate credit at reasonable interest rates and guaranteed farm price for their rice and corn produce. The use of renewable production inputs and natural-resource conservation and management should be optimized to insure that rice and corn farming systems are productive, profitable, stable and sustainable.

Postharvest operations, particularly the critical drying operation, should insure the maintenance of the processing and nutritive qualities of rice and corn. Rotting, aflatoxin contamination and stackburning (yellowing) can be minimized by immediate drying of the crop. Farmers' input is needed to insure that new dryers fit their requirements. Breeding for improved milling and eating qualities could also insure conservation and acceptability by consumers. Amylose content of 18-22% seems to be the preferred range for milled rice by Filipinos, but similar studies on white corn are scanty. Although technology is available to improve the processing qualities of rice and corn, there is little price incentive, for example, for head rice. Production of export-quality rice should result in improved market quality of milled rice for local consumption.

Introduction

Rice and corn dominate Philippine agriculture. First, these are the major crops and principal source of income of majority of the small farmers in the country. Second, milled rice and corn grits are the main staple food in the Philippines – milled rice of 80% of the whole population and corn grits, of 20% (regions in the Visayas and Mindanao). Per caput apparent consumption is 98 kg milled rice and 31 kg corn per year based on FAO (1986) and BAEcon (IFPRI, 1984) data, and 108 kg milled rice and 12 kg corn per year based on the 1982 nationwide nutrition survey (FNRI, 1984). Cereal intake is predominantly (83%) rice (FNRI, 1984).

The 1982 nationwide nutrition survey showed that the Filipino diet was 99.6% adequate in protein and 89.0% adequate in energy (FNRI, 1984) (Table 1). Milled rice contributed 56% of the dietary energy and 43% of the dietary protein while corn contributed 7% of the energy and 6% of the protein in the diet. Rice also contributed 29-49% of the thiamine, riboflavin, iron and niacin in the diet.

Table 1. Per capita intakes per day, percent adequacy and contributions of rice and corn to nutrient intake, Philippines, 1982 (FNRI, 1984)

Nutrient	*Per capita intake per day*	*Percent adequacy*[a]	*Percentage contribution by*	
			Rice	*Corn*
Raw weight/ day	915 g	–	297 g	34 g
Energy	1808 kcal	89.0	56.2	7.1
Protein	50.6 g	99.6	42.9	5.9
Fats	30 g	–	10.1	4.5
Carbohydrates	327 g	–	67.0	7.8
Calcium	0.45 g	80.4	18.9	1.6
Iron	10.8 mg	91.5	29.8	3.3
Thiamine	0.74 mg	71.8	44.7	4.4
Riboflavin	0.58 mg	56.3	29.3	3.8
Niacin	16.4 mg	119.7	49.1	2.8
Ascorbic acid	61.6 mg	91.1	0	0.2

[a]Based on recommended dietary allowances for Filipino per day for specific nutrients.

In terms of agricultural land utilization, around 55% of total area devoted to agricultural crops was planted to rice and corn in 1984. Although the two crops had similar harvested areas of 3 million ha each in the same year, total rice production was about 2.5 times that of corn production because of poor corn yields (FAO,

1986; Lantin and Octavio, 1986) (Table 2). White corn accounted for 80% of total corn area and 7 % of total corn production in 1984 (Lantin and Octavio, 1986). The rest was yellow corn. About 50% of the total corn supply was used as food and 38% for feed.

Table 2. Comparative data on rice (FAO, 1986) and corn (Lantin and Octavio, 1986) production in the Philippines

Property	*Rice (1985)*	*Corn (1984)*	
		White	*Total*
Area (000 ha)	3,320	2,586	3,227
Production (000 t)	8,300 (rough)	2,480	3,310
Mean yield (t/ha)	2.50 (rough)	0.96	1.03

Increase in rice production has been mainly from increasing productivity (FAO, 1986) (Table 3). Mean yields of palay doubled from as low as 1.3 t/ha to 2.5 t/ha as annual growth rate jumped from 0.5% in 1955-1965 to 3.7% in 1965-1980. Changes in corn production, on the other hand, were mainly due to area

Table 3. Rough rice production, production area and yield, Philippines, 1971-1985. (Source: BAE-con cited by Gonzales *et al.*, 1985, FAO, 1986)

Year	*Production (10^{-6} t)*	*Area (10^{-6} ha)*	*Yield (t/ha)*
1971	5.34	3.14	1.70
1972	5.10	3.26	1.57
1973	4.42	3.11	1.42
1974	5.56	3.41	1.63
1975	6.05	3.50	1.73
1976	6.16	3.56	1.73
1977	6.45	3.40	1.90
1978	6.89	3.51	1.97
1979	7.51	3.56	2.11
1980	7.85	3.64	2.16
1981	7.72	3.46	2.23
1982	8.11	3.43	2.36
1983	7.73	3.24	2.39
1984	7.84	3.14	2.50
1985	(8.30)	(3.32)	(2.50)

expansion (Gonzales *et al.*, 1985). Corn yields improved from 0.8 to 1.0 t/ha from 1970 to 1984 corresponding to similar values for white corn and from 0.6-1.0 t/ha to 1.0-1.3 t/ha for yellow corn (Lantin and Octavio, 1986) (Table 4). Importations in 1985 were 500,000 t milled rice (FAO, 1986) and 230,000 t corn (Pabuayon, 1986). Production data by region are presented in Appendix Table 1 for rice and Appendix Table 2 for corn.

Table 4. White and total corn production, total production area and mean yield, Philippines, 1971-1984. BAEcon (Lantin and Octavio, 1986)

Year	*Production (10^6 t)*		*Area (10^6 ha)*		*Yield (t/ha)*		
	White corn	*Total*	*White corn*	*Total*	*White corn*	*Yellow corn*	*Total*
1971	1.81	2.01	2.18	2.39	0.82	0.95	0.84
1972	1.81	2.01	2.18	2.43	0.83	0.81	0.83
1973	1.66	1.83	2.10	2.32	0.79	0.78	0.79
1974	2.07	2.24	2.43	2.71	0.85	0.61	0.83
1975	2.21	2.47	2.67	2.95	0.83	0.94	0.84
1976	2.43	2.69	2.79	3.16	0.87	0.70	0.85
1977	2.45	2.73	2.84	3.21	0.86	0.78	0.85
1978	2.37	2.75	2.71	3.11	0.87	0.95	0.88
1979	2.70	3.07	2.76	3.23	0.97	0.80	0.95
1980	2.69	3.10	2.72	3.16	0.99	0.92	0.98
1981	2.68	3.08	2.72	3.20	0.98	0.84	0.96
1982	2.70	3.28	2.78	3.34	0.97	1.02	0.98
1983	2.50	3.11	2.58	3.14	0.96	1.10	0.99
1984	2.48	3.31	2.59	3.23	0.96	1.29	1.03

The rice milling rate of palay to milled rice used in the Philippines is 0.65, allowing for hull, bran and brokens. Similarly, the reported recovery of corn grits is 65-70% of whole corn, allowing for 20-25% germs, fine grits and bran, and 10-15% wastage and loss (SEARCA, 1975).

Nutritionally, milled rice and corn grits and corn meal have similar energy value (FNRI, 1980) (Table 5). Yellow corn, however, is rich in β-carotene (provitamin A). Corn tends to have higher protein content than milled rice, but lower protein quality: both proteins are limiting in lysine content, but rice protein has a higher lysine level than corn protein (Roxas *et al.*, 1970, Graham *et al.*, 1980) (Table 6). In addition, normal corn is also deficient in tryptophan. Another nutritional defect of corn protein is its high leucine content, which affects isoleucine availability. *Opaque-2* or high-lysine corn protein has higher lysine and tryptophan contents and lower leucine content than normal corn protein but no better quality than rice protein (Table 6).

Table 5. Nutrient composition of milled rice and white and yellow corn grits and meals per 100 g (FNRI, 1980)

Nutrient per 100 g	*Milled rice*	*White corn*		*Yellow corn*	
		grits	*meal*	*grits*	*meal*
Moisture (g)	11.1	11.9	12.2	12.0	10.4
Food energy (kcal)	367	368	345	359	360
Food energy (kJ)	1,536	1,540	1,443	1,502	1,506
Protein (g)	7.4	8.7	7.6	7.7	8.5
Fat (g)	0.5	2.2	0.6	0.8	3.2
Total carbohydrates (g)	80.4	76.7	79.2	78.2	37.0
Fiber (g)	0.7	2.3	0.9	2.0	1.1
Ash (g)	0.6	0.5	0.4	1.4	0.9
Calcium (mg)	27	16	13	22	20
Phosphorus (mg)	155	72	56	213	148
Iron (mg)	1.0	0.8	0.4	1.3	1.7
β-Carotene (μg)	–	–	–	625	160
Thiamine (mg)	0.10	0.05	0.05	0.14	0.36
Riboflavin (mg)	0.05	0.05	0.01	0.03	0.12
Niacin (mg)	2.8	0.7	0.5	1.3	1.7

Table 6. Comparative protein composition and utilization and fecal dry weight in Peruvian infants fed milled rice (MacLean *et al.*, 1078) and degermed normal and *opaque-2* corn meals (Graham *et al.*, 1980)[a]

Property	*Milled rice*	*Degermed corn meal*	
		Normal	*Opaque-2*
Protein content (% N x 6.25)	7.2	7.1	6.5
Lysine content (g/16 g N)	3.9	2.2	3.4
Tryptophan content (g/16 g N)	1.4	0.5	0.7
Leucine content (g/16 g N)	8.8	12.9	9.9
Isoleucine content (g/16 g N)	4.3	3.9	4.0
Amino acid score (% based on 5.5% lysine as 100%)	71	40	62
Children (no.)	8	6	6
Daily N intake (mg/481 kJ)	240	256	256
Apparent N absorption (% of intake	66.6 ± 8.6	64.1 ± 11.4	69.6 ± 6.3
Apparent N retention (% of intake)	28.6 ± 9.4	15.1 ± 8.9	22.3 ± 5.5
Protein quality[b] (% of casein)	76.1	40.8	61.6
Utilizable protein[c] (%)	5.5	2.9	4.0
Fecal dry wt (g/day)	15.6 ± 2.3	29 ± 5	31 ± 4

[a]Energy intake of 481-601 kJ/kg body wt daily. Rice amino acid data from Roxas *et al.*, (1979).

[b]Based on mean apparent N retention of casein control diets.

[c]Protein content x protein quality ÷ 100.

In growing rats, a brown-rice sample (8.5% protein) had higher digestible energy, true protein digestibility, biological value and net protein utilization than a whole corn sample (11.4% protein) (Eggum, 1979). They had similar levels of utilizable protein. Studies with Peruvian infants verified the rat data, indicating that milled rice has better protein quality than normal corn and even *opaque-2* corn (MacLean *et al.*, 1978; Graham *et al.*, 1980) (Table 6). The higher fecal weight of infants when fed corn than with rice reflects the poorer energy digestibility of corn relative to rice as shown in rats (87.2% vs. 96.3%) (Eggum, 1979).

Assessment of the State of Technology for Rice and Corn in the Philippines

RICE

To date, rice and corn have the most developed production technologies among the Philippine crops. Rice research in the Philippines was started as early as 1909 with the creation of the Bureau of Agriculture (now Bureau of Plant Industry) and the College of Agriculture, University of the Philippines. Rice research at that time was fragmented and focused more on varietal collection and testing of both local and introduced varieties.

UPLB started a comprehensive research program of 1956 funded through Republic Act No. 2080. Basic and applied research on various aspects of rice production was started. Some of the research output of the program was used to support the "Rice Crash Program" in the early 60's.

With the creation of IRRI in 1960, a new horizon in rice research was evolved (PCARRD, 1986a). BPI and UPLBCA continued to pursue rice research emphasizing varietal improvement. Collaborative work between IRRI and national agencies involved in rice improvement, particularly in the "National Cooperative Rice Testing Program", was established. From 1955-1980, 90 varieties were released for commercial cultivation. Nine varieties were released in 1981-85: IR56, IR58, IR60, IR62, IR64, IR65 (waxy or glutinous), UPRi 4, BPI-Ri10 and BPI-Ri3 (glutinous). Breeding efforts have emphasized disease and pest resistance and translucent endosperm as a means to improve milling quality.

UPLB and IRRI now have basic information on the effectiveness of azolla, Sesbania and blue-green algae as sources of nitrogen for rice production and on the factors affecting nitrogen efficiency in lowland rice culture. However, fertilizer recommendations for lowland rice production remain very general. The soil survey and mapping in detailed fertility survey of rice lands by the Bureau of Soils have slowly progressed. This survey could provide the basis for more soil-specific fertilizer recommendations, which now need to be further verified in specific locations.

Development of early maturing varieties at IRRI (90-100 days) allows the rice crop in farming systems to avoid drought and provides more freedom in selecting a more favorable growing period for nonrice crops that can be grown in rotation with rice. Legumes are used extensively in farming systems. Cereal-legume, cereal-fish, and cereal-meat diets have generally better amino acid balance and protein

quality than either food alone, particularly rice; the deficiency of lysine in rice and the deficiency of cysteine-methionine in legumes are compensated by the excess of these amino acids in the other protein. In addition, legume crops improve soil fertility for the subsequent cereal crop.

Prior to 1969, rice production extension strategies have been independently packaged and implemented by various government agencies (PhilRice, 1986). In 1969, the Unified Rice Applied Research, Training and Information Program (URARTIP) was created to unify rice production recommendations and streamline extension support strategies. An information drive was facilitated by the revision of the "Rice Production Manual" and the publication of a semitechnical "Philippine Recommends for Rice" in 1970. In addition, URARTIP coordinated the on-farm teaching-learning process for newly developed package of technology made possible through the "Mini-kit" scheme, to check applicability to location-specific problems.

The URARTIP provided the support staff for the packaging of the latest production technology known as the 16 steps for Masagana 99 Rice Culture, based mainly on the results of the "Mini-kits". It also trained production technologists supporting the Masagana 99 program and later instituted the 5-month specialist training course on rice production and extension management.

Policies and programs to increase production are directed primarily at promoting the wider use of modern varieties, the expansion of irrigation and increased fertilizer application, through provision of seeds, credit, irrigation facilities, fertilizers, and producer support price (FAO, 1986). The development of modern varieties, increased use of fertilizer and irrigation, introduction of the KABSAKA technology, the intensification of the Masagana 99 program, and the implementation of other production programs contributed greatly to the accelerated growth in rice yields and production between 1974 and 1983 (PCARRD, 1986a) (Table 3). Diffusion of these technologies primarily through the Masagana 99 program and irrigation development coupled with favorable weather resulted in the transformation of the Philippines from a traditionally importing country into a marginal exporting country through 1978 to 1981. Between 1974 and 1979, rice production grew at an annual average rate of about 6%. Herdt and Capule (1983) calculated the increase in rice yields between 1965 and 1980 in the Philippines to be 26% from modern varieties, 31% from fertilizers, 24% from irrigation and only 19% from area expansion.

Since 1983, the issue of rice self-sufficiency has again become a major concern (PCARRD, 1986a). By 1982, the rice supply started to become tight, with the increasing demands of the growing population. Large production shortfalls in 1980, 1982 and 1983, triggered by bad weather and the slowing down of the Masagana 99 program, resulted in a drawdown of stocks (Table 7). Other problems like the outbreak of black bug in Palawan, tungro epidemic in certain regions of the country, soil health problems in areas of intensive cultivation, and postharvest losses aggravated the situation (PCARRD, 1986a). These problems worsened with the in-

creasing cost of inputs like fertilizers and pesticides. Apparent per caput consumption also increased during 1980-85 (Table 7), reflecting the effectiveness of the ceiling price program. Similarly, productivity in upland and saline, drought and flood-prone rainfed areas has remained low. In 1984, the Philippines became a rice importer for the first time since 1977, importing just over 190,000 t in 1984 and about 500,000 t in 1985 (Table 7).

Table 7. Trade, stocks, and consumption of milled rice, Philippines 1974-1985. BAEcon and FAO estimates (FAO, 1986)

Year	*Trade*		*Stocks*		*Apparent annual consumption*	
	Exports	*Imports*	*Gov't.*	*Total*	*Total*	*Per caput*
	(000 t)		*(000 t)*		*(000 t)*	*(kg)*
1974		168.0	180	836	3,236	79.4
1975	-	152.0	215	929	3,532	84.3
1976	1.0	55.4	219	778	3,849	89.4
1977	15.2	30.9	236	841	3,867	87.4
1978	46.0	-	537	1,212	3,997	88.0
1979	127.0	-	595	1,540	3,904	83.6
1980	236.0	-	742	1,575	4,303	89.8
1981	94.8	-	492	1,331	4,650	94.5
1982	0.5	-	601	1,520	4,572	90.5
1983	40.4	-	674	1,478	4,497	86.7
1984	0.3	191.2	104	990	5,256	98.8
1985	-	500.0	197	999	5,353	98.1

In the 1970's and early 1980's, the government extended credit to rice farmers through the Masagana 99 program (FAO, 1986) whose objective was to raise palay yields from the 1973 mean yield of 40 cavans (1.76 t) to 99 cavans (4.36 t) by providing credit and extension for the adoption of improved varieties and technology. Total loans granted doubled from 1973-74 to 1974-75 and declined almost continuously in 1984-85 (Table 8). Consequently, the land area and number of farmers covered by the program were reduced. With the contraction of the Masagana 99 program, the rapid spread in the use of modern varieties slowed down. The use of modern varieties increased steadily between 1974 and 1979 to reach about 76% of total area and remained steady from 1979 onward. Moreover, farmers under Masagana 99 were charged relatively lower interest (12%) than commercial rates. By 1984, these low charges were replaced by a substantially higher market rate (up to 34%).

As the credit granted to farmers was reduced, the cost of inputs rose. Fees charged for the use of irrigation were increased in 1976 from ₱25/ha in the wet sea-

Table 8. Government sponsored credit to rice farmers (Source: NFAC, MAF cited by FAO, 1986)

Year	*Total loan granted (000,000 ₱)*	*Number of farmers (000)*	*Area financed (000 ha)*
Masagana 99			
1973-74[a]	604	619	945
1974-75	1,289	885	1,459
1975-76	830	457	811
1976-77	438	234	391
1977-78	430	231	379
1978-79	421	207	365
1979-80	383	176	315
1980-81	337	158	290
1981-82	271	126	217
1982-83	292	114	205
1983-84	269	93	175
1984-85	151	46	80
Intensified Rice Production Program			
1985 (up to May)	117	30	56

[a] Each split year covers two phases (phase I and II) of the program.

son and ₱35/ha in the dry season to 100 kg palay/Ha (₱106) in the wet season to 150 kg palay/ha (₱159) in the dry season, resulting further in fewer farmers paying irrigation fees. Fertilizer prices were also raised by far more than the floor prices for rice. Before 1976, local fertilizer prices were below world levels; in most of the subsequent years, ex-warehouse prices for fertilizers exceeded those in the international market (Table 9). The ratio of retail fertilizer price to floor price of palay remained over 3 in 1981 onward.

The need to stimulate a recovery in palay production led to a number of policy changes in 1984 and 1985 (FAO, 1986). The Intensified Rice Production Program (IRPP) was introduced to provide farmers with credit and fixed interest charges which were below commercial rates. In addition, steps were taken to liberalize the importation of fertilizers and to relate fertilizer prices to international prices, which are currently relatively low. Floor prices to farmers were raised substantially. However, the program was constrained by large budgetary deficits and financial problems. Although the IRPP was launched to provide cheaper credit to rice farmers, the volume of credit it provided and the numbers of farmers covered were less than before (Table 8). Thus, most rice farmers had to pay very high interest rates. Steps to liberalize fertilizer trade and to link fertilizer prices to low international prices were shortly followed by increases in fertilizer prices. Although

Table 9. Fertilizer use and price, palay price and government procurement, fertilizer: palay price ratio and milled rice wholesale price border price ratio, Philippines, 1974-1985 (BAEcon, Fertilizer and Pesticide Authority, NFA, cited by FAO, 1986)

Year	Fertilizer use/ha[a] (kg)	Urea fertilizer price			Palay		Retail fertilizer: palay floor price	Milled rice wholesale price: border price ratio[c]
		Nominal retail (₱/kg)	Real ex warehouse[b] (₱/kg)	Warehouse: import prices	Nominal floor price (₱/kg)	Gov't. procurement (% of production)		
1974	30.6	2.47	2.37	0.65	0.81	<1	2.68	0.85
1975	23.7	4.02	3.20	0.67	1.00	2	4.02	0.69
1976	26.7	3.49	2.62	1.77	1.06	4	3.29	0.82
1977	29.1	3.37	2.25	1.57	1.10	5	3.06	1.05
1978	36.4	3.44	2.13	1.29	1.10	10	3.13	0.99
1979		3.86	2.00	1.31	1.25	8	3.09	0.95
1980	34.9	4.04	1.85	1.06	1.36	9	2.97	1.11
1981	22.4	4.84	1.91	1.00	1.50	6	3.23	1.09
1982	21.9	5.15	1.87	1.42	1.64	8	3.14	1.00
1983	17.5	5.40	1.93	1.56	1.75	9	3.09	0.83
1984		9.92	2.17	1.34	2.50	4	3.57	1.15
1985		12.18			3.43		3.55	1.18

[a]1974-78 data from World Rice Statistics IRRI; 1980, 1981 and 1983 data from BAEcon. From 39 to 86% of fertilizer supply was imported.

[b]Deflated by consumer price index from International Financial Statistics (1980 = 100).

[c]Manila wholesale price. Border price referred to C & F import prices for importing years (1974-77 and 1984) and to F.O.B. export prices for exporting years (1977-83).

floor prices to producers were substantially raised in 1984 and 1985, government procurement from producers was very small compared to the level of production and also lower than the target set (Table 9). Efforts are being made to increase the use of irrigation, but with reduced government subsidies: both development and operating costs are being collected from farmers, many of whom are already facing financial problems.

A shift in emphasis from consumer to producer support occurred in 1985 when the ceiling on retail prices was removed. Rice exportation was opened to private traders to stimulate competition for rice supplies and improve farm prices. The policy changes of 1984 and 1985 reflect the difficulties of reconciling different objectives in a situation where resources are limited: protecting both producer and consumer with limited resources to provide subsidies. In the fertilizer sector, it is difficult to allow higher profits to encourage domestic fertilizer production and at the same time, charge fertilizer prices sufficiently to encourage its use. With a rapid population growth (3%), it is likely that unless production can be increased sub-

stantially, the country will continue to import rice in the next few years (FAO, 1986). Major policy changes are expected from the MAF under the new revolutionary government.

The recent creation of the Philippine Rice Research Institute (PhilRice) by Executive Order No. 1016 in 1985 should boost and sharpen rice research and development and the breeding for varieties tailored to local requirements and specific environments (PhilRice, 1986). PhilRice was created to develop and implement a national rice research and development program that will sustain and further improve the gains made in rice production and strengthen efforts to solve location-specific problems. In addition, it hopes to improve income and economic conditions of small farmers by expanding and optimizing employment opportunities in the rural areas.

CORN

As early as the 1900's the University of the Philippines, College of Agriculture (UPCA) had been doing research on the varietal improvement of corn (PCARRD, 1986b). Prewar work was characterized initially by continued collection and evaluation of local strains (Bernardo *et al.*, 1959). Postwar effort included crosses among provincial strains and extraction of inbred lines. Cooperative effort in corn improvement started in 1952 in cooperation with BPI and Bureau of Agricultural Extension and characterized by intensive cooperative and coordinated research activities. In the late 1950's, a vigorous corn varietal program was implemented resulting in several hybrids. Outstanding sources of resistance to downy mildew were identified. The cytoplasmic inheritance of susceptibility to Helminthosporium leaf spot was discovered (Villareal and Lantican, 1965). In the 1960's, research focused on the development of high yielding open pollinated (OP) varieties. Among those released for farmers' use during the period were the UPCA var series 1-5 which were high yielding but quite susceptible to downy mildew. From the late sixties to the seventies, breeding work was intensified on downy mildew resistance. This resulted in the release of the Philippine DMR 1 and 2 and other OP downy mildew-resistant varieties. Chemical control of downy mildew through seed-dressing fungicide such as Ridomil was demonstrated (Exconde and Molina, 1978). In the early 1980's to the present, a more vigorous and comprehensive breeding program was implemented to include resistance to major pests and diseases as well as tolerance to difference stress conditions. It was also during this period when the private sector introduced the hybrids as a component of the corn production program in the Philippines. A range of improved OP and hybrid varieties are now available to corn farmers (Table 10). These varieties are not only high yielding but showed greater resistance to downy mildew infestation.

To date, modern packages of technology (POTs) are still being developed for the Philippine corn program. Despite a set of POTs for Philippine corn production, there are still major constraints in their adoption at the farm levels. Lack of a consistent and rational seed policy, for one, hinders the dispersal of high yielding

Table 10. Accredited corn varieties/hybrids in the Expanded Corn Program, 1986

Varieties Hybrids	*Grain Type*	*Maturity (days)*
Improved Varieties		
Phil. DMR Comp 2	White Flint	95-100
MIT Var 2	White Flint	95-100
Improved Tiniguib	White Flint	95-100
Tanco White (IPB Var 2)	White Flint	100-105
Ginintuan (IPB Var 1)	Yellow Orange Flint	100-105
Hybrids		
Cargill CS 711	Yellow Flint	100-105
Cargill CS 747	Yellow Flint	100-105
Pioneer P6181	Yellow Flint	100-105
Pioneer XCG 33	White Flint	95-100
Pioneer P3224	White Flint	100-105
Pioneer P3208	White Flint	100-110
Pioneer P3274	Yellow Flint	100-105
San Miguel Corp. SMC 102	White Flint	95-100
San Miguel Corp. SMC 301	Yellow Flint	105-110
San Miguel Corp. SMC 305	Yellow Flint	105-110
San Miguel Corp. SMC F3	Yellow Flint	100-105

Source: National Food and Agriculture Council
National Cooperative Test for Corn (Phil. Seed Board)

varieties of corn seeds particularly the OP type. A 1978 study of corn farmers in Cagayan Valley, for example, revealed that 70% still planted the traditional varieties while a fourth of the respondents reported that the seeds were either unavailable or very expensive. High input prices of fertilizer and chemicals also constrained the farmers' adoption of modern corn production farm management practices, hence, they have not applied fertilizer within the recommended levels.

Recognizing the importance of the corn sub-sector, the government launched the corn program with four major policy goals: 1) reduce production cost to support the livestock industry; 2) eliminate corn importation and make the country a corn exporter instead; 3) achieve self-sufficiency in corn production for food; and 4) improve income of small farmers. In 1969, the National White Corn and Feedgrains Program was launched to promote the production of corn, sorghum, and soybean. It was later replaced by the Masaganang Maisan Program in 1974 aimed primarily at meeting the increasing demand for white corn as food and producing sufficient yellow corn, sorghum, and soybean. The target yield for the program was set

at 2 t/ha. However, actual average yields in the program areas were only 1.5 t/ha for white corn, 1.1 t/ha to yellow corn and 1.7 t/ha for sorghum.

Because of the limited success of the Masaganang Maisan Program, it was replaced by Maisan '77. Patterned after Masagana 99 for rice, Maisan '77 promoted the utilization of white corn as feedgrains. Closely related to the program are two other – Maisan 99 and Maisan 22. The former was a high technology yellow corn program to promote the use of HYV and mechanized farming; the latter, to increase productivity in hilly areas from 0.3 to 1.5 metric ton/ha. Maisan '77 included activities for promoting soil conservation, for utilizing farm products and by-products for livestock production, and for using opaque corn to improve protein quality in the program areas.

In spite of government efforts, however, self-sufficiency in corn production was never attained. The major reasons cited (Perez, 1985; Lantin and Octavio, 1986) for the failure were: (1) lack of adequate technology, (2) lack of credit, (3) inadequate technician manpower and incentive, and (4) low corn price and high cost of marketing. Recognizing these problems, the government launched a new program called Maisagana program. Literally translated "bountiful harvest", the program aims at the accelerated production of corn to achieve self-sufficiency for human consumption and animal feed in two years and surplus production for export in three years. The Maisagana program consists of the following basic components: (1) technology package to promote the use of improved OP varieties and the hybrids, (2) provision of adequate and reliable inputs like seeds and fertilizers, (3) full credit support, (4) adequate extension support, (5) marketing assistance through NFA and (6) strong program organization and management.

Table 11 shows the total area planted and the number of farmer cooperators under the Maisagana Program for four cropping seasons from CY 1982 to CY 1983. On the average, 36% of the farmer cooperators availed of the production loan provided for the program, but a greater majority (64%) cooperated without availing of the loans. In fact, financed farmer cooperators decreased from 52% during the 1982 Phase A implementation to only 15% in 1983 Phase B.

Total area covered by the whole program increased by an average of 21% per cropping, while the total number of cooperators increased by more than 66% in four cropping seasons. Among the three varieties promoted, the highest growth rate in terms of area planted was shown for white corn variety, while the total area planted to yellow OP varieties decreased by about 2% during the same period.

To further facilitate the production of yellow corn immediately, the government launched the Expanded Yellow Corn Production Assistance Program in 1984 covering 100,000 ha, initially. Four percent of these covers sugar areas and idle lands which will be converted to yellow corn production. The new program provides three alternative financing schemes to farmer participants: (1) NFA Assistance, (2) End-user/Suppliers Assistance and (3) the Banking System Assistance. The Expanded Yellow Corn Program was superseded in 1985 by the Expanded

Table 11. Total area planted and number of farmer cooperators, Maisagana Program CY 1982-83

	Variety						Total	
	Hybrid		IPB		White Corn			
	With financing	Without financing	With financing	Without financing	With financing	Without financing	With financing	Without financing
1982 Phase A								
Area (has)	1,305	5,197	11,186	5,359	3,783	12,033	28,004	22,589
Number of farmers	6,303	3,446	7,251	3,735	2,168	7,084	15,722	14,265
1982 Phase B								
Area (has)	13,000	8,890	3,817	9,191	3,971	15,856	20,788	33,937
Number of farmers	6,357	5,073	2,485	6,371	1,151	8,567	19,993	20,011
1983 Phase A								
Area (has)	18,757	13,126	4,047	14,376	1,426	25,285	24,230	52,787
Number of farmers	9,679	8,836	2,580	11,250	1,103	14,142	13,362	34,228
1983 Phase B								
Area (has)	12,813	15,836	2,271	14,009	18,965	29,845	34,039	59,690
Number of farmers	6,045	8,526	1,586	14,023	9,267	70,825	16,898	93,374

Source: Ministry of Agriculture and Food.

Corn Program which again includes white corn as in the original Maisagana Program launched in 1982.

Researches on corn in 1981-85 have concentrated on varietal improvement, crop protection and cultural managements, with very little effort on postharvest, processing, utilization as well as socioeconomics and marketing (PCARRD, 1986b). Work on screening for suitability of corn varieties to various cropping patterns need to be expanded. Integrated approaches to cultural and pest managements are being pursued.

Pressing problems are refinement of available technology to reduce the cost of production, low farm prices of corn grain, increasing cost of production, lack of funds for financing, extension programs and adverse weather conditions. Corn importation, which ranged from 182,000 to 521,000 t between 1980 and 1985 was lowest in 1984 and highest in 1983 (Pabuayon, 1986). The increased importation reflected the increasing use of corn for feed while total food use remained relatively constant (Table 12). Production problems include soil classification as to NPK values required for specific fertilizer recommendations, specific liming recommendations for the estimated 1,100,000 ha acidic soils with pH < 5.3, optimum planting density, economic threshold level and economic injury level for corn borer and other pests, potential of microbial insecticides, and integrated weed management or control. Major policy changes are expected from the MAF under the present revolutionary government.

Table 12. Imports, total supply and feed and food use of corn Philippines, 1973-1974 to 1984-1985. BAI con data (Gonzales *et al.*, 1985).

Crop year	*Imports*	*Total supply*[a]	*Feed use and waste*	*Food use*	
				Total	*Per caput*
	(000 t)	(000 t)	(000 t)	(000 t)	(kg)
1973-74	91	2,445	738	1,317	33.4
1974-75	159	2,930	832	1,709	41.0
1975-76	54	3,104	884	1,822	42.5
1976-77	160	3,088	1,123	1,646	37.4
1977-78	134	3,084	1,205	1,556	34.5
1978-79	56	3,299	1,274	1,556	33.6
1979-80	93	3,480	1,559	1,553	32.7
1980-81	351	3,609	1,674	1,533	31.4
1981-82	275	3,740	1,786	1,539	30.8
1982-83	406	3,704	1,893	1,479	28.8
1983-84	321	3,771	1,877	1,400	26.6
1984-85	345	3,965	1,917	1,555	28.0

[a]Total of production, imports and beginning stocks. Ending stocks ranged from 104,000 to 264,000 t.

POSTHARVEST

The most critical postharvest problem is drying delay of which results in both quantitative and qualitative grain losses. Delayed drying after harvest is the main cause of the high incidence of aflatoxin in corn in the region (Ilag, 1973; Ilag *et al.*, 1974) (Table 13). Distinct variation between regions in the Philippines in *A. flavus*-infected field corn has been observed (Ilag, 1973) (Table 14). In the U.S. ears infected with European corn borer had the highest concentration of aflatoxin B_1 at harvest (Widstrom *et al.*, 1975) suggesting that damage of seed facilitates *A. flavus* infection. Bruises during shelling also facilitate infection (L. L. Ilag, personal communication). Epidemiological studies reveal higher incidence in liver cancer in corn-staple regions in the Philippines (Bulatao-Jayme *et al.*, 1976, 1981) (Table 15). Primary liver cancer ranks first (21%) among malignancies that reach autopsy (Bulatao-Jayme, 1976). Of 541 corn samples examined, only 3% were negative for aflatoxin and 69% had above 30 ppb aflatoxin (mean 102 ppb). By contrast 36 rice samples were 78% negative for aflatoxin but none had 30 ppb con-

Table 13. Natural infection of corn with *Aspergillus flavus* group, Philippines 1971-1973 (Ilag, 1973)

Sample	*No. of samples*	*Samples without A. flavus (%)*	*Mean A. flavus contaminated grains (% of total)*[a]
Field corn	39	86.7	5.2
Drying corn	12	2.2	58.1
Stored corn	27	23.1	63.3

[a]100 grains from each sample were tested for A. *flavus* group.

Table 14. Field infection of corn with *Asperfillus flavus* group in different provinces, Philippines 1971-1973 (Ilag, 1973)

Province	*Grains tested (no.)*	*Grains yielding A. flavus (%)*
Batangas	900	4.1
Bulacan	300	1.7
Camarines Sur	200	4.0
Cebu	300	51.5
Davao	300	15.7
Laguna	1,000	6.2
South Cotabato	600	5.2

Table 15. Corn intake, aflatoxin content, infection rate and aflatoxin exposure index by Philippine regions, 1975-77; in comparison to hepatocellular carcinoma index, 1973-1977 (Bulatao-Jayme *et al.*, 1981)

Region	Corn				Hepatocellular carcinoma index[b]
	Intake (g/day)	Aflatoxin (ppb)	Infection rate (%)	Aflatoxin exposure index[a]	
Central Visayas	215.0	54	89	1,033.3	18.5
Southwestern Mindanao	102.0	62	97	619.0	14.3
Eastern Visayas	105.7	55	93	540.7	14.2
Western Visayas	6.8	73	82	40.7	13.6
Metro Manila	0.1	62	98	0.6	11.5
Central Luzon	2.6	62	98	15.8	9.8
Southern Tagalog	1.6	58	64	5.9	9.6
Bicol	6.6	65	90	38.6	8.8
Cagayan Valley	14.7	37	33	17.9	8.4
Ilocos	2.0	36	57	4.1	5.7

[a]Product of intake x aflatoxin content x infection rate.

[b]Percentage of total malignancies mortality rate due to hepatocellular carcinoma. Correlated positively with aflatoxin exposure index $r = 0.9$** with Metro Manila excluded since more than half of the patients in Metro Manila come from other regions and its corn come also from other regions

tent (0-18 ppb only) (Bulatao-Jayme *et al.*, 1976). Similar results were earlier obtained by Santamaria *et al.*, (1972) (Table 16). Current tolerance level of aflatoxin in food is 20 ppb. Although aflatoxin incidence is minimal in traditional rice varieties (Santamaria *et al.*, 1972; Bulatao-Jayme *et al.*, 1976), aflatoxin level should be rechecked in early maturing varieties planted in the rainy season and harvested during periods of heavy rainfall. *Aspergillus* spp. infected rice would have poor milling quality and the resultant milled rice would be low in aflatoxin (Ilag and Juliano, 1982). But the bran and the infested grains are diverted as animal feed.

Delayed threshing of harvested rice plants may result in rotting or "stackburning" (Mendoza *et al.*, 1982). Yellow milled rice from stackburning has reduced protein quality from the heating of the grains (Eggum *et al.*, 1984) (Table 17) as a result of anaerobic respiration of microorganisms on wet straw and panicle. Yellow rices exceeding the NFA maximum limit of 2% yellow grains (Mendoza *et al.*, 1982) also cannot be exported. Stackburning may be minimized by effective aeration of cut straw. These postharvest losses could be further reduced through improved equipment used in threshing, drying and in storage (PhilRice, 1986).

Market quality is dependent on variety and its postharvest handling. Very little price premium is given head or whole-grain milled rice with the resultant high percentage brokens of market rice. There is little incentive to improve milling efficiency, although the technology is available. Breeding for translucent nonwaxy

Table 16. *Aspergillus flavus* infection and aflatoxin content of corn and its by-products from the Visayas and Mindanao and rice from Manila (Santamaria *et al.*, 1972)

Sample description	*No. of units plated*	*Units yielding A. flavus (%)*	*Aflatoxin B_1 (ppb)*
Whole corn on cobs, drying yard, rural area	21	71	343
Whole corn, shelled, drying yard, from above	20	55	107
Corn grits for human consumption, mill in rural area	18	94	29
Whole corn, shelled, dry, for milling	20	30	503
Corn grits taken from mill at bagging spout	20	25	86
Corn germ, used for oil milling or feed	21	47	233
Corn dust and fine debris, animal feed	20	90	343
Moldy rough rice from milling company bodega	30	0	0
Rough rice of poor germinability, IR8, 9 mo. old	40	27	7
Rough rice exposed in field expt., improperly dried, IR8	40	15	0
Rice, 2 years old, stored in bodega, IR8	40	2	5

Table 17. Comparison of mean composition and energy and protein utilization in rats of four yellow milled rices from "stackburning" of unthreshed panicles plus straw with those of three ordinary milled rices (Eggusm *et al.*, 1984).

Property (at 14% moisture)	*Yellow rice*	*White rice*
Crude protein (% N x 6.25)	7.4	8.7
Lysine (g/16 g N)	3.1	3.5
Energy content (kJ/g)	15.4	15.4
Balance data in growing rats		
Digestible energy (% of intake)	96.0	96.6
True digestibility (% of intake N)	92.0	98.4
Biological value (% of absorbed N)	66.4	67.2
Net protein utilization (% of intake N)	61.0	66.1

grains has improved milling recoveries but head rice yields are still lower by 5% than U.S. and Australian rices. Consumers prefer white (well-milled), translucent and head milled rices as indicated from retail market survey (Unnevehr *et al.*, 1985). Fancy varieties, mostly aromatic upland rices, are highly prized. Since rices are displayed in open bins, subject to dust and contamination, consumers normally wash them before cooking with concomitant loss of water-soluble vitamins and minerals. Varietal differences in milling quality exist among rice varieties. Under laboratory milling conditions, total milled rice recoveries of up to 72% and head rice recovery

of over 60% have been obtained. The current conversion factor for milled is 65% suggesting some diversion to feed use.

Corn is also converted to grits and boiled like milled rice. Varietal differences in milling quality or recovery of grits probably also exist but have not been systematically screened. The Filipino preference is for whole-grain, well-milled translucent raw rice (del Mundo and Juliano, 1981; Unnevehr *et al.*, 1985).

White corn is preferred for human consumption over yellow corn because of its superior taste; yellow corn has a characteristic flavor (M. M. Lantin, personal communication). Farmers also observe that white corn stores longer than yellow corn (Paris and Unnevehr, 1985). Starch properties vary widely among rice varieties. Preference by Filipinos is for soft, cooked rice equivalent to intermediate amylose (20-25%) rice such as C4-63 and for low-intermediate amylose rices (18-22%) upland rices (Merca *et al.*, 1979; del Mundo and Juliano, 1981). Gelatinization temperature (GT) of starch preferred is intermediate type for the former but may be low GT for upland rices. Corn varieties have been shown also to vary in amylose content. Adequate screening methods are available for a breeding program for eating quality. As an example, the recent variety IR64 with intermediate amylose and GT appears to have wide popularity.

Very little systematic study has been undertaken on the variety type most suitable for traditional value-added rice and corn products and improvements of traditional processing techniques as a means of income and employment generation in the rural areas. The nutritional effects of these processes have been studied in some detail (Juliano, 1985b). Rice grain chemistry and technology has been recently reviewed (Juliano, 1985a).

By-products and biomass utilization should also be considered such as the greater use of rice hull in steam engines for rice mills (PhilRice, 1986).

Policy Issues

The limited land frontier and high population growth rate are the two major factors that have induced the Philippines to adopt a strategy of crop intensification and technology generation if it is to keep food supplies abreast with demand (Gonzales and Umali, 1985). This strategy has tremendous implications to *technology* and *economic* policies associated with the production of rice and corn.

We define technology policies here to mean the broad activities of technology generation, transfer and adoption from production, marketing, processing into alternative products and the packaging of these products until they reach the end users. The issues here are: what should be the configuration of the technology policies for rice and corn? Under what overriding goals should these policies be considered? For example, should the emphasis of technology policies be on equity or growth? How should the roles of the government and private sectors be delineated in the generation of these technologies?

Closely related and complementary to technology policies are economic policies focused on economic efficiency as the major criterion. For example, the issues

on whether it is more economical to import than to domestically produce rice and corn fall under this category. The issues on input-output pricing policies, questions of incentives-disincentives in food production, as well as government market interventions versus private initiative, are also examples in the domain of economic policies.

Consistent synchronization of both types of policies is imperative in attaining a successful program in food production. Technological breakthroughs in food production should be balanced by the economic efficiency norm to optimize the allocation of the country's limited resources.

Under an economic regime of depressed economic activities constrained by difficulties in servicing foreign debts, the need to synchronize technology and economic policies becomes more pronounced. For example, incorporation of a desirable trait such as a disease/pest resistance into a variety has merits, as it will result in reduced cost of inputs such as pesticides. With self-sufficiency, greater emphasis on grain quality is evident particularly with the desire to export. Thai rices for export are characterized by long grains (>7mm) (Kongseree, 1979). Improved head rice yield on milling is also imperative. Varietal differences in cracking resistance during moisture absorption stress in rice (IRRI, 1985) and in milling performance of corn should be verified and a screening method developed and its cause determined.

Adequate information on the quality characteristics of parents used in the breeding program would insure the maintenance of desirable characteristics in the new varieties. A better understanding of the quality characteristics of the so-called fancy varieties and the better-quality white corn varieties is imperative to a breeding program for grain quality. Variety is an integral factor in the production of export-quality rice. With NFA now under MAF, quality assessment is coordinated. Rice grain quality had been more a responsibility of NFA than of MAF, although NFA has been involved in the assessment of milling quality of promising lines in the Philippine Seed Board.

Rice farmers in less favorable environments have not benefited from the modern rice varieties which are adapted to irrigated and favorable rainfed lands. In addition, these farmers are subject to a profit squeeze because of the reduction in rice prices through higher-than-border input prices and lower-than-border output prices during the 1970's. The breeding of varieties adapted to these less favorable environments have been initiated at IRRI and in national programs to improve the income of these farmer families.

Current Masagana 99 fertilizer and integrated pest management recommendations are too general and require adjustment in various regions to be effective and economical. Although most recent economic studies (Unnevehr *et al.*, 1984; Gonzales *et al.*, 1985) in rice production showed economic efficiency in domestically producing rice at different levels of technology, package of technology tailored to specific sites, including adverse environments, should be developed, verified and recommend to increase yield and profitability of farmers and to include integrated

crop and soil management and pest management (PCARRD, 1986a). A better understanding of the poor adoption of modern varieties under adverse environments by farmers is important in improving rice production in non-irrigated area. Farmers' active participation in technology transfer activities should focus on their problems and on how to improve adoption rates.

Increased productivity of rice-based farming systems must be also profitable, stable, and sustainable. Natural resource management needs greater emphasis; so does minimal use of chemical pesticides to insure minimal pesticide residues in the grain, straw and in the environment. Alternate sources of nutrients (straw, azolla, green manures, animal manures), nitrogen fixation by blue algae and other microorganisms in wetland rice soils are being investigated; so are botanical sources of pesticides.

The export potential for Philippine rice is bleak for several reasons. First, the market is thin and very unreliable (Siamwalla and Haykin, 1983). This thinning process is accentuated in Asia, the main producing and consuming region because of the introduction of HYVs that shifted supply in the major rice-growing parts of Asia. This thinning process makes unstable trading patterns resulting in high search costs because of the lack of regular channel of trade.

Second, the share of Asia in rice trade has also declined substantially over the previous years. The shift of Indonesia from its position as a major importer to a marginal exporter in the early 80's has substantially contributed to the rice glut, accentuating further the decline in rice prices. With the exit of Indonesia as an importer, the possible destination for Philippine rice if export is attempted, will be the Middle East for high quality rice and Africa for low quality broken rice. With the Middle East as a target, the Philippines cannot compete with Thailand and Pakistan in grain quality. The demand for rice import in Africa, particularly Nigeria, is a function of revenues from crude oil export. This revenue source, however, has dwindled substantially because of the continuous deterioration in the price of crude oil.

Third, the argument of economic comparative advantage can be applied to the potential of Philippine rice export. Projections for 1990 (Gonzales *et al.*, 1985) show that for the Philippines to gain economic efficiency in rice export, the minimum border price of 30% broken rice should range from $195/mt (rainfed lowland) to $218/mt (irrigated). The border price level of this rice quality in Bangkok, Thailand to date is $150/mt (FOB) which is way lower than the Philippine's capability.

In the case of corn, there is enough empirical evidence (Gonzales *et al.*, 1985; Lantin and Octavio, 1986) on the economic desirability of domestically producing corn rather than importing the cereal. The constraints, however, tend to be focused on the needed delivery services that accompany the corn technology. If the corn program is to target 90% of the corn farmers who are small producers, then a consistent policy on seed production and distribution of OP varieties needs to be sustained. Hybrid corn gives a higher yield than OP corn even under low production inputs, but OP corn gives a more stable agronomic performance across environ-

ments. In addition, given small corn farmers' practices, the OP varieties are more suited and accessible to them. Hybrid seeds have to be purchased each crop while for the open-pollinated corn, the farmers can select their own seeds from crop stand which needs recycling only every three cropping seasons provided there is no source of contamination from other varieties.

Hybrid corn, despite its potential profitability, requires high inputs which are very prohibitive to small farmers. Cost of seed alone is at most ₱42/kg or approximately ₱840/ha.

On the other hand, considerable research effort has also been concentrated on hybrid rice in view of the success of hybrid rice in the People's Republic of China, where 20-30% yield increases over the best varieties are reported. However, the economics of hybrid rice production is being studied at IRRI, because of the additional labor requirements which would contribute to high cost of hybrid seeds. Hybrid seeds also have to be purchased each season. Ordinary rice seeds do not require frequent replacement since rice is essentially self-pollinated.

Low-input technology should be viewed in the optimizing of use of renewable inputs in soil fertility and in pest management through natural resource management to increase rice and corn yields.

Agricultural machinery and equipment for use in rural areas for labor intensive production steps are undergoing fabrication, adaption and feasibility studies (PCARRD, 1986a). However, even up to the present, these developed technologies have not been fully adopted by the end-users, namely the farmers, processors and entrepreneurs (PhilRice, 1986). Generally, the farmers and processors still use traditional tools, equipment and techniques for socio-economic reasons. Labor-related problems and high postharvest losses still occur, resource utilization is not optimized and cost of production is still high. Emphasis should be given to appropriate field machineries or implements and processes that are relevant to the present needs of farmers and processors.

Improvement of postharvest handling of wet grains to minimize quantitative and qualitative losses is an important means to increase overall food production. The aflatoxin level in white corn needs to be restudied and *Aspergillus* infection prevented by immediate drying of harvested corn, in view of its linkage to higher incidence of liver cancer. The relationship of the damage to corn by insects, and harvesters and sheller, and *A. flavus* infestation should also be studied in the humid regions with more severe aflatoxin problem. Rotting and stackburning of unthreshed rice can be prevented by mechanical threshers and dryers, particularly by a two-stage drying system. The first stage or high speed drying can be done by a flash dryer to about 17% moisture followed by in-store drying (PhilRice, 1986). Grain breakage becomes a problem at this lower moisture drying. Preliminary studies suggest that all rice varieties are susceptible to stackburning. Proper drying technology is available to minimize grain breakage during the drying operation. Efforts are being made by NFA to set field standards for rough rice procurement based on moisture content, purity, immatures, and damaged and discolored grains (FAO/NFA, 1986).

Integrated pest management of rice and corn during storage should be pursued more actively by NAPHIRE and other agencies to minimize losses. Possible varietal differences should be investigated and incorporated into new varieties to minimize pesticide applications and concommitant residue problems.

Packaging of milled rice or corn grits in hygienic sealed bags or cartons may discourage further washing prior to cooking and thus conserve vitamins and minerals. Cooking in excess water should be discouraged to conserve nutrients.

NFA has done some studies on parboiling of rice. A rice milling complex, the Northern Philippine Grain Complex, is being established in the Cagayan Valley but with the parboiling plant and oil refinery for bran oil being deferred. A more exhaustive feasibility study needs to be made on suitable varieties for parboiling since only two varieties were tested (IR36 and IR42). Because of the added cost of parboiling and poor acceptability of cream-colored parboiled rice by Filipinos, parboiled rice will be mainly for export. At present, world rice prices are low and the economics of exporting parboiled rice should be thoroughly studied. Aflatoxin contamination is common in improperly processed parboiled rice, including *pinipig*. Rice products (n = 166) had 28% positive for aflatoxin and had mean aflatoxin content of 33.3 ppb but 15 boiled rice samples had 20% positive for aflatoxin and only 0.6 ppb mean content (Bulatao-Jayme *et al.*, 1981).

Additional study should be made on the economics of oil extraction from rice bran outside the large mill complex because of the variable hull contamination of commercial bran. Extrusion cooking of bran through an extruder effectively inactivates the lipase, together with trypsin inhibitor. Inactivation of trypsin inhibitor improves the nutritional value of bran to poultry. Oil extraction from stabilized bran is optional in the feed industry, inasmuch as bran oil is needed in the feed for improved energy content. Huller bran has too low an oil content for economic oil extraction.

The production of value-added rice and corn food products, including noodles, expanded snacks, precooked weaning foods, etc. should be encouraged. Traditional processes should be studied and improved to insure the preparation of uniform-quality hygienic food products. The nutritional value of these products and the types of rices most suitable for each product should be determined, since thermal processes may decrease the nutritional value of rice protein, particularly lysine. Wet processes may also introduce aflatoxin in the processed food (Quebral, 1976) (Table 18). Parboiled rice has higher aflatoxin level than raw rice owing to the prolonged soaking of *palay* (3-4 days) prior to steaming (Bandara, 1985). The practice of buying glutinuous or waxy palay only partially dry for *pinipig* – making increases the risk of aflatoxin contamination, in addition to the steeping step.

Policy Directions

Before policy directions for the rice and corn sub-sectors are specified, it must be reiterated that the basic role of government should be to provide an en-

Table 18. Summary of Food and Nutrition Research Center, NSDB, analysis for aflatoxin content of corn and rice foods through October 23, 1970 (cited by Quebral, 1976)

Product	No. of samples			Aflatoxin content (ppb)	
	Total	Without aflatoxin	> 30 ppb aflatoxin	Range	Mean of positive
Corn					
Dried	37	0	30	3 - 398	106
Boiled	13	3	0	0 - 20	11
Popped (with sugar)	17	9	0	0 - 24	14
Popped (with salt)	12	4	1	0 - 660	20
Canned sweet corn	6	2	0	0 - 9	6
Bran	3	0	3	197 - 265	242
Corn starch	3	2	0	0 - trace	–
Corn with coconut	17	3	3	0 - 143	37
Rice					
Straw	14	11	0	0 - trace	–
Rice and sugar	23	18	0	0 - 22	13
Rice, sugar, and coconut milk	54	19	3	0 - 786	39
Rice, sugar, and *linga*	4	3	0	0 - trace	–
Puffed rice	2	1	0	0 - 3	3
Bran	3	0	1	28 - 31	29
Pinipig	6	2	0	0 - 6	5
Cereal preparation	5	0	0	trace - 14	9
Binlid (bakewers')	2	0	0	trace - 11	11

vironment in which the private sector can be most productive and not to directly intervene in the economic activities of the food sub-sector. Recent studies (David, 1983; Unnevehr, 1983) have shown that direct government intervention in the market results in economic inefficiency. Therefore, it would be more economically desirable in the long run for the government to intervene only in economic activities which the private sector is incapable of doing, on an interim basis.

On the technology side, there is a need to strengthen domestic institutional capability to generate, transfer and assess technology for rice and corn. The need is more pronounced in corn than rice. But even with the presence of IRRI in the Philippines, a strong national rice program complemented by an international rice research effort is desirable in the long run.

It has been demonstrated that social returns to rice (Evenson and Flores, 1978) and corn (Perez, 1985) research have high-pay-offs and yet the funds allocated to agricultural research in the Philippines, like in other less developed coun-

tries, are not even 1% of the gross national product (GNP) (Daniels and Nestel, 1981).

In view of this, there is a need to financially support more dynamic research activities in the food sub-sector. This support should be for breeding strategies, researches on technology adoption and on farm trials, post-harvest activities, food processing and packaging. With the changing tastes and preferences of consumers, researches should be directed to the processing and packaging of the alternative end uses of rice and corn products.

As mentioned earlier, there are gains in economic efficiency in producing rice and corn domestically instead of importing the cereals. For rice in particular, there is a need to look at maintenance research to defend the technology gains the Philippines has already attained over the years without necessarily diverting focus to technology research in the unfavorable rice environments.

Because of the demand for high quality grains for local consumption and in the world market, once self-sufficiency is attained, breeding efforts should involve multidisciplinary teams to ensure that the new varieties will possess improved milling and eating qualities in addition to agronomic properties. The quality criteria should be based on the Filipino preferences since only 4% of world rice production reaches the highly competitive world trade. For nutritional considerations, protein level should at least be maintained at about 7% in milled rice or 8% in brown rice, because rice is the principal source of protein, except in areas where corn is the staple.

Breeding should also emphasize tolerance to adverse environments to improve yields and benefit the farmers in these non-irrigated areas since the benefits to the modern rice varieties have been limited mainly to the irrigated areas. Adequate disease and pest resistance should reduce pesticide expenditure. Corn borer and earworm resistance should reduce the incidence of aflatoxin in corn.

For corn, the direction of the program should be the small producers who compose the majority of the sub-sector. There are still, however, constraints in reaching the small corn farmers. One of the major bottlenecks is the unavailability of improved OP corn seeds at cost affordable by small producers. A set of consistent policies on seed production, and distribution and delivery services associated with such policies should be developed to minimize this constraint.

For rice and corn, packages of technologies (POT) should be continuously developed and tried. These POT's should be tailored to specific environments incorporating integrated crop, soil and pest managements to optimize the utilization of all inputs and reduce cost of production. Financial institutions should include with the POT adequate financing/loans to farmers. Thus, the present government's reduction of taxes on fertilizers and pesticides will increase the income of farmers.

Farmers should not be only on the receiving end of POT, but must be active participants to ensure the success of technology transfer activities. Agricultural research on resource-poor farmers has come up with the farmer-first-and-last

model (Chambers and Ghildyal, 1985; Chambers and Jiggins, 1986), which fits the diverse and complex conditions and needs of resource-poor farmers better and makes more sparing and cost-effective use of scarce scientists than current technology transfer techniques. Rapid rural appraisal is proposed to conventional large-scale surveys as used at Faculty of Agriculture, Khon Kaen University in Thailand (1985). These new techniques should be tested to accelerate farmer participation in technology transfer.

Postharvest research on fast drying of corn and rice to below about 17% moisture immediately after harvest should reduce the incidence of aflatoxin and yellow rice. Filipino consumers should be given the priority to food with minimum levels of toxicants and nutritionally-depreciated protein. Prevention of aflatoxin incidence is cheaper than detoxification of aflatoxin contaminated grain.

Improved grading of rough rice and milled rice and increased premium for head rice should improve the market quality of rice. Giving higher price premium to good quality palay based on such a grading system would upgrade the milling quality (FAO/NFA, 1986).

The NFA parboiled rice project should be reviewed. Improvement of traditional processed rice foods should be undertaken by government agencies such as NIST and by universities' food science departments. Cooked cereals may be improved nutritionally by incubation and culture of microorganisms providing high lysine protein such as in the case of *tempeh*.

Conclusions and Recommendations

Improvements in rice production had been concentrated in the irrigated areas and the relatively resource-rich farmers. With the universal concern and challenge for the resource-poor farmers to produce and earn more to achieve self-sufficiency in the cereals, rice and corn breeders are improving yield potential for adverse environments in addition to pest and disease resistance. Since these areas represent very diverse fertility environments, packages of technology have to be tailored to specific locations. Soil surveys of the whole country have to be completed. Technology transfer methods involving farmer participation such as the farmer-first-and-last model, should be evaluated. The model fits the diverse and complex conditions and needs of resource-poor farmers and makes more growing and cost-effective use of scarce scientists than existing methods (Chambers and Jiggins, 1986). Farmers should be assured of seed supply, guaranteed farm price of rice and corn, subsidized fertilizer and pesticide prices, and adequate credit at reasonable interest rates.

Postharvest operations, particularly the drying operation, should insure the maintenance of processing and nutritive qualities of rice and corn. Upgrading of grain quality has the required technology but lacks the economic or price incentive by the government. Breeding for improved milling and eating qualities for rice and corn would also insure food conservation and acceptability by consumers. Amylose content of 18-22% in milled rice seems to be preferred by Filipino con-

sumers based on various studies, but the preferred range is not known for white corn. The incidence of aflatoxin should be studied and measures undertaken to minimize its occurrence by proper drying. Because of the competitive nature of world rice trade, the export potential of the Philippines is bleak.

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Appendix Table 1. Rice yield, production and area harvested by region, Philippines, 1971-1984 BAEcon data (cited by Gonzales *et al*, 1985)

Rerion	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*
Yield (mt/ha)														
PHILIPPINES	1.70	1.57	1.42	1.63	1.73	1.73	1.90	1.97	2.11	2.16	2.23	2.36	2.39	2.50
Region I	2.03	1.55	1.34	1.53	1.25	1.69	1.64	1.81	2.02	2.08	1.83	2.21	2.48	2.22
Region II	1.82	1.72	1.61	1.84	1.90	1.84	2.10	1.94	2.017	2.14	2.14	2.32	2.40	2.43
Region III	2.26	1.67	1.74	2.17	2.00	2.15	3.32	2.87	3.08	2.80	2.87	3.30	3.41	0.47
Region IV	1.65	1.41	1.43	1.59	1.62	1.67	1.79	1.90	1.95	1.82	1.91	1.93	2.13	2.29
Region V	1.27	1.99	1.43	1.61	2.80	1.82	1.97	2.09	2.13	2.07	2.04	2.07	1.99	2.15
Region VI	1.55	1.45	1.40	1.58	1.58	1.71	1.89	1.83	2.03	2.12	2.29	2.32	2.06	2.68
Region VII	1.12	1.13	1.24	1.50	1.35	1.43	1.51	1.64	0.94	1.50	1.52	1.28	1.42	1.59
Region VIII	1.31	1.19	1.12	1.26	1.19	1.25	1.29	1.36	2.39	1.64	1.82	1.79	1.50	1.98
Region IX	1.29	1.18	1.32	1.10	1.91	2.10	2.22	2.64	2.83	2.57	2.13	2.24	2.17	2.44
Region X	1.60	1.46	0.95	1.20	1.28	1.35	1.27	1.46	1.64	2.06	2.47	2.45	2.50	2.65
Region XI	1.60	1.85	1.43	1.46	1.57	1.63	1.88	2.37	2.50	2.71	2.63	2.65	2.62	3.10
Region XII	–	–	–	–	–	–	1.34	1.46	1.61	2.04	2.72	2.64	2.59	2.87
Production (mt)														
PHILIPPINES	5,342,915	5,100,085	4,416,430	5,555,555	6,047,995	6,159,475	6,450,075	6,894,925	7,514,785	7,845,770	7,722,750	8,107,875	7,730,525	7,840,935
Region I	653,350	651,960	430,190	590,200	422,000	577,460	511,040	575,820	666,800	666,820	630,080	795,015	853,720	726,445
Region II	700,500	678,200	577,630	668,835	712,625	741,090	812,880	602,075	885,110	812,640	737,870	838,235	932,350	741,710
Region III	1,012,605	661,390	765,595	1,097,855	1,003,275	957,275	1,035,530	1,188,340	1,262,015	1,207,650	1,346,930	1,599,865	1,688,025	1,188,255
Region IV	667,170	595,505	620,345	709,755	724,475	770,395	819,690	836,640	849,860	804,045	774,180	740,720	796,365	861,585
Region V	377,840	545,020	437,650	547,555	971,955	614,980	658,315	629,225	625,175	682,590	629,385	625,790	545,900	654,185
Region VI	607,285	576,400	520,380	662,510	691,375	768,330	894,825	820,960	977,000	1,166,415	1,204,880	1,153,745	948,590	1,192,565
Region VII	196,715	108,415	87,290	119,280	114,140	128,255	132,430	129,980	131,195	171,855	239,820	167,585	121,555	157,715
Region VIII	256,185	221,900	181,900	203,975	216,350	227,160	233,275	235,620	266,040	291,815	337,205	305,685	288,170	378,280
Region IX	151,680	149,855	168,410	151,590	262,580	294,360	319.375	377,780	427,930	379,120	296,875	322,720	262,980	328,720
Region X	340,655	338,215	237,520	328,810	376,275	425,655	200,250	235,820	277,380	264,695	321,225	350,585	277,960	305,335
Region XI	468,930	575,625	371,520	477,190	552,945	614,515	310,595	385,530	454,330	572,690	489,695	512,405	458,555	577,245
Region XII	–	–	–	–	–	–	527,870	677,135	691,950	825,435	714,605	695,325	555,355	718,895
Area (ha)														
PHILIPPINES	3,136,750	3,255,730	3,110,400	3,408,570	3,498,380	3,563,600	3,402,170	3,508,860	3,560,680	3,636,810	3,459,130	3,432,830	3,239,630	3,140,670
Region I	321,310	421,460	322,140	351,370	338,660	342,590	310,770	317,690	329,990	321,210	343,460	359,190	344,520	326,570
Region II	385,320	393,300	357,950	364,340	374,190	402,980	386,360	413,790	427,110	379,720	344,870	360,870	389,360	305,140
Region III	447,560	395,180	451,310	506,550	500,640	464,720	312,210	413,540	410,160	431,240	469,440	485,340	494,900	400,904
Region IV	405,260	423,220	432,440	446,250	447,040	461,080	457,120	439,330	436,490	441,500	405,370	383,010	374,610	375,920
Region V	298,480	273,560	305,980	340,530	347,780	338,590	334,410	301,280	293,600	329,420	307,930	301,750	275,060	304,050
Region VI	364,770	398,460	370,560	419,560	438,910	448,730	474,170	447,840	480,750	548,760	527,080	497,370	460,920	444,930
Region VII	95,540	96,050	70,150	96,620	84,820	89,600	88,000	79,250	140,250	114,810	157,630	130,630	85,720	105,270
Region VIII	194,980	186,730	162,180	162,030	182,040	181,200	180,530	172,930	111,530	178,340	185,820	171,140	192,170	191,210
Region IX	117,590	126,790	126,540	137,980	137,430	140,290	143,610	143,040	150,980	147,570	139,440	144,020	121,310	134,800
Region X	212,960	229,860	251,200	272,790	294,050	316,170	157,810	161,220	168,640	128,370	129,950	142,920	111,300	115,020
Region XI	292,980	311,120	259,950	327,550	352,820	377,650	164,700	162,720	181,560	211,020	185,920	193,050	175,020	186,240
Region XII	–	–	–	–	–	–	392,480	456,230	429,620	404,850	282,220	262,540	214,740	250,620

Appendix Table 2. Corn yield, production and area harvested by region, Philippines, 1971-1984 BAEcon data (cited by Gonzales *et al.*, 1985)

Region	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*
Yield (mt/ha)														
PHILIPPINES	0.83	0.82	0.78	0.83	0.84	0.81	0.86	0.89	0.95	0.98	0.98	0.98	0.99	1.02
Region I	0.45	0.68	0.56	0.55	0.50	0.50	0.56	0.63	0.69	0.76	0.76	0.83	0.94	0.90
Region II	0.94	0.94	0.77	0.80	0.80	0.83	0.82	0.92	1.00	1.01	0.72	0.85	0.83	0.87
Region III	0.68	0.75	0.66	0.58	0.66	0.64	0.70	0.71	0.84	0.81	0.62	0.80	0.74	0.66
Region IV	0.95	0.82	0.98	0.82	0.83	0.87	0.99	1.20	1.17	1.32	1.22	0.91	0.95	0.85
Region V	0.71	0.59	0.59	0.67	0.62	0.62	0.61	0.65	0.70	0.68	0.60	0.61	0.63	0.73
Region VI	0.64	0.57	0.56	0.61	0.64	0.59	0.64	0.67	0.74	0.53	0.54	0.64	0.66	0.73
Region VII	0.55	0.51	0.49	0.53	0.50	0.51	0.50	0.50	0.50	0.50	0.48	0.49	0.53	0.57
Region VIII	0.86	0.79	0.75	0.72	0.70	0.75	0.81	0.85	0.88	0.96	1.01	1.07	0.95	1.01
Region IX	0.72	0.58	0.57	0.63	0.61	0.64	0.88	0.70	0.77	0.73	0.67	0.68	0.73	0.76
Region X	0.56	0.61	0.58	0.52	0.48	0.52	0.52	0.57	0.60	0.80	0.80	0.92	0.90	1.08
Region XI	1.19	1.19	1.22	1.24	1.24	1.26	1.26	1.27	1.39	1.36	1.34	1.34	1.38	1.38
Region XII	0.98	1.18	1.01	1.24	1.25	1.10	1.05	1.00	1.07	1.11	1.27	1.35	1.38	1.42
Production (mt)														
PHILIPPINES	2,011,850	2,204,223	1,842,823	2,257,533	2,513,865	2,572,303	2,774,770	2,796,805	3,090,255	3,122,790	3,109,685	3,290,175	3,125,885	3,346,235
Region I	21,525	42,255	27,769	34,759	31,475	21,620	25,575	28,355	33,245	41,065	41,790	51,410	60,265	63,905
Region II	224,660	252,983	216,326	252,567	277,010	292,635	286,015	309,610	330,030	325,045	206,965	252,405	257,375	257,070
Region III	5,780	6,050	4,950	4,575	4,160	3,905	3,680	4,210	6,350	6,945	5,055	6,390	5,605	6,105
Region IV	164,520	133,870	188,921	194,239	204,115	241,950	291,735	274,810	283,665	315,925	309,085	246,725	257,610	202,510
Region V	70,680	70,543	79,424	101,654	96,730	97,320	95,135	101,700	111,320	111,765	108,045	99,855	97,780	124,315
Region VI	45,470	35,425	36,295	40,595	46,475	43,540	48,050	48,490	47,755	36,330	39,345	46,985	39,395	51,440
Region VII	196,370	180,935	174,574	219,706	223,380	244,050	241,435	252,605	248,925	241,135	223,795	241,045	245,395	282,445
Region VIII	83,360	74,151	78,609	96,951	98,765	107,145	120,935	124,000	135,940	161,190	189,780	219,135	190,315	201,360
Region IX	137,795	149,751	108,676	126,016	122,750	134,865	142,805	146,775	171,505	163,880	179,600	186,985	195,065	212,895
Region X	188,995	194,110	177,640	164,815	155,485	16,113	165,360	184,800	187,865	239,300	212,820	213,960	183,550	232,850
Region XI	461,700	495,545	449,394	599,210	770,905	895,485	910,665	910,400	1,040,375	993,995	1,001,665	1,067,930	1,038,790	1,052,540
Region XII	410,995	388,605	300,245	422,446	482,515	473,675	443,380	410,330	493,280	486,215	591,740	657,360	554,740	658,800
Area (ha)														
PHILIPPINES	242,950	2,454,270	2,350,600	2,726,390	3,009,910	3,193,160	3,242,720	3,158,070	3,252,430	3,201,072	3,238,690	3,360,700	3,157,480	3,270,210
Region I	47,540	61,970	49,500	62,750	63,070	43,380	45,880	45,170	47,900	54,030	54,620	61,850	64,180	71,420
Region II	238,500	268,330	279,470	315,620	345,950	351,780	349,670	337,240	330,420	322,640	289,320	297,470	310,830	294,800
Region III	8,500	8,070	7,230	7,890	6,350	6,100	5,220	5,890	7,560	8,580	8,210	7,950	7,620	9,290
Region IV	172,350	164,040	193,560	236,170	246,530	279,370	295,000	228,820	242,570	238,720	254,040	271,280	272,040	239,220
REgion V	99,400	120,270	134,190	150,920	155,560	155,780	156,270	156,410	160,040	163,680	179,040	164,210	155,160	169,940
Region VI	71,050	62,150	64,810	66,550	72,620	73,180	74,500	71,840	64,970	68,030	73,610	73,900	59,580	70,780
Region VII	354,750	355,320	354,730	415,560	447,630	475,730	484,560	504,030	499,130	485,732	470,870	487,860	463,100	492,600
Region VIII	96,850	93,940	104,130	133,930	140,340	142,980	149,930	145,220	154,680	167,380	187,840	204,020	200,890	198,760
Region IX	190,030	259,610	190,750	199,320	201,990	211,140	209,860	210,230	222,250	224,270	266,420	275,570	266,180	279,590
Region X	337,490	313630	306,280	313,930	323,930	309,870	318,000	324,210	313,110	298,500	241,340	232,560	204,580	218,560
Region XI	388,830	416,210	368,590	483,560	619,250	713,380	730,580	717,900	747,630	732,360	748,650	798,240	750,120	764,420
Region XII	420,660	328,730	297,360	340,190	386,690	430,470	423,250	411,110	462,170	437,170	464,730	485,790	403,200	462,830