POTENTIAL FOR CASSAVA BREEDING IN ASIA

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Ten years of research on cassava at CIAT confirms that cassava is a a highly efficient calorie producing crop, especially under sub-optimal or marginal conditions of the tropics where very few other crops maintain productivity. The CIAT cassava program has developed new technology that gives high and stable yields on farms. Advanced hybrid clones can double the yield of traditional cultivars even without modifying farmers' cultural practices significantly. When the best adapted hybrid clone is grown with adequate cultural practices, tripling the current farm yield is not an overly difficult task under a variety of environmental conditions.

Yet, through our agonizing effort to bring new technology to production fields, we have learned that social and economic factors now far outweigh the biological potential of technology for the success of research and extension programs in this particular crop. Social and economic factors include government policy toward low income and disadvantaged people, the capacity of research institutions, as well as marketing structure and processing and consumption patterns. This is especially true when cassava is consumed as a fresh root for human food, and the scope of new cassava technology to disseminate rapidly for human food is dim in the Latin American continent, unless major changes occur in the attitude of governments towards cassava.

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1 The paper has benefited from the input of J.K. Lynam in the market overview of the various countries.

We view more potential for increasing cassava production through breeding in Asian countries, not only because much more cassava is produced in Asia (Table 1, nearly 40% of total world cassava production) than in Latin America but also because national research institutions are generally stronger and cassava is a vital portion of the national or local agricultural economy in many parts of Asia.

I. National Cassava Breeding Programs and their Background

Thailand

Thailand produces between 12 and 17 million tons of fresh roots on about 1.2 million hectares with an average yield between 10 and 14 ton/ha (Yield data from FAO 1981 seems to be overly inflated). This product is converted into chips, pellets, and starch principally for exportation. Most of the production takes place on small farms in northeastern Thailand where cassava is the only source of cash income for hundreds of thousands of resource-poor farmers. Total exports in 1981 were 6.7 million tons of dried product mainly to the European Economic Community, where cassava pellets enter at a favorable tariff compared to grains. The present policy of the EEC is to restrict import to 5 million tons per year at the favorable tariff rate. Cassava is not at present competitive with maize or sorghum at world market prices. The dramatic past growth in production took place almost entirely through expansion of area planted rather than through improvement in yield per unit area. Thus all the Thai officials agree that the era of unrestricted area expansion has ended and research effort should be directed to increasing productivity so that cassava can effectively compete directly with other basic energy sources.

The Thai research program, Department of Agriculture, is one of the strongest national programs in the world, covering all aspects of cassava production with a strong emphasis on breeding. CIAT participation with Thailand began in 1975, both in training researchers and sending germplasm materials. Virtually all the key researchers have been trained in CIAT and their network of breeding, cultural practice, and regional trials and on-farm evaluation is impressive. The local cultivar Rayong 1, selected from local germplasm, is highly venerable and widely grown. Only recently with the incorporation of CIAT germplasm in the crosses are new materials superior to Rayong 1 coming out.

Philippines

The best estimates suggest that the Philippines produces about 0.4 million tons of cassava with an average yield between 4 and 5 ton/ha. A recent economic survey found that small farmers were the major producer of the crop and they consumed about 48% of the production as food within the family, 15% for animal feed within the family, and sold 37% outside. The mayor current markets for cassava are fresh for human food and roots for the production of starch. Starch is principally produced on large estates in Mindinao. Both fresh human consumption and cassava starch production have been relatively stagnant through the 1970's. Although the total starch market has been growing rapidly, this has been filled by domestic production of maize starch. Any growth prospects for cassava lie in the animal feed market. Mixed feed production has been growing at 12% a year through the 1970's, with most of the feed going to poultry. Domestic maize production has not grown fast enough to keep pace with demand, requiring imports of 350 thousand tons in 1980 or 10% of maize requirements. The ability for cassava to compete in this market will depend or raising the current low level of cassava yields and in developing inexpensive drying technologies.

The Philippines Root Crop Research and Training Center (PRCRTC), Visayas State College of Agriculture (VISCA), Leyte has been officially decreed by the President of the Republic and the Philippines Council for Agriculture and Research (PCARR) as the national center for root crop research and training. This program is relatively new and personnel have limited experience in cassava research. The program includes all aspects of cassava production and utilization. The breeding section has now established a basic work program including local germplasm evaluation and yield trials. Active evaluation of CIAT hybrid seed materials started in 1982. There is a movement to set up standard regional trials with participation by PRCRTC, Institute of Plant Breeding, University of Philippines at Los Baños (IPB, UPLB), and Bureau of Plant Industry (BPI).

In the past, the CIAT cassava program worked through the South Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) at Los Baños, IPB at UPLB, and PRCRTC. Partly because of our direct commitment with SEARCA, initially easy approach to UPLB and relatively slow initial progress in cassava breeding at PRCRTC, we failed to give due importance to PRCRTC. However, now CIAT fully recognizes PRCRTC as the only centralized cassava research and training organization in the Philippines and primary importance will be given to PRCRTC in material and information exchange.

China

Official estimates put cassava area in China at around 350 thousand hectares. In addition, the unofficial plantings of cassava used for feeding swine in private holdings seem to account for a considerable additional area. Cassava is utilized (1) for human consumption (2) as animal feed in collective (official) swine production, (3) as animal feed in non-official swine production, (4) for starch production from cassava grown under intensive agriculture, and (5) for starch production from cassava grown in marginal areas. Breeding potential seems to be particularly high for (2) and (3). For (4) and (5), breeding may have a decisive impact depending upon official policy.

The South China Academy of Tropical Crop Research (SCATCR), Bureau of State Farm and Land Reclamation, Ministry of Agriculture, located on Hainan Island, is the only institution in which cassava research of practical significance is undertaken at present. Its breeding program is modest but contains all the basic field activities, including a local germplasm collection, hybridization and stages in yield evaluation. Extension schemes seem to be exceptionally sound through commune and state farm systems. Thus, once a relevant technology is developed and officially recognized, technology transfer will not be a problem.

Malaysia

This country is devoting some 16 thousand hectares to cassava production. Most of the product is used for starch production principally for export. At the Malaysian Agricultural Research and Development Institute (MARDI), a former CIAT training participant has developed as well-organized breeding program. MARDI depends on annual importation of F_1 seeds from CIAT to obtain material for selection. Some of the selections thus made have shown promising results.

Indonesia

Indonesia produced 13.7 million tons of cassava in 1980. Cassava ranks as the second most important food crop after rice. Cassava is consumed in many forms but the most important is in the form of fresh roots or as a dried product called gaplek. Per capita consumption levels average 45 kg per capita with cassava serving a particularly critical role in the diets of the rural poor.

While food markets are important, the largest market for cassava in Indonesia is for starch. While some of this starch is used for industrial purposes, most goes into human food uses, a market which still has substantial growth capacity, particularly if Indonesia moves into the production of fructose to replace sugar imports. Finally, Indonesia is a small but consistent exporter of cassava chips and pellets, a market which serves as a surplus vent and which sets a price floor in domestic markets. Cassava markets are well integrated, at least on Java and in nearby Lumpung province in Sumatra.

While market demand is no constraint, potential for expanding cassava production varies. On Java production has increased through increasing yields but yield levels are still relatively low at 9.7 t/ha. On the outer islands cassava production is expanding very rapidly in response to investment in starch and pelleting plants. Yields are relatively high at 11 t/ha but area expansion is the principal means of increasing production, with labor availability being the principal constraint on faster expansion.

Research on cassava in Indonesia has been limited in the past. However, with recent investments in and reorganization of agricultural research in

Indonesia by the World Bank, research on cassava is planned to increase. A breeder in charge of cassava has just returned from graduate study in the U.S. The foundations for building a functional cassava program therefore exist.

India

Indian production of cassava is about 6.0 million tons per year or 360 thousand hectares, with the rather high average yield of 16.7 t/ha. Production is limited to the poorer lands in Southern India not suitable for rice production particularly in Kerala State. Cassava is almost solely used for human food and average annual consumption in Kerala State reach levels of over 100 kg per capita. Since 77% of farmers have less than 0.5 ha of land, population pressure on the land is intense. With the recent increase in planting of tree crops area in cassava has declined and production has declined from 5 to 4 million tons.

The Central Tuber Crops Research Institute has a large research program covering cassava genetics, cytology, breeding and agronomy. Improved agronomy practices have been largely responsible for yield increases in the fifties and sixties. There is a strong demand for higher yielding and good quality cultivars and the extension scheme seems to be sound; hence, there is a solid opportunity for breeding.

India in terms of cassava is a very special case in Asia as it is the only country with African Mosaic disease. The breeding program will have to combine African Mosaic resistance from African germplasm with high yield potential and quality from local and Latin American germplasm.

Vietnam

FAO statistics places cassava acreage in Vietnam at 480 thousand hectares with an average yield of 7.2 t/ha. The government officials put it at about 250 thousand hectares. The product is highly important as human food but the current yield is very low. Research institutions are weak at present and the government is asking scientific help from CIAT.

II. Present Achievement

All the current local cultivars in Asia countries are selections from old, local germplasm which generally consisted of very limited genetic variability. While many of these cultivars are highly successful, such as Rayong 1 in Thailand, South China 205 in China, M-4 in India and Black Twigg in Malaysia, the experiences of local cassava breeders suggest that there is not much scope for quantum yield improvement depending solely on local germplasm.

CIAT started inviting Asian cassava researchers to training at CIAT and sending germplasm materials in 1975. Germplasm exchange, mainly through F_1 hybrid seeds, was modest and sporadic in the early years, but in recent years a large number of seeds from many parents have been selected for local conditions and were sent to stronger national programs (Table 2).

While many of earlier germplasm materials had been lost, at least Thai and Malaysian breeders have made interesting selections out of these materials. One of such selections in the Thai program, CM 305-13 tends to yield higher than Rayong 1 on well fertilized soil (Figure 1). Another selection, CM 407-7, maintains higher starch content than Rayong 1 while its fresh root yield is similar to Rayong 1. These selections tended to yield higher than Rayong 1 on well managed farms (Table 3), however, the yield advantage was not sufficiently large to convince farmers to change their cultivar rapidly. Besides, CM 305-13 is more susceptible to CBB than Rayong 1 and both selections tend to germinate poorly in poorly managed fields, while Rayong 1 seems to be more tolerant to rough treatment. Similar results have been obtained in the Malaysian program also.

Both CM 305-13 and CM 407-7 were selected from a very narrow germplasm base (800 seeds from 16 crosses made in 1974 without much relevant selection of cross parents) and obviously are not capable of causing quantum yield improvement. Yet, they amply indicate usefulness of Latin American germplasm in Asian conditions. More recent CIAT germplasm introduced to Asian programs is expected to give much better selection opportunities because it is greater in quantity and the cross parents are better selected.

One such interesting parent is M Col 1684. M Col 1684 itself and its hybrid clones have been showing extremely high yielding capacity (40~60 t/ha) at Caribia station, which seems to have similar edafo-climatic conditions to Thai and Philippines cassava growing areas. M Col 1684 has been giving high yields at many locations in our regional trial network since 1978 upto date. CM 507-37, one of the M Col 1684 hybrids from 1981 and CM 982-20, another M Col 1684 hybrid from this year,have shown similar high yield and wide adaptability. CM 507-37 also gave highly successful results in on-farm trials at Llanos, Pie de Monte this year.

Recently, the Thai breeders have also become aware of M Col 1684 hybrids. In recently selected hybrid populations at Huai Pong Station, the proportion of M Col 1684 hybrids is high and the result seems to be highly promising (Figure 2). It is not our basic concept to supply limited germplasm to national programs; thus, our seed materials always contain great genetic variability. Yet, the identification of highly promising parents gives hope of quick progress. Besides, the Asian cassava growing environments contain less stress factors than in Latin America; thus, danger of a narrow germplasm base is less and breeding progress is expected to be quicker in Asia. Aside from M Col 1684, other cross parents such as M Col 1468 (CMC 40), and M Bra 12 have been identified as promising and thousands of hybrid seeds have been sent to Asian programs.

Cassava breeding programs in Thailand, China, the Philippines and Malaysia are capable of selecting the best genotypes for their own conditions, though the scope of the programs and their stages of development are different. Recent massive introduction of advanced CIAT germplasm materials seems to give a unique opportunity for quick progress in yield selection as well as giving more resistance to adverse yield factors.

III. Demand Situation for Cassava Product

Our Latin American experience indicates that a superior cassava production technology will not be adopted by farmers unless there is strong demand for the additional production made possible by the new technology. This seems to apply to the Asian cases where cassava is principally consumed as a human food, except in India and Indonesia. Even in Thailand where the great majority of cassava product is exported as animal feed, the demand situation is not quite as rosy, at least for the short term future. Thai cassava exports benefit from the favorable tariff treatment by the EC, but the EC is setting a maximum quota on cassava imports from Thailand. In other Asian situations where cassava is produced for other than human consumption, demand ceases to become a constraint only when cassava can provide cheaper energy than other alternatives.

On the other hand, there is convinving evidence that demand for animal feed in the long run will increase astronomically. During the decade of 1970, meat consumption per capita increased significantly world-wide and this tendency was particularly remarkable in Communist countries, traditionally low meat eating countries such as Japan, and newly rich Arabic countries (Fig. 3). Per capita consumption of pork and chicken is expected to jump substantially toward the year 2000 (Fig. 4). By 2000, the present meat production has to be nearly doubled to the level of 250 million tons. About half the increase in meat consumption will be due to population increase and the other half due to increased incomes and increased per capita consumption (Fig. 5).

As a result of this tendency, importation of cereal grains by the USSR, Arabic countries and Japan increased astronomically during the seventies (Fig. 6). Greater demand for meat production is the major cause for this import increase. A similar increase of cereal importantion occured also in China. Whether or not the imported cereals were for human consumption or animal feed, the message is that China is in desperate need of carbohydrates and this will be even more serious when the Chinese population wants to eat more meat.

In addition, there is a worldwide trend toward increasing production of glucose/fuctose sweetener. Cassava is deemed as one of the ideal raw materials for this production. China alone imported 710 thousand tons of refined sugar in 1980 and need for reducing this import is acute.

These all boil down to the following conclusions:

(1) If the current productivity level is not significantly improved demand for cassava product will not increase and cassava in Asia will not

change its present status of a relatively unimportant crop. In Thailand, cassava production will be nearly totally dependent on the EC's tariff and quota policy.

(2) Demand will become essentially unrestricted if a major improvement in productivity can be made in such a way that cassava can compete with maize, sorghum and sugar cane. Cassava will bring an additional importance to agricultural production in currently less favored lands.

IV. Goal of Cassava Breeding

For any cassava program to be really an exciting undertaking, one must demonstrate that cassava can compete with other crops as a cheap, efficient energy source without economic protection. Our experience with Caribia selection (Table 4), Colombian regional trials (Table 5), and on-farm trials (Fig. 7) amply confirm that is possible. To set a selection target, an economic analysis of on-farm cassava prices at which cassava can compete with other crops without protection is of vital importance.

Taking an example in the Thai situation, we can consider three levels of selection goals (Table 6). The first case is the least ambitious one in which no definite policy for cassava is implemented and little or no increase in demand is expected. The only justification for doing research is that cassava is an important crop hence there has to be a research program but definition of breeding objectives and selection goals have not been defined. While many national cassava programs fall into this category, Thai cassava research program is well beyond this level.

The second level specifies yield, dry matter content and resistance to major diseases and pests as primary breeding objectives with the ultimate selection goal of 30~50% yield increase within experiment stations and 20~30% increase in production fields. While this level of yield improvement may not be enough to change the status of cassava to that of an internationally competitive crop, the higher production efficiency thus obtained will provide the administration with additional alternatives such as releasing land currently endangered by erosion to other use. The Thai breeders at present seem to be aining at this level.

The third level is the most ambitious one in which a revolutionary yield increase by breeding should be the goal. Cassava yields should be such that it can comfortably compete with any other crop as energy source. A 100% yield increase or constant 50 t/ha within the experiment station and a 50% yield increase or constant 25 t/ha in production fields are set as the selection goal, (the final figures depend on the economic situation). Substantial demand increase can be exported, thus providing continued cash income for the poorest farm families in the Northeast.

This may require a radical change in the mentality of many parties involved, yet all the data available suggest it is possible. All that is to be done is to repeat our Caribia, regional trial, and on-farm trial experiences in Huai Pong Station and farms in the Northeast. Once this is demonstrated possible, the situation exists to permit rapid dissemination of technology in Thailand and Asian countries.

Table 1. Cassava production in Asia, 1981.

	Area (million ha)	Yield (fresh, t/ha)	Production (fresh, million t)
Thailand	1.05	17.0	17.9
Indonesia	1.41	9.7	13.7
India	0.35	16.8	5.8
Vietnam	0.48	7.2	3.4
China	0.25	13.1	3.3
Philippines	0.20	11.5	2.3
Malaysia	0.04	10.3	0.4
Asia total	3.87	12.3	47.6

DATA: FAO Year Book, 1982

Table 2. Cassava F_1 hybrid seeds distributed to Asian countries.

Country \ Year	1975	1976	1977	1978	1979	1980	1981	1982	Total
Thailand	900		6170	7720		3050	1400	15350	34590
Philippines	900		950				5100	10250	17200
China								8700	8700
Malaysia	900		1500			2050	1250	4050	9750
Indonesia	900		700						1600
India	900		850						1750
Rep. China (Taiwan)	500							1200	
Total	5000		10170	7720		5100	7750	39550	75290

Table 3. Result of on-farm trials in Thailand

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Province	Farm No.	Starch yield (ton/ha)			
		CM 407-7 (Huey Pong 4)	CM 305-13 (Huey Pong 5)	Rayong 1	Local (Rayong 1 on farm)
Rayong	1	3.30	3.15	3.46	2.26
	2	5.53	6.00	6.31	2.83
	3	6.25	3.78	3.90	2.49
	4	3.25	2.72	3.78	2.14
	5	5.26	6.07	4.74	4.34
	6	8.88	7.29	6.26	5.93
Nakhon Ratchasima	1	7.08	4.61	4.06	3.08
	2	4.76	6.15	4.90	3.46
	3	3.90	2.31	1.40	1.84
Khon Kaen	1	3.46	4.47	2.92	3.15
Total average		5.17	4.66	4.17	3.15

Table 4. Result of yield trial at Caribia - 1981/82-II

Hybrid clones	Root fresh yield (ton/ha)	Root dry matter content (%)	Root dry yield (ton/ha)
CM 1288-17 *	65	33	21.5
CM 976-15 *	58	35	20.3
CM 982-20 *	64	31	19.6
CM 981-8 *	51	36	18.4
CM 1016-3 *	58	31	18.0
CM 1322-2	62	29	17.8
CM 1016-34 *	54	32	17.6
CM 1015-16 *	52	33	17.1
CM 1350-7 *	52	33	16.9
CM 1015-34 *	49	34	16.7
CM 1252-6 *	49	34	16.5
CM 1297-9 *	48	33	16.0
CM 1016-35 *	53	30	16.0
CM 696-1 *	56	28	15.6
CM 1015-42 *	50	31	15.6
CM 1305-3 *	53	30	15.5
CM 1016-4 *	50	31	15.3
CM 962-4 *	49	30	14.9
CM 1014-12 *	47	32	14.8
CM 1286-7	56	26	14.5
<u>Germplasm accession</u>			
M Col 1684	64	32	20.3
M Col 1468 (CMC 40)	43	29	12.5
M Col 22	34	31	10.6
<u>Local cultivar</u>			
Secundina	18	33	5.8
Manteca	14	30	4.2

* Hybrid clone from M Col 22 or M Col 1684

Table 5. Average yield data of promising cassava germplasm accessions and hybrid lines. Summary of seven years of trials by CIAT regional trial and varietal improvement sections at 12 Colombian locations.

Genotype		Fresh Root Yield (t/ha/yr)	Root Dry Matter Content (%)	Dry Root Yield (t/ha/yr)
Germplasm Accession				
M Col 22	(47) 1/	22	34	7.4
M Col 1468 or CMC 40	(55)	28	30	8.4
M Col 1684	(55)	30	31	9.3
M Ven 218	(28)	25	33	8.2
Hybrid Line				
CM 91-3	(25)	29	34	9.8
CM 321-188	(24)	33	35	11.4
CM 342-55	(22)	32	29	9.2
CM 342-170	(21)	29	33	9.4
CM 489-1	(23)	35	29	10.3
CM 507-37	(20)	28	31	8.8
CM 523-7	(20)	23	37	8.4
Local Control	(79)	17	33	5.7

1/ Figures in parenthesis indicate number of trials in which each genotype has been tested.

SOURCE: CIAT. 1981. Cassava Program 1981 Annual Report. Cali, Colombia.

Table 6. Possible cassava breeding objectives in Thailand.

Situation	Demand for cassava product	Policy for cassava production	Breeding objective	Selection goal
I	No increase	No policy	Anything that can be done.	Any progress
II	No increase	Reorientation toward more efficient production within the present economic structure.	Yield, dry matter content, CBB resistance.	30~50% yield increase in experiment station; 20~30% yield increase in production fields.
III	Substantial increase	Cassava being highly competitive as an energy source without tariff protection.	Dry matter yield, yield stability.	100% yield increase in experiment station (50 t/ha); 50% yield increase in production fields (25 t/ha).

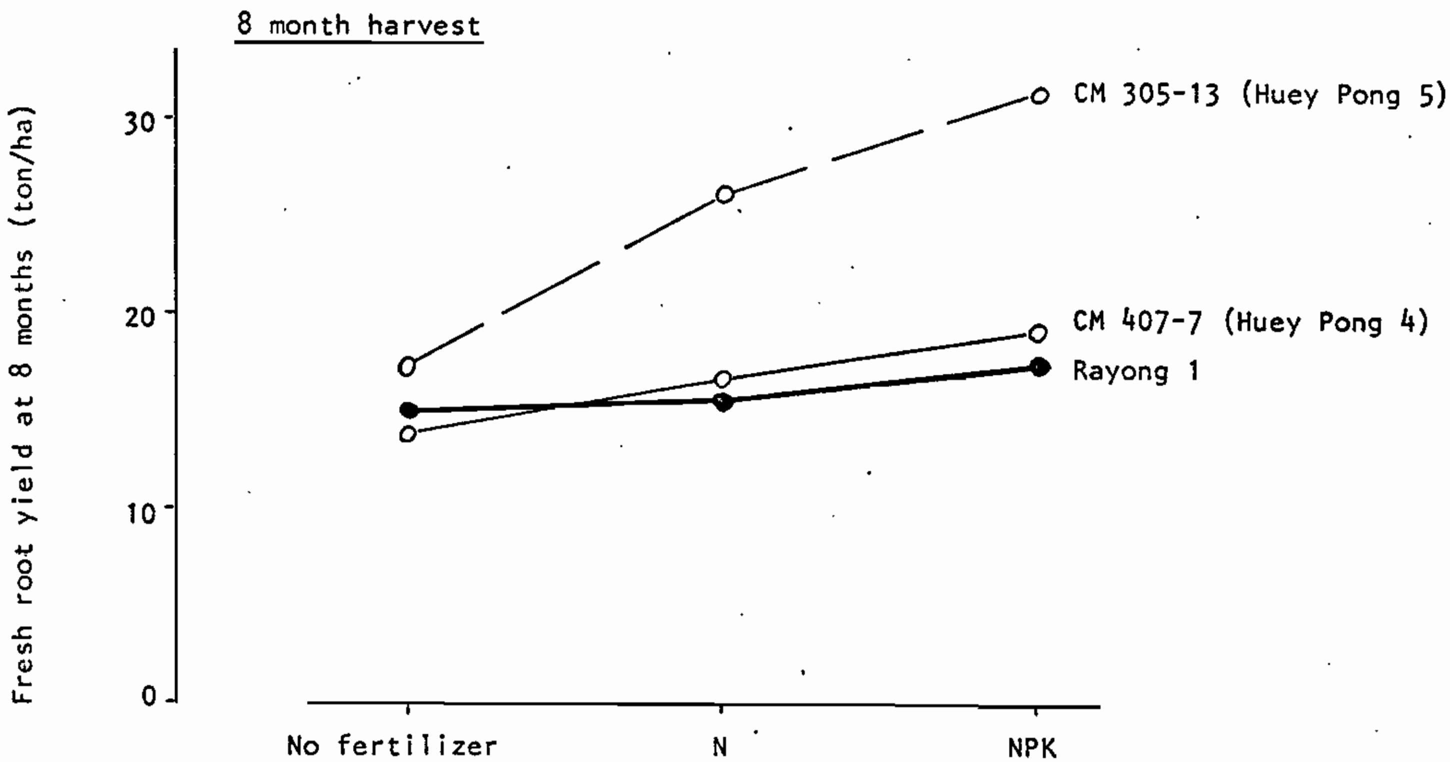

Figure 1. Early harvesting yield of three clones at three different fertilizer levels (Umemura - Huai Pong Station).

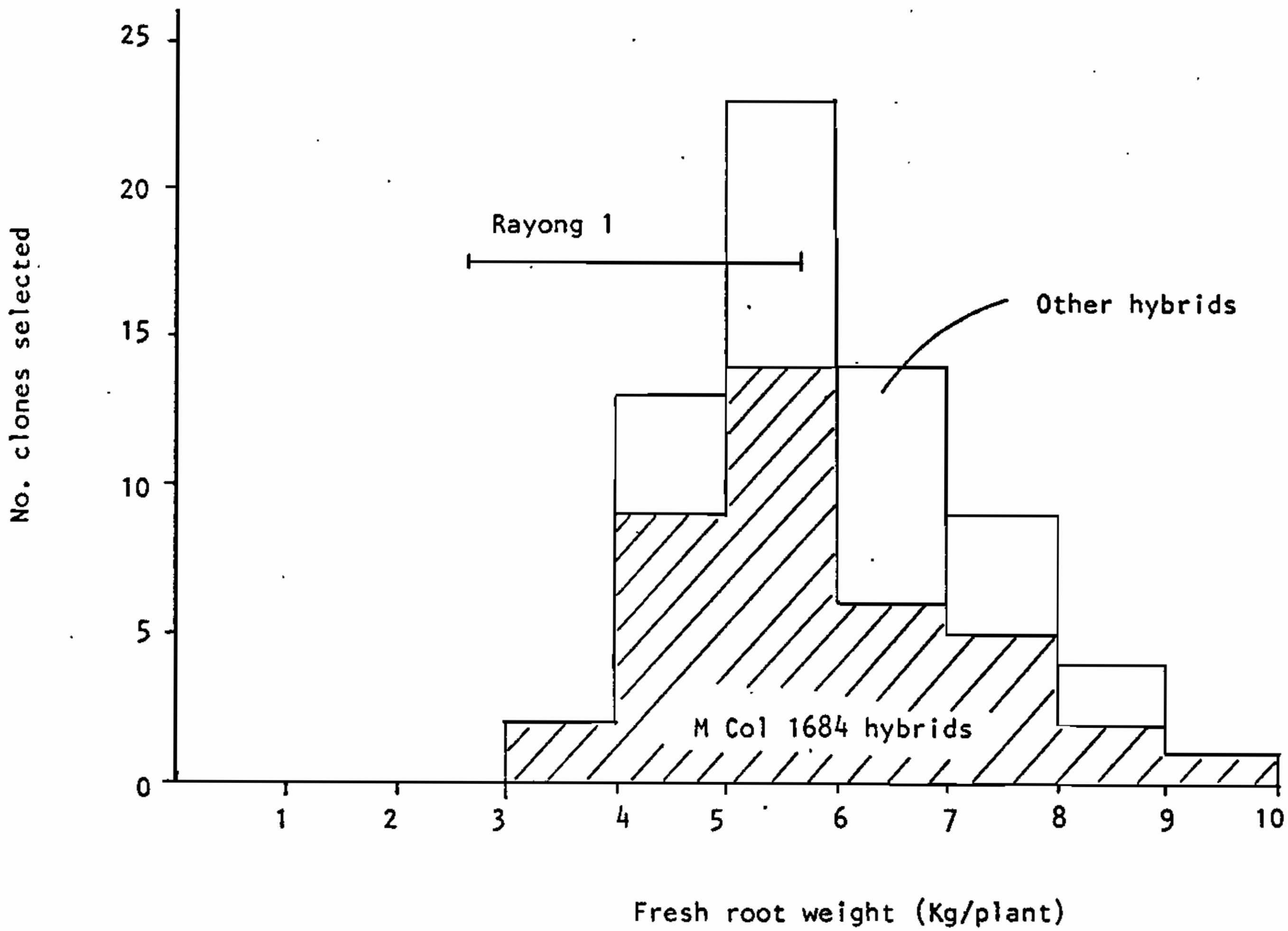

Figure 2. Hybrid clones selected in single-row trial at Huai Pong Station, Thailand 1982 (Data: Huai Pong Field Crop Experiment Station, Dept. Agr. Thailand).

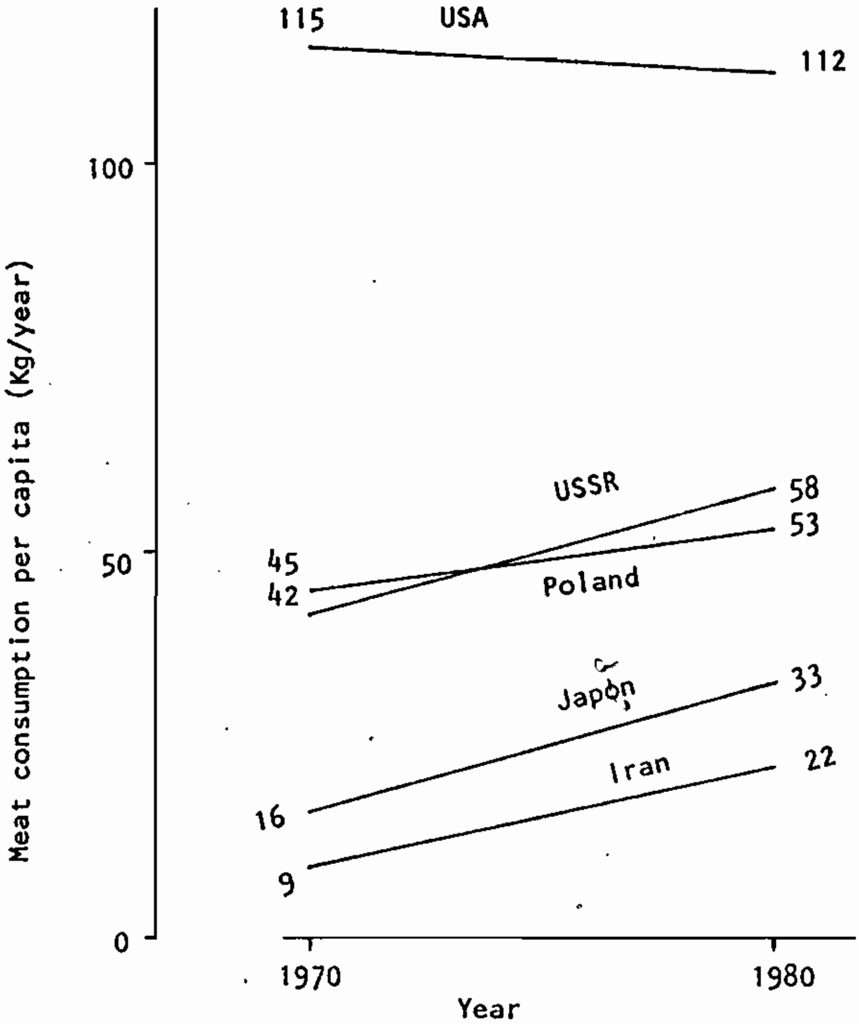

Figure 3. Change in meat consumption in 10 years in different countries.

(Data: FAO year book in Nippon no Joken Vol. 6. Food. NHK publication, Tokyo).

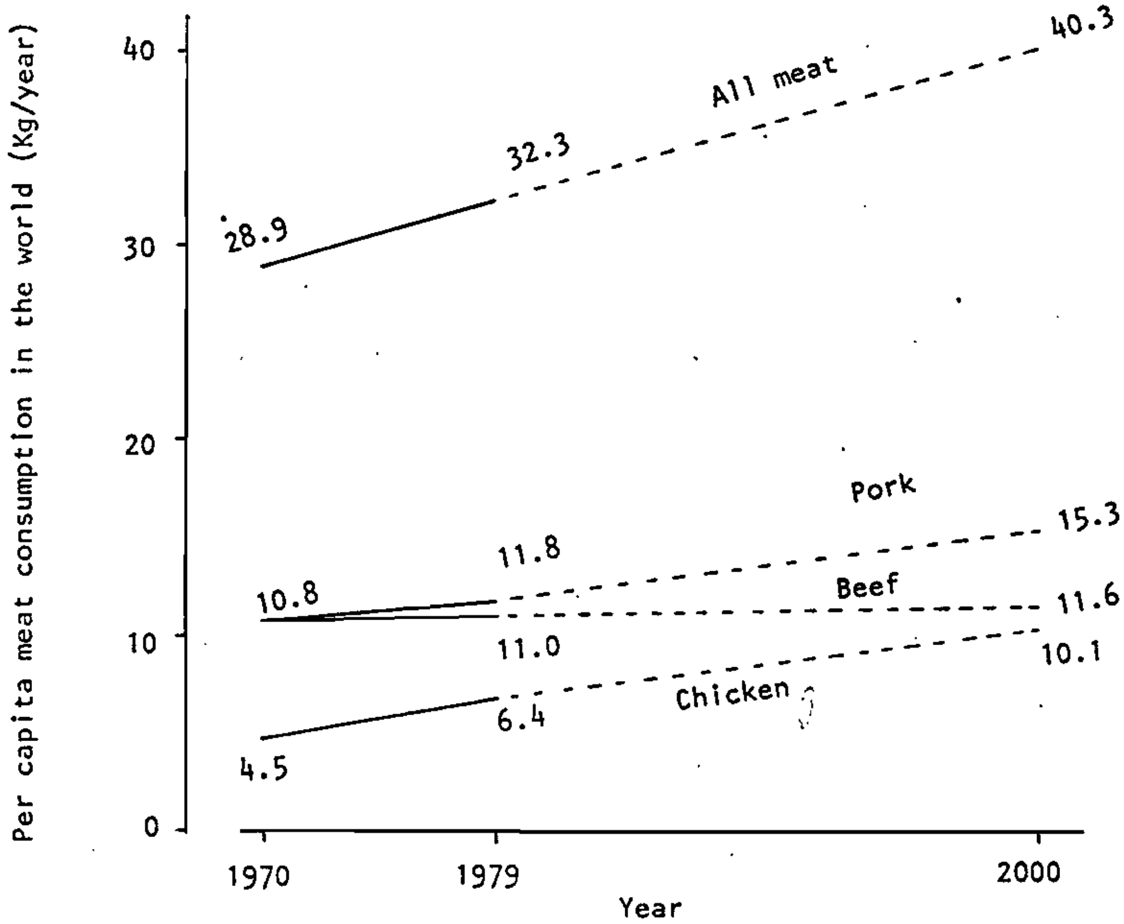

Figure 4. Expected meat consumption per capita in 2000

(Data: Nomura Institute in Nippon no Joken Vol. 6. Food NHK publication, Tokyo).

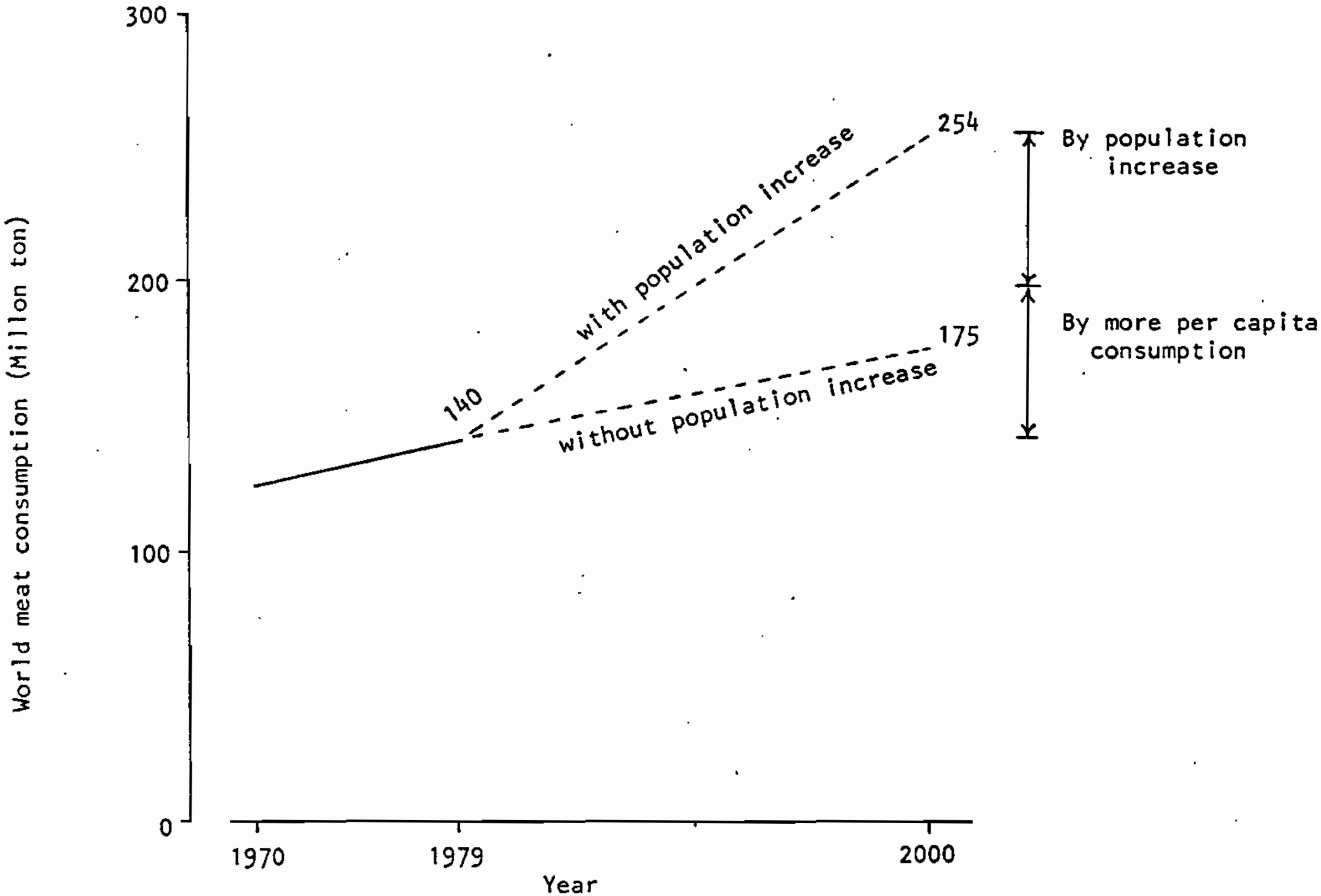

Figure 5. Expected meat consumption in 2000

(DATA: Nomura Institute in Nippon no Joken Vol. 6. Food NHK publication, Tokyo).

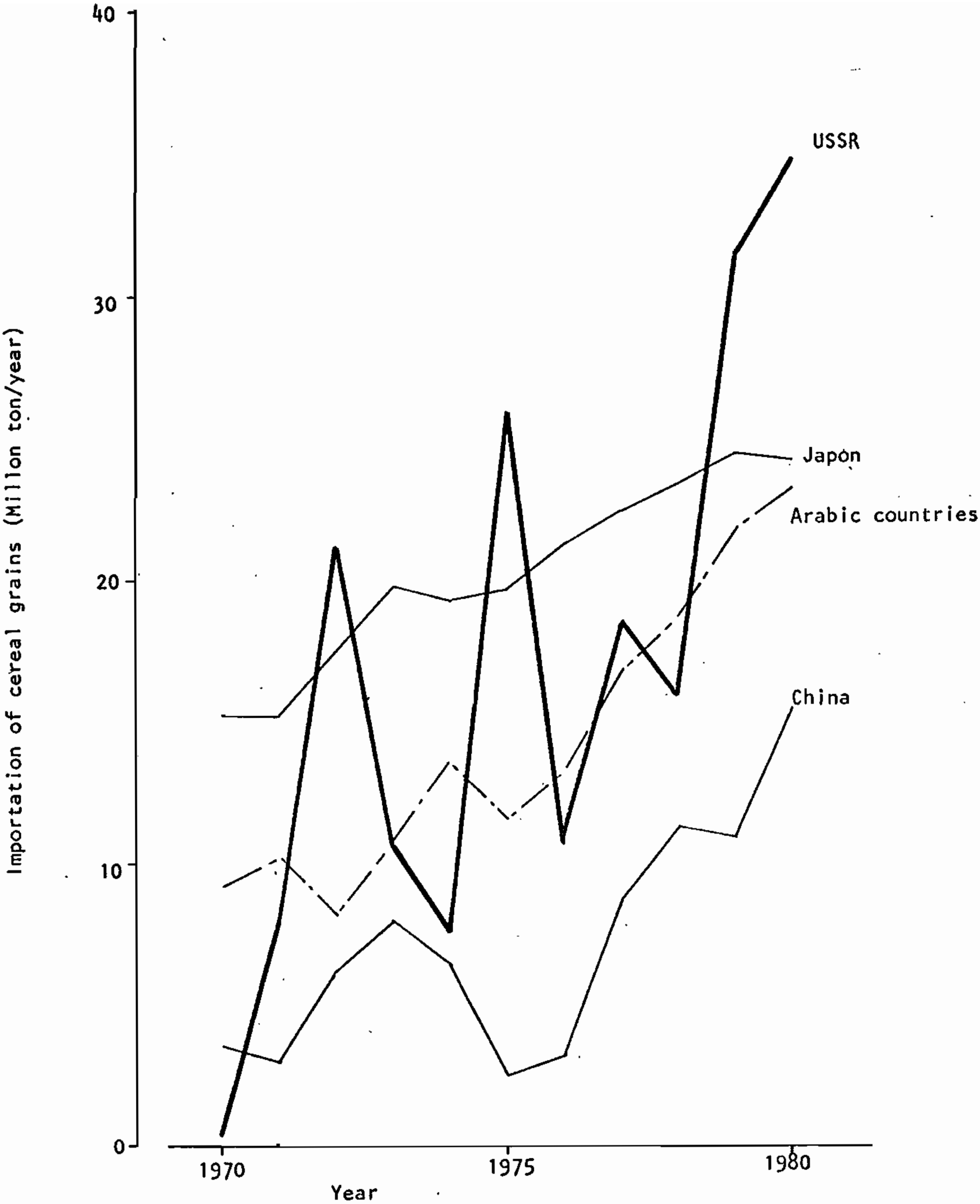

Figure 6. Importation of cereal grains by different countries during 70s.
(DATA: In Nippon no Joken. Vol. 6. Food NHK publication. Tokyo).

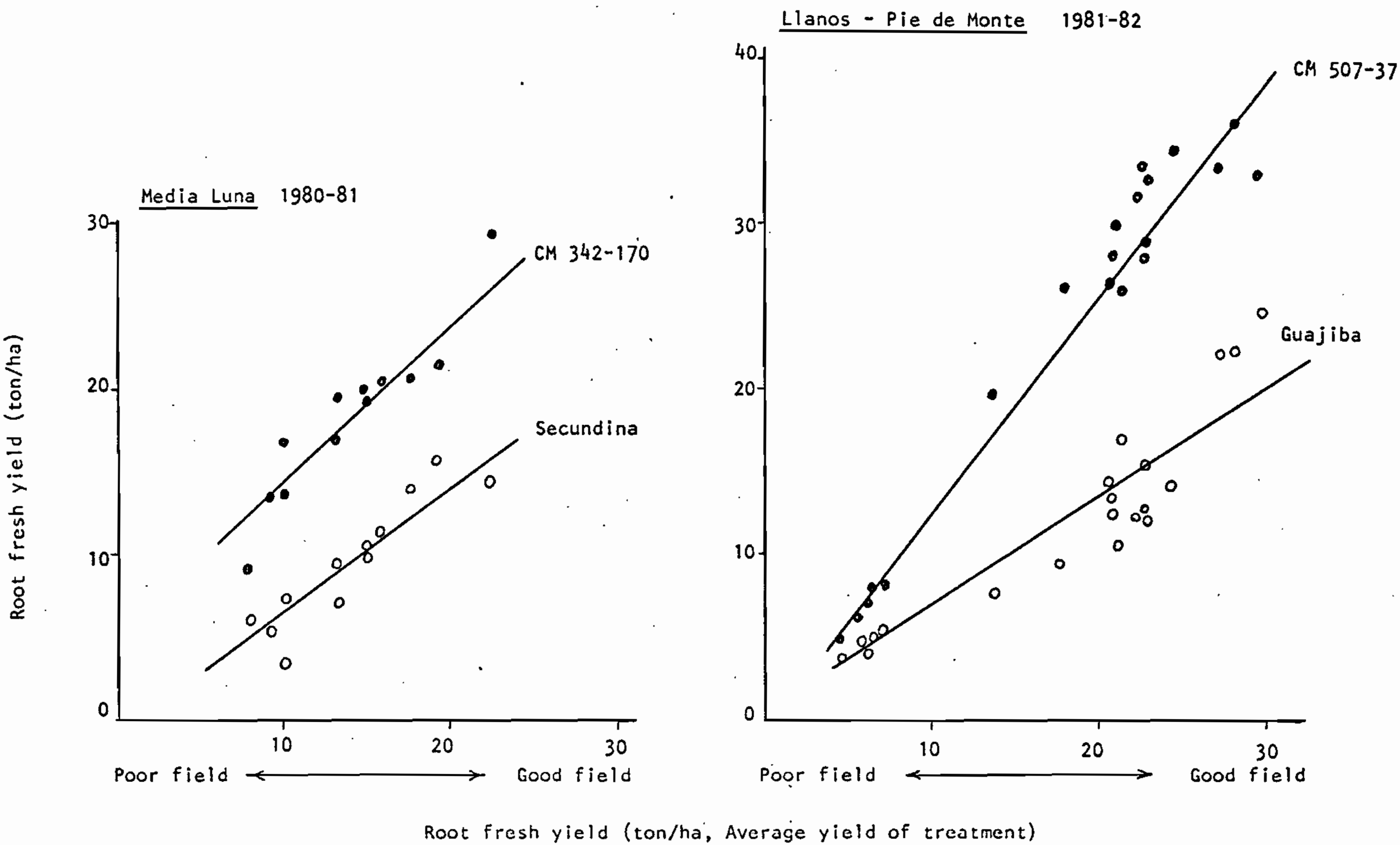

Figure 7. RESULTS OF ON-FARM TRIALS BY ROD-JKL, ECONOMICS SECTION