VEGETABLE PRODUCTION AND GERMPLASM CONSERVATION IN ASIA-PACIFIC REGION

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ABSTRACT

Of the more than 30 tropical vegetables grown in the Asia-Pacific Region, tomatoes, cabbages, eggplant, cucumber, pepper and chillies, onions, beans and potatoes in the Asian part and aroids, sweet potatoes and yams in the Pacific Islands are more important. Vegetable production, excluding roots and tubers, in the Region during 1977-87 increased from 154 million tons to 207 million tons at a growth rate of 3%, against 2.1% in the rest of the world. Per caput production and consumption of vegetables in the Region ranged from 8 kg/year in Bhutan to 225 kg/year in Republic of Korea and for the Region as a whole it was 72 kg against 126 kg for the rest of the world. The average yield of most vegetables in the Region was about half to one-third of that in the rest of the world, and there were wide inter-country yield differences, some countries recording yields as high as anywhere in the world. Thus, there is ample scope for improving vegetable yield and there are great prospects for TCDC (technical cooperation among developing countries).

Due to increased adoption of uniform varieties, displacement of indigenous vegetables by European introductions, and shifting cultivation in several countries, the vegetable genetic resources are eroding fast. Cooperative action is needed for strengthening national efforts for conservation and utilization of genetic resources. FAO attaches high priority to improved production and conservation of vegetables and has several on-going projects at national and regional levels.

Introduction

Of the more than 100 species of vegetables grown, about 30 vegetables are somewhat widely grown in the tropical Asia-Pacific Region. A regional expert consultation on vegetable production organized by FAO in 1986 identified the following vegetables as most common vegetables in Asian countries : tomatoes, cabbages, eggplant, cucumber, pepper and chillies, onions, and beans. In the Pacific Island countries, root vegetables, viz. sweet potato, taro, yam and cassava are staple foods. In several Asian countries, potato is an important vegetable and some of the legumes such as mungbean and soybean are also considered as vegetables.

Total production of vegetables plus watermelons in individual countries of the Asia -Pacific Region, the Region as a whole, the rest of the world and world as a whole during 1977-87 is presented in Table 1. The figures exclude roots and tubers and legumes such as mungbean and soybean. Asia-Pacific Region in this paper refers fo the group of 30 countries which fall within the geographical territory of the FAO's region for Asia and the Pacific. Of these, three countries, namely, Australia, Japan, and New Zealand are developed countries and the remaining 27 countries are developing countries.

It may be seen from Table 1 that with a production of about 207 million tons of vegetables in the Asia-Pacific Region in 1987, the Region accounted for 49.2% of the world's vegetable production. In 1977 the production was 154 million tons and the Region' s share to the world's production was about 47%. In other words, during the decade 1977

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Table 1 Vegetable (incl. melons) total production

Unit : 1000 tons

Country	1977	1984	1985	1986	1987	Average Annual Growth Rate 1977-87
Developing Countries						
1. Bangladesh	1001	1200	1208	1202	1212	2.0%
2. Bhutan	10	5	7	9	11	−2.2%
3. Burma	1782	2052	2068	2151	2188	2.1%
4. China	70884	89805	96130	101613	106678	4.2%
5. Cook Islands	2	2	2	2	2	−1.1%
6. Dem. Kampuchea	450	430	450	460	466	2.7%
7. DPR. Korea	1983	2687	2821	2940	3020	4.5%
8. Fiji	12	10	10	10	10	−1.2%
9. India	38639	45608	47322	48512	48265	2.5%
10. Indonesia	2097	3057	3683	3426	3343	5.3%
11. Iran	3592	4090	4152	4166	4176	1.5%
12. Laos	155	215	226	235	244	4.5%
13. Malaysia	461	475	462	463	466	−0.1%
14. Maldives	15	17	18	18	18	2.4%
15. Mongolia	17	35	41	47	50	10.0%
16. Nepal	220	255	260	265	270	2.1%
17. Pakistan	1753	2573	2575	2748	2739	4.6%
18. Papua New Guinea	235	267	270	278	283	1.9%
19. Philippines	921	807	771	797	809	−2.7%
20. Rep. of Korea	7611	8737	8603	9472	8545	0.3%
21. Samoa	—	1	1	1	1	0.1%
22. Solomon Islands	5	5	5	6	6	1.6%
23. Sri Lanka	506	836	636	876	921	6.5%
24. Thailand	2622	3062	3018	3059	3118	1.6%
25. Tonga	7	7	7	7	7	0.4%
26. Vanuatu	6	7	7	7	8	2.5%
27. Vietnam	2143	3313	3526	3798	3828	6.2%
Sub-total	137295	169247	177471	185869	189950	3.3%
Developed countries						
28. Australia	997	1287	1291	1323	1365	6.0%
29. Japan	15465	15275	15116	15428	15506	0.0%
30. New Zealand	349	444	445	454	476	2.8%
Sub-total	16810	17006	16852	17204	17346	0.3%
Asia-Pacific total	154016	186253	194323	203073	207296	3.0%
Rest of world	173917	209582	211003	211382	213685	2.1%
World	328023	395835	405326	414455	420981	2.5%

-87, with an increase of 53.3 million tons in vegetable production, registering an average annual compound growth rate of 3%, the Asia-Pacific Region performed better than the rest of the world which registered a growth rate of 2.1%.

All 30 countries of the Region produced vegetables. Performance of the individual countries varied considerably. China with its about 107 million tons production of vegetables, accounted for slightly more than half of the Region's production. India, the second largest producer of vegetables, with an annual production of over 48 million tons, accounted for about 23% of the Region's production. Japan was the third largest producer with an annual production of about 15-16 million tons. Bulk of the Region's increase in production occurred due to significant increases in China's (36 million tons) and India's

(10 million tons) vegetable productions, the two jointly accounting for 85% of the increases.

As regards rate of growth of vegetable production in the different countries, 25 countries registered positive growth rates and remaining five countries, namely, Bhutan, Cook Islands, Fiji, Malaysia, and Philippines, registered negative growths. Mongolia, although from a small base (1977) level production, recorded the highest average annual compound growth rate of 10%. Among the larger producers, a growth rate of 4.2% in case of China, from a base level production of about 71 million tons in 1977, could be considered as a fairly high growth rate. India's growth rate of 2.5% was also satisfactory. Besides China and Mongolia, there were seven countries, namely, DPR Korea, Indonesia, Laos, Pakistan, Sri Lanka and Vietnam, among the developing countries, and Australia among the developed countries, which registered average annual growth rates higher than 4%.

It may be out of the scope of this paper to give country-wise production details of all individual vegetables. However, trends of production, yield and area of three major vegetables, namely, cabbages, tomatoes and onions may be summarized. The Region with annual productions of about 15, 8 and 11 million tons of cabbages, tomatoes and dry onions, respectively, accounted correspondingly for 39%, 13% and 42% of the world's productions of these crops. During the decade 1977-87, the rate of growth of cabbages both in the Region and the rest of the world was around 1.5% to 1.6%. In case of tomatoes, in the rest of the world, not only the production was 7.5 times of that in the Region but its production growth rate (3.1%) was also higher than that in the Region (2.4%) In other words, given the present growth rates, the Region's share of the world's tomato production will further decline. As regards dry onions, the Region's growth rate exceeded the rest of the world's growth rate by 1.3 percentage points, and it is hoped that during the next 5 to 7 years, the Region should be able to produce about half of the world's dry onions.

Yields of cabbages, tomatoes and onions (dry) in the Asia-Pacific Region were half to three-fourths of those in the rest of the world. The yield gap of over 12 t/ha in case of tomatoes (Table 2) was rather a serious gap. Moreover, the rates of growth in the rest of the world were higher than those in the Region for all the three crops.

There were remarkable inter-country differences in yield levels. Cabbage yield ranged from 5 to 6 t/ha in Thailand and India to about 60 t/ha in Republic of Korea and 40 t/ha in Japan. Tomato yield ranged from as low as 5 to 7 t/ha in Bangladesh, Fiji, Indonesia, Laos, Malaysia, Papua New Guinea, Sri Lanka, and Thailand to as high as 50 to 60 t/ha in Japan and New Zealand and about 30 to 35 t/ha in Australia and Republic of Korea. As regards dry onions, the yields were as low as 2 to 4 t/ha in Bangladesh, Indonesia, Laos, Maldives, and Vietnam and as high as 36 to 43 t/ha in Republic of Korea, Australia and Japan.

Per caput production of vegetables in the Region as a whole increased from 67 kg in 1975 to 72 kg in 1985 (Table 3). In the developing countries as a whole it increased from 64 kg to 70 kg whereas in the developed countries taken together it decreased from 125 to 122 kg between 1975 and 1985. Per caput vegetable production/consumption (assuming negligible net trade in the Region) in 1985 in the developing countries as a group was 57% of that in the developed countries as a group.

Per caput production/consumption in the individual developing countries varied remarkably. It was lowest, 8 to 14 kg, in Bhutan and Bangladesh and highest, 225 kg and 210 kg in Republic of Korea and Mongolia, respectively. An annual consumption of 125 kg of vegetables per caput is recommended for Asian countries. Considering this standard, only five countries, namely, Republic of Korea, Mongolia, DPR Korea, New Zealand and Japan meet the recommended level of production/consumption. Fourteen countries produced vegetables ranging from 52 kg to 102 kg per caput per year. The remaining 11 countries, namely, Bangladesh, Bhutan, Fiji, Indonesia, Malaysia, Nepal, Pakistan,

Table 2 Average yield (kg/ha) of selected vegetables in 1987 and yield growth rates for the period 1977-87

Country	Cabbage		Tomatoes		Dry onions	
	kg/ha	GR 1977-87	kg/ha	GR 1977-87	kg/ha	GR 1977-87
Developing Countries						
Bangladesh	8714	1.3%	7200	0.2%	4091	−0.6%
Bhutan						
Burma					9912	6.6%
China	16746	2.4%	15244	1.5%	15085	2.3%
Cook Islands			30813	9.9%		
Dem. Kumpuchea						
DPR Korea	12500	−0.6%	14222	0.9%	14333	1.0%
Fiji			7143	0.1%	7500	0.1%
India	5988	0.2%	9512	0.5%	9964	−0.9%
Indonesia	13750	2.6%	4286	−3.0%	4324	0.7%
Iran			8675	−0.2%	17619	3.1%
Laos			6000	8.2%	1731	−0.6%
Malaysia	11111	0.1%	5000	0.1%		
Maldives					2510	0.6%
Mongolia						
Nepal						
Pakistan					11300	0.5%
Papua New Guinea			5295	10.1%		
Philippines	11242	4.5%	8043	0.1%	8501	2.2%
Rep. of Korea	65000	0.0%	35000	4.1%	36364	4.4%
Samoa						
Solomon Islands						
Sri Lanka	17630	10.9%	6939	9.3%	8652	2.2%
Thailand	5324	−0.1%	4527	−0.3%	11413	9.4%
Tonga			20000	−1.0%		
Vanuatu						
Vietnam	21500	−1.1%			2885	0.4%
Sub-total	17539	0.9%	12450	1.0%	10835	1.2%
Developed countries						
Australia	28250	−2.6%	28051	3.0%	37152	3.0%
Japan	40241	0.4%	52229	−0.4%	43003	1.1%
New Zealand	22000	0.1%	64368	0.7%		
Sub-total	39509	0.3%	43644	−0.3%	42209	1.2%
Asia-Pacific total	20033	0.5%	13908	0.4%	12032	1.0%
Rest of world	24712	1.2%	26042	2.0%	16628	1.5%
World	22671	0.9%	23429	1.8%	14316	1.2%

Philippines, Western Samoa, Solomon Islands, and Sri Lanka, produced even less than one-third of the recommended level of vegetable intake.

Major constraints on improved production of vegetables

The constraints on improved production of vegetables may be grouped in three categories : (a) climatological, (b) technological, and (c) socio-economical.

Climatological

Hot and humid habitats, with little difference in day and night temperatures, characterize most vegetable areas in the Asia-Pacific Region. These areas are usually in

Table 3 Per caput per year production of vegetables (including melons) in 1975 and 1985

Country	1975 kg/cap/year	1985 kg/cap/year
Developing Countries		
Bangladesh	14.6	12.7
Bhutan	7.7	7.6
Burma	54.5	52.0
China	83.3	93.2
Cook Islands	111.1	100.0
Dem. Kampuchea	61.3	62.5
DPR Korea	121.1	141.1
Fiji	22.4	23.2
India	55.5	60.0
Indonesia	19.0	15.1
Iran	104.6	91.0
Laos	42.7	53.9
Malaysia	36.0	30.3
Maldives	116.7	102.3
Mongolia	150.0	210.0
Nepal	16.8	16.3
Pakistan	29.7	26.6
Papua New Guinea	83.7	75.0
Philippines	32.9	39.5
Rep. of Korea	173.7	224.6
Samoa, W.	6.6	6.1
Solomon Islands	25.0	24.4
Sri Lanka	17.4	20.8
Thailand	67.6	58.5
Tonga	70.0	64.0
Vanuatu	50.0	51.5
Vietnam	50.2	52.7
Sub-total	63.5	69.7
Developed countries		
Australia	65.7	80.4
Japan	132.3	126.7
New Zealand	106.0	136.7
Sub-total	124.5	121.6
Asia-Pacific total	67.1	72.4

monsoonal zones which are often subject to proverbial uncertainties of rainfall and monsoonal vagaries such as flood, drought, typhoons and hurricanes. Moreover, hot and humid conditions are highly conducive to proliferation of pests, diseases and weeds. Even in temperate countries such as the DPR Korea, temperature in summer months can be as high as 37-38°C with high humidity, which significantly depresses vegetable production.

Technological

1) *Limited number of improved varieties* : Except for major vegetable crops, there is a dearth of suitable high-yielding varieties. Several countries in the Region lack appropriate breeding infrastructure to develop locally-adapted varieties. International institutions such as CIP, CIAT and AVRDC, have been developing promising varieties of tropical vegetables, but their effective adoption and further improvement to fit local agro-ecological conditions, particularly hot and humid areas, are often weak. Introduced varieties succumb sooner to local pests and diseases ; hardly any vegetable varieties are

truly resistant. Further, vegetable breeders are often handicapped due to limited genetic variability in their breeding materials. Moreover, indigenous variability is eroding fast, and if not conserved adequately will be lost forever.

2) *Inadequate supply of quality seed* : In most developing countries, usually not more than 10% to 15% of the total seed belongs to the "quality seed" category. Cost of seed, particularly of locally-developed and imported hybrids, is very high ; for instance, one kg of hybrid tomato seed costs Indian farmers about US$ 800. Costs often are out of bounds for small and resource-poor vegetable growers. Suitable manpower and research support for producing quality seeds are two of the major constraints. It is not uncommon to find unbalanced development of the different components, such as choice of variety, seed production technology, post-harvest handling, and distribution. There is a general lack of synergistic interaction between private and public sector seed production in developing countries. In several countries, particularly the Pacific Island countries, there are no seed acts and regulations. In some countries, even where rules and acts exist, they are not enforced effectively.

3) *Lack of appropriate packages of vegetable production* : Generally lacking are appropriate packages of technologies which encompass appropriate varieties, seeding and seedling management, fertilizer and water management, pest management, and harvest. These are needed for different agro-ecological and socio-economic settings such as rainfed vs irrigated, low-input vs. high-input, and home gardening vs. commercial. Research has often not been integrated, and covers only one or the other component without taking a holistic approach.

4) *Incidence of diseases, pests and weeds* : Given the hot and humid settings of tropical vegetables and considering that the Region is the center of diversity of several of the tropical vegetables, there are a large number of diseases, pests and weeds which constitute the most limiting factors for improved and sustained vegetable production. Severe losses are caused by early and late blights in potato and tomato ; phomopsis and bacterial blights and little leaf in brinjal (eggplant) ; mildews and wilt in cucurbits, fruit rots in chillies, tomato and cucurbits ; bacterial wilt in tomato and brinjal ; fusarium wilt in pea ; purple blotch in onion ; leaf spots and bacterial rot in cole crops ; root rots, stem blight and anthracnose in beans ; Phytophthora blight in Colocasia ; scab in sweet potato ; stem gall in coriander ; and damping off and viral diseases in a number of vegetables. Serious viral diseases include mosaic and leaf roll in potato, mosaic and leaf curl in tomato and chillies, mosaic in beans and cucurbits, and yellow vein mosaic in okra. Nematodes also cause serious losses, as high as 70% in tomato, brinjal, chillies and okra.

5) Vegetables are frequently grown on fertile well-drained soils, irrigated, heavily manured with FYM and compost, or planted at wide spacings. Therefore, the weed menace is more serious than in other crops. Vegetable crop losses due to weeds are governed by several factors, but weed density and spectrum, growing season, and the vegetable crop itself are most important. Generally, summer and kharif vegetables suffer more than winter vegetables directly due to severity of weed infestation.

Further, vegetables are attacked by a host of insect pests, although infestation varies from locality to locality. In winter and summer vegetables in tropical Asia, leaf hoppers, aphids, thrips, stem and fruit borers, leaf miners, defoliators, cutworms, white flies, etc., need continuous attention to prevent their population from reaching economic injury level. To combat veritable insect pests, large quantities of pesticides are used on vegetables. Calendar spraying, especially in commercial vegetable areas, is common. In several countries, viz. Malaysia, India and Thailand, pesticide residues above tolerance limits have been reported. Some major pests such as cabbage worm have shown pesticide resistance. To alleviate the adverse effects of excessive pesticide use, integrated pest management for vegetable crops should receive high priority.

6) *Lack of extension support* : There is an acute shortage of extension staff specifically

trained for scientific production of vegetables. Unlike major food crops, no specific vegetable extension programs transfer research findings to farmers. As an example to highlight this apathy, of the 14,000 extension workers (PPL) and 250 extension specialists (PPS) employed by Indonesia's Director General of Food crops, none has special horticulture training. Moreover, each extension field worker must cover all crops in his duty area, and has very limited time to devote to vegetable crops. As they constitute a major group and each crop has specific and exacting requirements, a separate extension staff for vegetable crops should be provided at the field level.

7) *High post-harvest losses* : It may be underlined that on the average, 25% to 30% of the vegetables produced are lost due to inefficient harvest and post-harvest handling. It is agonizing that due to lack of appropriate post-harvest technologies, the costly pre-harvest investments are often wasted.

8) *Lack of trained manpower* : It may be emphasized that in developing countries, there is a general dearth of suitably trained manpower in almost all disciplines of vegetable production, most particularly in breeding, seed production, pest management, mechanization, and post-harvest handling.

Socio-economic

Main socio-economic constraints are as follows :

1) Limited and inadequate market support and infrastructures, and facilities for transport, processing and storage.

2) Negligible infrastructural support for credit and subsidy, and lack of appropriate price incentive.

3) Inadequate planning for vegetable production distribution and consumption.

4) People generally have indifferent attitudes and lack of awareness about nutritional attributes of vegetables, and ignorance of proper production/cultivation methods.

In order to alleviate the above constraints, multidisciplinary research and development efforts should be made by governments, which has generally been neglected in the past. Further, as mentioned earlier, there are remarkable inter-country differences in vegetable yield. While yields of some of the countries, including developing countries are as high as anywhere else in the world, in majority of the developing countries the yields are very low. Thus there is ample scope for increasing yields and there is good prospect for inter-country technical cooperation in the Region. An FAO RAPA expert consultation had identified following proven technologies in different countries which could be shared under the spirit of TCDC (technical cooperation among developing countries) :

1) Production of processing tomatoes in the Philippines.

2) Production of potatoes under rice-based farming systems in Sri Lanka and the Philippines.

3) Production of garlic in Indonesia.

4) Baby corn production oriented to export in Thailand.

5) Development of hybrid varieties and hybrid seed production in China and India.

6) Plastic film mulching technique in China, DPR Korea and Republic of Korea.

7) Import substitution through indigenous seed production in India, Sri Lanka and Philippines.

8) Integrated Pest Management in vegetables in the Philippines and the Malaysia.

9) Subsidy and other specific supports provided to vegetable growers in Fiji, Malaysia and the Philippines.

10) F_1 hybrid tomato seed production in Thailand and the Philippines for export.

Conservation and utilization of vegetable germplasm

Three of the primary centers of diversity of crop plants, namely, Hindustan center, Indochina-Indonesia center, and China-Japan center, fall within the Asia-Pacific Region.

These centers are the places of origin of a large number of tropical vegetable crops, as given below (IBPGR, 1977) :

eggplant	snake gourd	roselle	Brassicas (including
wax gourd	pigeonpea	drumstick	Chinese cabbage)
loofah	hyacinth bean	winged bean	
cucumber	mungbean	taro	amaranth
watermelon	yard long bean	yam	artichoke
melon	kangkong	*Allium* spp.	water chestnut
bitter gourd	okra	soybean	

Further, matching the impressive agro-ecological diversity in the Region, several of the introduced vegetables such as tomato, pepper and chillies, sweet potato, pumpkin, squash, radish, musk melon, etc. have accumulated equally impressive genetic diversity. But due to high socio-economic and population pressures, the genetic resources are eroding fast. Due to ever-increasing commercial production of vegetables, generally based on a few hybrid varieties, the land races, an eminent reservoir of genes, are being lost rapidly. For instance, in China about half of the Chinese cabbage acreage is under F_1 hybrids. In Republic of Korea, F_1 hybrid seeds constitute more than 90% of the commercial seeds of important vegetables. This trend is not only causing genetic erosion but is also increasing the vulnerability of widely grown varieties to pests and diseases, which is often to be fought through increasing sprays of pesticide "cocktails".

Another major cause of genetic erosion of vegetables is the introduction of European type vegetables in the tropics. Indigenous leafy vegetables are the major casualties of such irrational introductions, while the local types are nutritionally superior and more resistant to biotic and abiotic stresses as compared with the introduced forms. From the above, it is clear that the need for conservation of indigenous variability and its use in broadening the genetic basis can hardly be over-emphasized.

Several of the countries in the Region, through their own resources or/and with external assistance have been making efforts to conserve and utilize vegetable germplasm. China is one of the richest centers of diversity for vegetable germplasm. About 174 botanical varieties in 36 families are grown, of which 31 families are seed plants and five families are fungi. In all, there are 438 botanical varieties. Existing collections of germplasm comprise 16,000 local cultivars. Leafy vegetables, accounting for about 37% of the botanical varieties of vegetables, are most important. Chinese cabbage is most popular with about 1,000 cultivars. Several Chinese cabbage cultivars are very late bolting type, tolerant to summer high temperature and high humidity and some have good resistance to TUMV, TMV and CMV (Chen Hang, 1986).

China has an active vegetable breeding program and has been using the resources judiciously. Between 1980 and 1985, 94 market cultivars of 15 different vegetables were released. Breeding of hybrid varieties is the most important program. Techniques of hybrid seed production have been standardized. Several promising self-incompatible and male sterile lines of Chinese cabbage which in F_1 combinations give high yield, are late bolting and-most important- resistant to TUMV have been developed. Disease-resistant cucumber varieties were also developed.

India, the second largest vegetable-producing country in the Region, also has a wealth of vegetable germplasm and an estimated 10,000 distinct vegetable germplasm accessions are maintained at different centers in the country. Main germplasm repositories are National Bureau of Plant Genetic Resources (NBPGR), Indian Agriculture Research Institute (Division of Vegetables), and Indian Horticultural Research Institute, Hassarghatta, Bangalore. In the 1950s, a large number of indigenous and exotic collections were evaluated and several promising varieties, such as Pusa Ruby in tomato and Pusa Purple long in brinjal which are still popular, were selected. Certain exotic varieties viz. Bonneville, Arkel, Little Marvel, Early Badger, etc. in garden peas ; Sioux, Best of All and Marglobe in tomato ; Contender in French beans ; and Sugar Baby and Ashahi Yamato

in watermelon, emerged as leading commercial varieties not only in India but in other Asian countries also.

In India, in recent years, the introductions are usually used for hybridization and not as straight selections. In tomatoes, Punjab Chhuhara, a variety derived through hybridization, revolutionalized tomato production in Punjab state. Variety S1-120 was the first root-knot nematode-resistant variety (Choudhury, 1988). Arka Vikas and Pusa Gaurav were relatively heat-tolerant and expanded the tomato zone of the country. F_1 hybrids such as Karnataka Hybrid, Mangal, Hybrid 1 and Hybrid 2 are highly heterotic for yield and some of the hybrids are even resistant to bacterial wilt, and some are suitable for processing and have better shelf life. In cauliflower, wide range of conventional varieties, synthetics and hybrids have been developed which are not only high-yielding but have adaptation to wide temperature regimes, 25°C to 40°C, and are resistant to several of the common diseases. Such successes have been attained in brinjal, radish, onions, chillies and several other vegetables.

The Southeast Asian countries, primarily through a regional cooperative network of the International Board for Plant Genetic Resources (IBPGR), operated in a systematic manner for capturing and conserving the resources and fixed the following criteria for prioritizing collections : (1) an assessment of existing collections in the countries, including size, scope and quality ; (2) the degree of importance of the crop, especially in relation to agricultural improvement and development and the desire for collections of germplasm for breeding ; (3) an assessment of those species which show significant diversity in the region ; and (4) an assessment of the germplasm threatened with loss. Based on these criteria the countries assigned collection priorities to individual vegetables and geographical areas. Collections made by IBPGR support during 1977-84 are given in Table 4 (Singh, 1982 ; IBPGR 1984). Part of these collections have been characterized and catalogued.

Some of the South Asian countries such as Bangladesh, Bhutan, Nepal and Pakistan also made vegetable collections through IBPGR assistance (Table 5) (IBPGR, 1984)

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Table 4 Number of accessions of vegetable germplasm collected by IBPGR support in Southeast Asia, 1977-84

Crops	Indonesia	Malaysia	Papua New Guinea	Philippines	Thailand
Vegetables					
Amaranth	75				115
Bitter gourd				72	250
Cabbage				713	7
Eggplant				222	70
Muskmelon				117	
Okra				22	
Onion				71	9
Capsicum spp					
Lyfa				68	
Squash				98	
Tomatoes				416	200
Hyacinth bean					20
Ipomoea aquatica					50
Aibika (*Abelmoschus manihot*)			158		
Winged bean	502	826	252	332	528
Vigna spp. (including *V. radiata*)	1229	22		3762	1329
Roots and tubers					
Sweet potato	446	488	506	584	550
Taro	75	37	143	160	
Amorphophallus spp.	80	23			
Curcuma spp.	277				
Xanthosoma spp.	30				
Dioscorea spp.	150	144	88	23	256

Table 5 IBPGR-supported vegetable collections in some South Asian countries, 1980-80

Country	Number of species	Number of accessions
Bangladesh	4	459
Bhutan	9	83
Nepal	3	11
Pakistan	10	285

IBPGR was held in Tsukuba in October 1980. Using the criteria listed on page 9, the symposium assigned collection priorities to vegetables, including roots, in different Far East and Pacific Island countries (IBPGR, 1981) (Table 6).

It is clear that in the Pacific Islands, aroids, yams, sweet potato, winged bean, and aibika are high priority crops for exploration activities. In the Far East countries, particulary due to high threat of erosion of indigenous variability due to adoption of uniform F_1 hybrids, exploration and collection of Chinese cabbage had the highest priority.

Rating 'A' for all the crops mentioned in Table 6 in the Pacific Islands suggests that high indigenous variability exists in these countries. Several of the taro and sweet potato form flower and set seeds in the sub-region, thus seedlings have been adding to the variability, but variability for some of the important diseases such as *Phytophthora colocasiae* leaf blight in taro and witches' broom disease in sweet potato does not exist in the local materials. In *Dioscorea*, however, which multiplies clonally, the variability is not only high but also contains resistance genes for most of the major diseases including *Colletotrichum* dieback. Accessions maintained by different island countries are given in Table 7.

Because of the high incidence of certain diseases, particularly in case of taro and sweet potato for which effective control measures are not available, it becomes difficult to maintain living field collections. For instance, in Solomon Islands, of the 187 taro accessions only a few promising ones could be saved through tissue culture preservation and the rest succumbed to a lethal virus disease which occurs in Solomon Islands, Similarly, the sweet potato collection in Solomon Islands succumbed to witches' broom disease (WBD) and was abandoned. Thus, *ex situ* conservation of root and tuber germplasm was not only costly but was also fraught with the dangers of elimination due to pest and disease attacks. A regional genebank to serve as a base collection, equipped with full facilities and manpower, may be established to relieve the individual countries

Table 6 Priorities for exploration activities in Far East and Pacific Islands, 1980

Crop	Japan	China	Korea	Pacific Islands
Aroids	3C	-	-	1A
Sweet potato	2C	3C	2C	1A
Winged bean	-	-	-	1A
Red bean	2C	2B	2B	-
Chinese cabbage	1C	1A	1C	-
Yam	3B	-	-	1A
Cucumber	1C	2B	3C	-
Eggplant	2C	2B	3C	-
Tomato	1	1C	2C	-
Aibika	-	-	-	1A

Note : In terms of priorities, 1, 2, 3, respectively, show high, medium, and low national needs and A, B, C, respectively, show high, medium, and low indigenous resources (in terms of germplasm diversity).

Table 7 Number of accessions of different root and tuber crops maintained in Pacific Island countries, 1986

Species	Cook Islands	Fiji	Papua New Guinea	Solomon Islands	Samoa W.	Tonga	Vanuatu
Cassava	8	28		19	12	23	45
Edible aroids							
Alocasia taro	2			4	9		2
Colocasia taro	76	72	136	187	29	14	150
Cyrtosperma taro	1						
Amorphophallus sp.	1						
Xanthosoma taro	3			2	4	8	15
Sweet potato	14	14	506	59	23	41	68
Yam	4		53	90	28		5

of the difficult job. The countries should, however, maintain their working and active collections. The regional as well as the country centers should develop adequate tissue culture facilities for maintenance and exchange of the materials.

Tissue culture is extremely useful for elimination of viruses, rapid multiplication of desirable genotypes and for exchange of germplasm. Several of the Pacific Island countries, especially Solomon Islands and Fiji, have resorted to this technique for the above purposes. The best six Fijian cassava cultivars are now held in tissue culture. The best 10 Colocasia taro cultivars in Fiji were grown from meristems and were found to yield better than plants of the same cultivar that were not cultured.

Some of the major root crop diseases, particularly viral diseases are restricted to only some of the islands. In order to avoid concomitant spread of viral diseases while exchanging cultivars and other germplasm, adequate viral indexing facilities should exist in the sub-region. Unfortunately, such a facility presently does not exist and the materials are sent to other regions for indexing which is time-consuming. Thus, the need for development of a suitable viral indexing facility in the sub-region can hardly be over-emphasized.

The commercial varieties of root crops in the Pacific Island countries were usually derived as selections from land races occurring in the individual countries or in the sub-region. A systematic evaluation of indigenous collections is likely to result in identification of promising lines for high yield, greater resistance and wider adaptability. Furthermore, cross-breeding programs between selected cultivars should be resorted to for generating new variability as well as for recombination breeding. In Fiji, during the last five years, more than 200 crosses were made between the best 11 cultivars of *Colocasia* taro and several thousand seedlings from promising crosses are being screened, particularly for taro beetle and leaf blight. A recurrent selection program is aimed at breeding high-yielding cultivars with good taste and texture and high dry matter content. Seeds from the most promising crosses have also been sent to other Pacific Islands for evaluation under local conditions. Recently, Fiji and the University of South Pacific, Apia, Samoa, have developed new high-yielding varieties of taro which are expected to catch up with the farmers and thus replace the older varieties.

In Solomon Islands where taro leaf blight and virus diseases are most rampant, breeding for resistance to these diseases assumes high priorioy. Crosses were made between local high-yielding agronomic bases and a wild taro collected from Thailand and produced progenies which combined high yield as well as resistance. The most promising lines derived from these crosses are being tested at different locations. The taro leaf blight resistance in the Thai collection was controlled by a single gene (vertical resistance) and thus there are high chances of its breaking down. Fortunately, a horizontal resistance source was identified from India and is being used in cross-breeding program in Solomon Islands for developing durable resistance. The promising progenies derived from such

crosses have been sent for evaluation in Papua New Guinea and other islands where taro leaf blight is a major problem. Similar breeding programs should be initiated and further strengthened for other root crops. Exchange of early segregating materials as well as stabilized progenies should be encouraged and further supported.

The Asian Vegetable Research and Development Center (AVRDC), Taiwan, has been playing an important role in conservation, utilization and distribution of genetic resources of its mandate vegetable crops. The Center had selected six vegetables for close attention. They were mungbean, soybean, tomato, sweet potato, white potato and Chinese cabbage, but by 1978 white potato was dropped and lately the Center has added peppers to its mandate crops. By 1988, the Center held more than 25,000 accessions of six crops and had distributed 222,977 germplasm and breeding lines/materials (Table 8) (Marlowe, 1988). The Center was designated by the IBPGR to be the world repository for mungbean germplasm and Asian-Pacific repository for sweet potato collections.

Several of the breeding lines distributed by AVRDC were released as commercial varieties in different countries. For instance, by 1988, Indonesia had released 14 varieties, including two varieties of Chinese cabbage and four varieties each of mungbean, soybean and tomato using AVRDC genetic materials. The AVRDC accessions have been characterized and catalogued systematically. For example, the Center has screened most of its 5,800 tomato accessions for heat tolerance and resistance to bacterial wilt, tobacco mosaic virus, late blight, leaf mold, gray leaf spot, and root-knot nematode.

From the foregoing it emerges that the indigenous vegetable germplasm is eroding fast. Some of the countries on their own and/or with international support have collected and are maintaining part of the variability. Some of the collections, particularly root and tuber crop germplasm in the Pacific Islands, due to diseases and paucity of manpower and resources got partly eroded from gene banks/living collections. Therefore, there is an urgent need for systematic collection and effective conservation of vegetable germplasm in most of the developing countries of the Region. National governments and international agencies-multilateral and bilateral, should strengthen national and regional capabilities for undertaking this very vital work.

Majority of the national collections have not been characterized adequately, let alone evaluation. Due to this gap, the collections are not being exploited adequately and their significance is not being fully appreciated by those who allocate resources for germplasm activities. Collection/conservation centers should no longer ignore proper characterization/evaluation of their stocks. The IBPGR has issued descriptor lists for most of the major tropical and sub-tropical vegetables including root and tuber crops, which should be adopted widely. This will also facilitate inter-country sharing of the information on uniform basis.

As mentioned earlier, several countries in the Region have benefitted greatly from introduction of varieties and other germplasm. Introduction and tropicalization of varieties of tomatoes, cabbages, onion, cauliflower, radish and others have expanded the vegetable basis of countries in the Region. The trend is likely to continue in the future,

Table 8 Genetic resource activities at the AVRDC, 1987

Vegetables	No. of accessions maintained	No. of cumulative germplasm distributed*
Chinese cabbage	804	18298
Mungbean	5107	61889
Soybean	11670	88292
Sweet potato	1187	5775**
Tomato	5800	48723
Pepper	5100	—

* Includes breeding lines, ** Distributed as vegetative clones

but to take full advantage of this trend, it is necessary to catalogue cultivars (released during the past 10 years or so) and available germplasm in each country. Under the auspices of the Asia-Pacific Network on Vegetables (described later), FAO RAPA, in close collaboration with the member institutions, is preparing a regional germplasm catalogue which will be disseminated to all countries to promote and facilitate exchange of cultivars and other germplasm. The Network with assistance from the Regional Project (described later) will monitor performance and use of the materials exchanged and organize regional trials of promising lines pooled from different countries.

Role of FAO in vegetable production and germplasm conservation in the Asia-Pacific Region

FAO attaches high priority to improved production and germplasm conservation of vegetables in the Region. In the recent years, the Organization has been operating 16 national-level projects in nine countries, and two regional projects on vegetable crops (Table 9). The aim of these projects is to strengthen national capabilities, including manpower, so that the countries could become self-reliant.

FAO, among other things, has been promoting TCDC activities in vegetable research and development through its regional projects. The stated objectives of the project RAS/86/003 are:

1) Establish cooperative research networks among the cooperating countries especially in plant breeding, variety trials, germplasm conservation and utilization and agronomic practices.
2) Strengthen the research and extension capabilities of the involved centers.
3) Obtain and identify improved cultivars and suitable crop production and research

Table 9 FAO's ongoing or recently concluded projects on vegetables

Country	No. of project	Title of project
Bangladesh	GCP/BGD/022/DEN	Vegetable Seed Production
Bangladesh	TCP/BGD/6755	Emergency Supply of Vegetable Seed
Bhutan	BHU/83/002	Manpower Development-Horticultural Products (including vegetables)
China	CPR/80/023	Beijing Vegetable Research Center
DPR Korea	TCP/DRK/4402	Consultancy in Horticultural Development (including vegetables)
DPR Korea	TCP/DRK/4504	Tissue Culture Laboratory for Fruit and Vegetable Production
Nepal	GCP/NEP/040/SWI	Vegetable Seed Production-Phase II
Pakistan	TCP/PAK/6651	Vegetable Seed Production in Baluchistan
Sri Lanka	SRL/82/002	Multiplication of Planting Materials of Roots and Tubers
Sri Lanka	SRL/83/002	Winged Bean Research and Development
Sri Lanka	SRL/84/013	Horticulture Development Phase II (PA) (including vegetables)
Thailand	TCP/THA/4513	Increased Tomato Production
Thailand	TCP/THA/6653	Vegetable Cash Crop Production for Opium Replacement
Vietnam	VIE/80/005	Horticulture : Research Development and Training (including vegetables)
Vietnam	VIE/85/016	Horticulture Development (including vegetables)
Vietnam	TCP/VIE/6760	Strengthening Seed Potato Production
Regional	RAS/86/003	Vegetable Crops R&D
Regional	RAS/86/034	Root Crop Systems Development

techniques for better crop management.
4) Evolve suitable post-harvest technology techniques and assessments to maintain and evaluate quality and minimize crop losses. These losses include total monetary value, nutritive value and bulk.
5) Encourage collection, conservation, documentation and exchange of germplasm, seed of superior varieties and plant material between national, regional and international research institutes and programs.
6) Establish national and regional linkages with the appropriate international institutes and agencies.
7) Facilitate training for national personnel on a substantial scale at varying levels in the required fields of specialization at appropriate national and international centers. These include seed production, tissue culture/micropropagation and plant breeding.
8) Facilitate dissemination of information and sharing of experiences.
9) Encourage national governments to improve the mechanisms for the flow of information through effective extension services from research to the farming community engaged in vegetable crop production.

Through two FAO Regional Expert Consultations on Vegetables in 1986 and 1988, held at FAO Regional Office for Asia and the Pacific (RAPA), Bangkok, the status and prospects of vegetable production were analysed and an expanded regional project to include all major vegetable producing countries was prepared. The 1988 Consultation had established a regional network on vegetable production. Fourteen institutes from nine countries have already joined the network. The network will address primarily the following issues :

a) information and documentation
b) development of capable manpower
c) exchange of planting materials and germplasm

Most of the vegetable production, research and development projects have a sizeable component of genetic resources. These projects have been assisting the countries, in collaboration with IBPGR and other relevant programs, in exploration, collection, conservation, and utilization activities. Furthermore, FAO has been providing the Secretariat of IBPGR ever since its inception in 1974. Recently, the Organization has established an International Commission on Plant Genetic Resources which aims to support effective conservation and free availability of genetic resources to all *bonafide* users in the world.

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Discussion

Henry, G. (CIAT) : 1. Could you indicate the changes in the funding and investment from FAO for vegetable projects in the last 5 years ? 2. What will be the share of vegetable research by FAO in relation to other crops in the next five years ?

Answer : 1. I cannot give you the exact amount of FAO funding for vegetable projects (the figures could be obtained from FAO Headquarters). In the last 5-7 years emphasis has been placed on the funding of vegetable or fruit projects in particular in view of the success achieved in cereal production in the region. Of about 250 field projects related to crops, 15 to 18 corresponding to an increase of 25% were related to vegetables. 2. In recent years, in the Asia-Pacific Region, along with the government policies on accent on crop diversification in member countries, increasing attention is being paid to horticultural crops, including vegetables for nutritional adequacy and additional source of income. Greater attention is also diverted to other non-cereal crops like legumes, oilseed crops and root and tuber crops.

Ram Phal (India) : I feel that AVRDC which is located in Taiwan is working on too few vegetables and that its findings are not applicable to a wide range of environments. Could FAO promote the establishment of an international center that would cover research and development activities on a larger number of vegetables in a more approprate location than Taiwan, for example in India ?

Answer : Although AVRDC is working only on a few vegetables, it has carried out excellent studies on its mandate crops, namely, mungbean, soybean, cabbage, tomato, sweet potato and recently on pepper. As regards other international initiatives, the CGIAR is currently debating whether an international institute dealing with research and development on vegetables should be established. FAO is presently operating two regional projects, one in the Asian region and the Pacific island sub-region (on root and tuber vegetables). It has established a regional cooperative network on vegetables to promote information sharing and germplasm exchange. The regional project sponsored by FAO involves China, DPR Korea and Pakistan. This project will be expanded to include 15 countries under the leadership of China. This regional project could become a supporting wing of the CGIAR system or a self-sustained regional project.

Saxena, M. C. (ICARDA) : Diseases and pests have been identified as the major constraints on production in the region. The use of pesticides is common. Is there any program emphasizing the reduction in the use of pesticides and adoption of integrated pest management (IPM) ?

Answer : FAO gives high priority to the IPM strategy for avoiding excessive and careless use of pesticides for the management of pests and diseases. The Organization is currently operating a very successful project on IPM in rice in the Asian countries. FAO RAPA organized an expert consultation on IPM in vegetables a few months ago and prepared a regional project on IPM in vegetables. which is likely to receive funding support from UNDP/other sources. Furthermore, FAO has developed an International Code of Conduct for Safe and Efficient Use of Pesticides and is helping developing countries in implementing this Code. The host country, Japan is in fact presently supporting a regional project in the Asia-Pacific Region operated in Thailand with the participation of 20 countries on the implementation of the Code, of which IPM is the cornerstone.