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Tropical Vegetables and their Genetic Resources

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INTERNATIONAL BOARD FOR PLANT GENETIC RESOURCES

TROPICAL VEGETABLES AND THEIR GENETIC RESOURCES

by

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PREFACE

In 1976 the International Board for Plant Genetic Resources commissioned the Royal Tropical Institute of the Netherlands to produce a consultant's report on vegetable germplasm with special reference to tropical types. It was envisaged that this report should be of a review nature but should include as far as possible an outline plan for the collection, evaluation, use and conservation of vegetable germplasm.

The study was carried out by Dr. G.J.H. Grubben of the Department of Agricultural Research, RTI, following guidelines provided by the Secretariat of the IBPGR. The assistance of the Institute for Horticultural Plant Breeding , Wageningen and the constructive criticism of Dr. J. A. Frahm-Leliveld and Ir. F.M.A. Geurts are gratefully appreciated.

Special thanks are due to Mrs. N. Zeven-Hissink who collated the information on the addresses of institutes and plant breeders in the Annexes. Mr. H.D. Tindall prepared the information presented in Annex IV.

The editors are grateful to the photo-library of the Food and Agriculture Organization of the United Nations for all the illustrations except those on page 100 which were provided by Dr. Grubben. Mr. J.A. Birkett kindly provided invaluable advice on layout.

This report is to be regarded as a first step towards international cooperation becoming effective since it indicates what germplasm already exists in collections, what material the vegetable research and breeding programmes require and in which species some genetic erosion is occurring.

CONTENTS

I INTRODUCTION

1. Object of the report 1
2. Definition and classification of vegetables 2
3. General remarks on genetic resources 4
4. Sources of information 4
References 5

II IMPORTANCE OF PRODUCTION AND CONSUMPTION OF VEGETABLES IN THE TROPICS

1. Domestication and types of cultivation 7
2. Records and estimates of production and consumption 7
3. Nutritional value 9
4. Actual consumption in different areas 16
Latin America 18
Africa 19
Asia 20
5. Conclusions and recommendations 20
References 21

III SOLANACEOUS FRUITS

1. General 25
2. Tomato 25
3. Capsicum peppers 30
4. Eggplant 34
References 37

V CUCURBITS

1. General 39
2. Watermelon 40
3. Melon 43
4. Cucumber 45
5. Pumpkins and squashes 46
6. Wax gourd 48
7. Bottle gourd 50
8. Loofah 51
9. Bitter gourd 51
10. Chayote 52

References 54

ALLIUMS

1. General 55
2. Onion 55
3. Shallot 60
4. Japanese bunching onion 61
5. Garlic 62
6. Leek 62

References 63

I LEGUMINOUS VEGETABLES

1. General 65
2. Common or French bean 65
3. Lima bean 68
4. Hyacinth bean 70

VI LEGUMINOUS VEGETABLES (cont'd)

5. Mung bean 71

6. Yardlong bean 73

7. Winged bean 75

8. Other leguminous vegetables 76

References 78

VII BRASSICAS

1. General 81

2. White cabbage 83

3. Chinese cabbage 86

4. Cauliflower and broccoli 87

5. Various leaf cabbages 88

References 89

VIII LEAF VEGETABLES

1. General 91

2. Common annual leaf vegetables 96

(Amaranth, Ceylon spinach, Beet, Sokoyokoto, Taro, Jute mallow, Roselle, Kangkong, Sweet potato, Lettuce Cassava, African eggplants, Waterleaf, Cowpea and Yardlong bean, Cocoyam)

3. Shrubs and trees 107

4. Minor wild and cultivated leaf vegetables 108

5. General recommendations 109

References 109

IX OTHER WARM WEATHER VEGETABLES

1. Introduction 111
2. Okra 111
3. Sweetcorn 114
4. Palm cabbage 114
5. Bamboo 114
6. Arracacha 114
7. Mushrooms 115
8. Various species of minor importance 115

References 115

X OTHER TEMPERATE VEGETABLES

1. Introduction 117
2. Carrot 117
3. Radish 118

References 118

XI CONCLUSIONS

1. Production and consumption 119
2. Groups and species of vegetables 119
3. Availability of vegetable seeds in the tropics 125

ANNEX I

Notes on collecting vegetable germplasm 127

ANNEX II

Directory of institutions involved with vegetable germplasm resources 135

A. Institutions 137

B. Research workers 157

C. Seed growers 183

ANNEX III

Tropical vegetables - common names 185

ANNEX IV

Centres of diversity of the major vegetable species 195

FRONT COVER AND FRONTISPIECE

The front cover shows an Indonesian woman at market in Borobodur selling locally grown vegetables. This page shows a Malawi boy proudly showing off a giant cabbage he has grown. The more meagre examples shown on the cover may contain genetic combinations which can be used to help food production.

I. INTRODUCTION

1. OBJECT OF THE REPORT

Vegetables are important in maintaining a satisfactory nutritional level in both temperate and tropical regions. However, it is evident that research on vegetable growing techniques is not adequately developed in most tropical countries, not only in comparison with vegetable crop research in temperate zones but also with research on basic tropical food crops such as the cereals, tubers and pulsers. This is due to the large number of species which are generally classified as "vegetables".

There is erosion of vegetable germplasm in temperate regions and steps for the conservation of valuable primitive cultivars and wild material have been considered on a national level as well as by international organisations. The present report, conducted by the Royal Tropical Institute, Amsterdam, at the request of the IBPGR had the following terms of reference:

(a) To record the economic and nutritional importance of vegetables used in tropical areas.

(b) To identify important species where there is the threat of genetic erosion and list species in which the collection of germplasms for breeding purposes is urgently required.

(c) To outline proposals for the collection, conservation,evaluation and use of germplasm.

(d) To summarise the location and scope of germplasm collections which are already being maintained in developed as well as developing countries.

The choice of the tropical and subtropical areas mentioned in this report, was linked with the regional priorities of the IBPGR (1976) and the tropical areas selected are listed below:

(a) AFRICA

Ethiopia

Eastern Africa: Burundi, Kenya, Malagasy Republic, Malawi, Mozambique, Ruanda, Somalia, Sudan, Tanzania, Uganda, Zambia.

West Africa: Angola, Benin, Cameroon, Central African Republic, Chad, Congo, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauretania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Upper Volta; Zaire.

(b) AMERICA

Meso-America: the Caribbean, Costa Rica, El Salvador, Guatemala, the Guyanas, Honduras, Mexico, Nicaragua, Panama.

Brazil and Paraguay.

Andean Zone: Bolivia, Colombia, Ecuador, Peru, Venezuela.

(c) ASIA

South Asia: Bangladesh, Burma, India, Sri Lanka

Southeast Asia: the nations of Indochina, Indonesia, Malaysia, the Pacific Islands, Philippines, Singapore, Thailand, Taiwan

Far East: China (Southern part)

2. DEFINITION AND CLASSIFICATION OF VEGETABLES

Vegetables can be described as plants which provide a source of food, often low in calories and dry matter content, which are consumed in addition to a starchy basic food in order to make it more palatable. Vegetables add protective nutrients, especially vitamins and minerals, to the diet. Potatoes and other tubers which are rich in calories are sometimes included with vegetables, as are many pulses. Other vegetable species such as hot peppers and parsley are often listed as spices and flavourings. Melons are sometimes recorded as fruits.

Vegetables may be grouped according to: (a) their economic importance; (b) the consumed product, e.g. leaf vegetables such as tubers, roots etc.; (c) their nutritional importance e.g. vegetables which are rich in vitamin C, rich in B-carotene etc. The taxonomic classification is most suitable for studying the genetic resources of vegetables. However, for practical reasons, a number of species with an identical edible product, but belonging to many different taxa have been brought into one group, viz. the leaf vegetables. A number of vegetables belonging to small taxa and of minor importance have been incorporated in two extra groups. Thus the classification used in this study is as follows.

(a) Solanaceous fruit vegetables: tomato, *Capsicum* pepper, eggplant

(b) Cucurbits: cucumber, melon, watermelon, pumpkin, gourds, squashes

(c) Alliums: onion, shallot, garlic, Japanese bunching onion, leek

(d) Leguminous vegetables: common bean, Lima bean, hyacinth bean, winged bean, yardlong bean, mung bean, locust bean etc.

(e) Brassicas: white cabbage, cauliflower and broccoli, Chinese cabbage, kale and mustard.

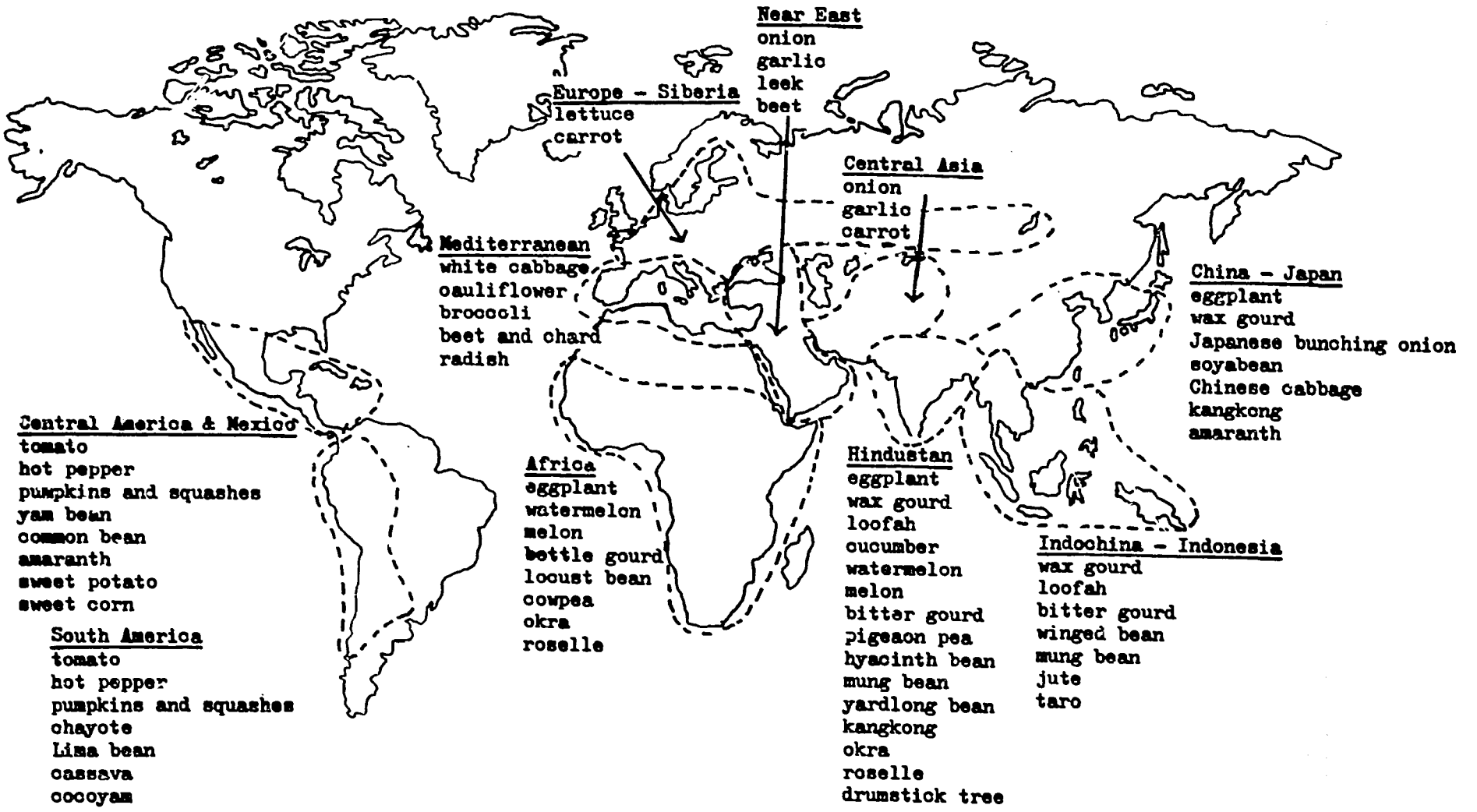
(f) Leaf vegetables: amaranth, beet leaves, kangkong, *Corchorus*, lettuce, spinach, *Solanum* spp.; *Xanthosoma*, drumstick tree etc.

(g) Other tropical vegetables: okra, palm cabbage, bamboo shoots, mushrooms

(h) Other temperate vegetables: carrot, radish.

The centres of diversity of these vegetables are shown in Fig. 1. and Annex IV. A list of vernacular names is provided in Annex III.

Fig. 1 Centres of diversity of important vegetables mentioned in this report



3. GENERAL REMARKS ON GENETIC RESOURCES

Many years ago, primitive species used as a vegetable were moved from their centre of origin to other areas and continuous mutations, crossing with related species and selection by man and nature has given rise to secondary centres of diversity, with many types and cultivars which are distinct from the original ones. The development of modern horticulture has led to an enormous decrease in the number of vegetable species which were originally used by our ancestors. It also involves a narrowing of the genetic base of this small number of species because the originally large number of local, unselected cultivars is replaced by a fewer highly selected, high-yielding and high-quality cultivars. Plant breeders have to rely on the genetic resources which can be found in the wild ancestors and primitive cultivars, present in the primary and secondary centres of diversity of these crops.

The loss of the wild ancestors or primitive or old-modern cultivars, (called "genetic erosion") means an impoverishment of the germplasm (the sum total of hereditary material) of that particular species. This may be prevented by the establishment of gene or germplasm banks, which collect and keep, in longterm storage, all the germplasm that can be found of certain species. If storage is in the form of seed, this may be kept in samples of some 18,000 seeds. A cold store of -20°C and a R.H. of 30%, which is in equilibrium with a seed moisture content of about 6% on a dry weight basis, will be satisfactory for most species. Vegetatively propagated crops must be kept in living collections, which is much more expensive. The gene bank may be considered as a part of a genetic resources centre, with the germplasm being made available to plant breeders. This requires a great investment in evaluation, documentation and distribution of the material.

4. SOURCES OF INFORMATION

The main sources of information on research in breeding and cultivation of vegetables in tropical areas may be found in the following journals:

(a) Abstracts on Tropical Agriculture, published by the Royal Tropical Institute, Amsterdam, The Netherlands. Volume 1 (1975). A continuation of Tropical Abstracts, Vol. 1-29 (1945-1974).

(b) Horticultural Abstracts. Published by the Commonwealth Bureau of Horticulture and Plantation Crops, East Malling Research Station, Maidstone, England, U.K.

(c) Plant Breeding Abstracts, Published by the Commonwealth Agricultural Bureaux, Farnham Royal, Slough, England, U.K.

The classification of centres of genetic diversity as revised by Zeven and Zhukovsky (1975) has been used in this report. Important references are cited at the end of each section but more comprehensive bibliographical references for most important species will be found in Hawkes, Williams and Hanson (1976).

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General

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LEON, J. 1974: Handbook of Plant Introduction in Tropical Crops. FAO Agricultural Studies 93, Rome

SIMMONDS, N.W. (ed.) 1976: Evolution of Crop Plants. London, New York

WILLIAMS, J.T., C.A. LAMOUREUX, and N. WULIJARNI-SOETJIPTO (eds.) 1975 South East Asian Plant Genetic Resources, Bogor

Lists of vegetable cultivars

(See also the Seed Catalogues of the Seed Growers listed in Annex 2C and the handbooks listed in section 2.6 page 29.)

ANON. 1974: Gemeenschappelijke lijst van groentegewassen; Tweede volledige uitgage Eerste aanvulling. Publikatieblad van de Europese Gemeenschappen, The Hague

ANON. 1975: Field crop, horticultural and pasture recommendations. University Botswana, Lesotho & Swaziland, Agricultural Research Division Swaziland Advisory Bulletin 1

KEDAR, N. 1974: List of vegetable cultivars suitable for growing in various Asian and Caribbean countries, in: Agricultural Research Programmes in joint rural development projects, Annual Report 1971/72 Jerusalem

LIBERT, J.R. 1971: List of vegetable varieties grown in intertropical Africa, FAO (APGC:MISC/6), Rome

MINGES, P.A. 1972: Descriptive list of vegetable varieties introduced since 1936 by public and private breeders in North America (1936-1968). St. Joseph (Michigan)

A typical market scene in the tropics showing locally grown fruit and vegetables. This picture was taken in Curacao in the Antilles Islands.

II. IMPORTANCE OF VEGETABLE PRODUCTION AND CONSUMPTION IN THE TROPICS

1. DOMESTICATION AND TYPES OF CULTIVATION

At least 10,000 years ago primitive man started to domesticate wild vegetable species, and the following five phases can be distinguished:

(a) Wild plants were collected from the indigenous vegetation and used as a supplement to the collected or cultivated energy-rich basic food. About 1,500 species may have been used for this purpose.

(b) A number of these wild vegetables, together with the food crops grown in the compounds, were protected leading to selection of primitive cultivars. Estimated to be about 500 species.

(c) The more suitable of these protected species were cultivated in home gardens or in mixed cropping in the fields and most were used for home consumption. About 200 species with many primitive cultivars may have been selected.

(d) Some of these cultivated vegetables were used for small scale, labour-intensive market garden production and usually grown in a monoculture system. About 80 species probably used in this way.

(e) Some of the market vegetables were selected for highly intensified cultivation. These numbered about 20 species, with a small number of modern cultivars.

In developed countries, vegetables are grown in highly intensive cultivation systems. About 75% can be identified with phase (e), 10% with phase (d) and 15% with phase (c). Approximately half of the vegetables consumed in developing countries come from small-scale market gardens (d), whereas phase (c) accounts for about 40% with the remainder in phases (a), (b) and (e). The processes of modernisation, urbanisation and diversification have led to an accelerated change from the most primitive type of cultivation to a relatively sophisticated market gardening operation.

In the tropics commercial vegetables are often grown with extensive methods (phase (d)) similar to those which are applied in food crop production, requiring 150-250 man days/ha from establishment to maturity. Other systems require 300-600 man days per ha, including irrigation, fertiliser and pesticide applications. Mechanisation is late in the tropics, but is becoming more common in subtropical regions. In the USA, mechanically harvested tomatoes for processing need no more than 40 man days per ha; this is equivalent to a production rate of 700 kg per man day, 10-20 times greater than the normal production in the tropics.

2. RECORDS AND ESTIMATES OF PRODUCTION AND CONSUMPTION

Although statistical data are scarce, an acceptable picture of vegetable production and consumption in developing countries has been attempted in this report. In many countries statistics are not available, and moreover where

data exist, the amount of data reported differs from country to country. Estimates refer mainly to crops grown in fields and market gardens but exclude those which are grown in small family gardens or in mixed cropping and are used for home consumption. Table 1 provides some data, FAO (1974).

The best estimate of consumption can be made by nutrition surveys in selected countries in specific regions. The figures in table 2 have been derived from a multitude of nutrition surveys, the most important being mentioned in the references, section 2.6. The types of vegetable are arranged in 24 groupings. As sufficient data for centrally planned countries were not available, 75% of the consumption in developed countries has been taken, as a rough estimate. The estimate of the for-sale-production has been based on the degree of urbanisation and the number of people with an agricultural occupation, (United Nations Demographic Yearbook 1974), and on personal observations from markets, in the fields and in home gardens. It is assumed that urban people in developed countries buy their vegetables exclusively in the market, whereas urban people from small towns in the tropics may obtain part of their vegetable supply from family gardens.

It is estimated that about 53% of the vegetables grown in developing countries are produced for home consumption, whereas this percentage drops to 13% for developed countries. Tomatoes, onions and European-type vegetables such as carrots and cauliflowers are highly commercialised vegetables in the tropics, whereas other such as green leaf vegetables are usually grown for home consumption.

The quantity of vegetables exported (see table 1) is only a small part of the total production. FAO tables only quote tomato, onion and pepper. The export of certain vegetables is very important for the economy of particular developed countries. For example, fresh tomatoes from Mexico and Morocco, onions from Egypt, canned asparagus and mushrooms from Taiwan, hot peppers from India, French beans, cucumber and bell peppers from Senegal and Kenya.

It should be noted that some important vegetables in tables 1 and 2 are listed individually, whereas some other types are included together in larger groups. For instance, the grean leaf vegetables, ranking second in this list, include several different species, none of which would belong to the ten most important species, if taken individually.

The total economic value of the world vegetable production, assuming a farm value of about US $0.10 per kg, is roughly US $25 billion.

The total world production of vegetables is presented in table 3. An estimate based on data collected for this report, which is derived from table 2, has been compared with the estimate in the FAO Production Yearbook (1974) which includes estimates for non-reporting countries and non-reported quantities. It may be concluded that the consumption in developing countries is only 46% of that in developed countries. The estimate of consumption for the S.W. and C. Asia (102 kg/head/annum), as mentioned in the FAO Production Yearbook appears to be much higher than the estimate derived from our own data (59 kg/head/annum). The other figures for developed and developing countries are more or less in agreement.

3. NUTRITIONAL VALUE

Vegetables make several important contributions to tropical diets:

(a) They enrich the diet with nutrients.

(b) They render the staple food more palatable and hence improve the intake.

(c) They improve the digestion.

(d) They sometimes have a curative action.

The addition of vitamins, minerals and other nutrients to the diet is the most important factor. In general, consumers do not realise the contribution that vegetables make to the nutritive value of their diet. This is more generally acknowledged in developed countries.

The composition of some vegetables, compared with that of cereals, tubers and pulses, is presented in table 4. This indicates that vegetables may contain important additions to the nutrients which are insufficiently available in basic foodstuffs. However, it is not easy to provide a general estimate of their nutritive value in tropical diets. Table 5 illustrates the relative importance of the different vegetable groups and species. The composition and nutritional value of vegetables may be broadly summarised as follows:

(i) The dry-matter content of vegetables varies considerably with the species or cultivar as well as with climatic and soil conditions during growth, cultivation methods, harvesting, storage treatments etc. The analyses relate to the cleaned, unprepared edible portion.

(ii) The waste includes the basal stem portion and rootlets of leafy vegetables, trimmings and outer leaves of cabbage and lettuce, scrapings of carrot roots, parings of cucumber and pumpkin, tops and strings of bean pods, shells of Lima beans, skins and trimmings of onions, etc. The percentage of waste varies from 4% for eggplant to 44% for bamboo shoots. The overhead loss in produce, i.e. unsaleable and deteriorated material and the part reserved for seed production, amounts to an average of 20% for all vegetables. The approximate consumption of purchased vegetable produce is probably 80% of the total production.

(iii) The composition of vegetables in both the fresh condition and based on a dry matter content varies considerably, although the same type of product, such as dark green leaves, fleshy white or green cucurbit fruits, leguminous pods or white fleshed tubers, show great similarity in composition.

(iv) The protein content of vegetables is considered to be relatively unimportant in developed countries, but it appears to be highly important in countries with an overall deficiency in proteins. The amino-acid composition of many vegetables is well balanced, rich in methionine and lysine and with a fairly high biological value, viz. about 60% of the reference protein.

(v) The fibre content is less important in the tropics than it is in developed countries, due to the generally coarser nature of prepared food in the tropics. In this context, it should be noted that a high intake of fibre effectively prevents constipation and digestive problems.

Table 1. Vegetable production and export as registered in the FAO Production and Trade Yearbooks (1974) for developed, centrally planned and developing countries.

		developed	
		production 10^6 ton	export 10^3 t
1.	tomato	19.0	634
2.	peppers (sweet & hot)	1.8	19
3.	eggplant	1.3	-
4.	fleshy cucurbits (cucumber, gourds, squashes, pumpkins)	4.2	-
5.	melon, watermelon	6.7	-
6.	heading coles (white cabbage, heading Chinese cabbage, red Savoy, Brussels sprouts)	7.6 b)	-
7.	cauliflower, broccoli	2.2	-
8.	leaf cabbage (mustard, kale, petsai)	-	-
9.	onion, shallot (dry)	5.7	709
10.	green onions, leek, Welsh onion	0.7	-
11.	garlic	0.4	-
12.	leguminous pods (snapbean, yard-long bean, wing bean, soya)	1.0 c)	-
13.	green beans (common bean, Lima bean, soya)	1.4	-
14.	green peas (pea, cowpea, pigeon pea)	3.5	-
15.	dry beans (for sprouting)	-	-
16.	lettuce	-	-
17.	leaf vegetables (excl. 8,10,16)	-	-
18.	carrot	4.1	-
19.	roots, tubers (turnip, beetroot, Lotus, yam bean etc. excl. 18)	-	-
20.	shoots, stalks, sprouts, flowers (artichoke, asperge, bamboo, rhubarb, Sesbania)	1.2 d)	-
21.	sweet corn	-	-
22.	okra	-	-
23.	various seeds (cucurbits etc., excl. 13, 14, 15)	-	-
24.	mushrooms, ferns etc.	-	-
	T o t a l :	60.8	1,362

centrally planned		developing			
production 10^6 t	export 10^3 t	10^3 ha	ton/ha	production 10^6 t	export 10^3 t
6.6	285	744	14.4	10.7	583
0.7	19	286	6.1	1.7	167 a)
0.05	-	102	11.4	1.2	-
1.5	-	274	11.0	3.0	-
4.4	-	852	12.3	10.5	-
3.5	-	262	10.8	2.8	-
0.3	-	106	8.2	0.9	-
-	-	-	-	-	-
4.1	115	732	7.9	5.8	364
0.1	-	69	9.6	0.7	-
0.1	-	196	4.5	0.9	-
-	-	53	6.3	0.3	-
0.2	-	108	3.6	0.4	-
0.5	-	187	2.7	0.5	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
1.0	-	41	11.2	0.5	-
-	-	-	-	-	-
-	-	17	11.2	0.02	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
23.0	419	4,029	39.9		1,114

a) mainly dried hot pepper b) mainly white cabbage c) mainly snap beans d) artichokes

Table 2. Estimated daily vegetable consumption (g per head, net intake, raw edible product) and annual production in developed, centrally planned and developing countries.

type of vegetable	developed countries			c. planned countries	developing countries							world
	cons. g/day	production x 10^6 t	for sale %	production x 10^6 t	consumption g/caput/day Africa	America	SW/ C.Asia	Other areas	mean	production x 10^6 t	for sale %	production x 10^6 t
1. tomato	34	11.6	85	14.3	9	11	41	12	14	12.5	80	38.4
2. peppers	3	1.0	90	1.3	6	7	6	2	4	3.4	40	5.7
3. eggplant	2	0.7	90	0.8	2	2	7	15	10	8.9	30	10.4
4. fleshy cucurbits	16	5.5	85	6.7	3	8	9	19	14	12.1	30	24.3
5. melon, water-melon	18	6.2	85	7.6	3	5	19	4	6	4.8	50	18.6
6. heading cabbage	19	6.5	85	8.0	2	6	12	7	7	5.7	40	20.2
7. cauliflower, broccoli	14	4.8	85	5.9	0	1	4	1	1	1.0	90	11.7
8. leaf cabbage	3	1.0	80	1.3	1	1	2	4	3	2.5	50	4.8
9. onions and shallots(dry)	15	5.1	90	6.3	4	2	14	4	5	4.1	80	15.5
10. green onions, leek, bunching onion	3	1.0	85	1.3	0	0	5	2	2	1.5	40	3.8
11. garlic	1	0.3	95	0.4	0	1	2	1	1	0.7	70	1.4
12. leguminous pods	9	3.1	75	3.8	0	1	2	6	4	3.4	50	10.3
13. green beans	3	1.0	85	1.3	2	1	2	2	2	1.7	40	4.0
14. green peas	9	3.1	85	3.8	1	1	5	1	1	1.2	40	8.1
15. dry beans(for sprouting)	0	0	-	0.1	0	0	0	2	1	1.0	40	1.1
16. lettuce	15	5.1	85	6.3	1	1	3	1	1	1.1	80	12.5
17. green leaf veg.(excl. 8, 10, 16)	20	6.8	75	8.4	21	5	11	15	13	11.7	30	26.9
18. carrot	11	3.8	85	4.5	1	1	6	1	2	1.3	80	9.7
19. roots, tubers (excl. 18)	7	2.4	75	2.9	2	2	4	2	2	1.9	40	7.2
20. shoots, sprouts, flowers, stalks	6	2.1	80	2.5	1	2	2	3	2	2.1	50	6.7
21. sweet corn	11	3.8	80	0.1	0	0	0	0	0	0	-	3.9
22. okra	1	0.3	65	0.4	6	2	3	4	4	3.4	40	4.1
23. various seeds (excl. 13,14, 15)	0	0	-	0.1	3	0	2	1	1	1.2	30	1.3
24. mushrooms	1	0.3	95	0.4	1	0	1	1	1	0.7	30	1.4
Total :	221	75.5	87	88.6	69	60	162	110	101	87.9	47	252.0

Table 3. Annual production and consumption of vegetables in the major regions of the world.

	1 total world production x 10^6 t	2 population x 10^6 t	3 consumption kg/head	4 consumption kg/head	5 total world production x 10^6 t
World total	282.3	3906	58	57	252.0
Developed	88.0	750	94	81	75.5
North America	25.4	235	86		
Western Europe	46.3	365	102		
Oceania	1.4	16	70		
Other	14.9	134	89		
Developing	96.7	1928	40	37	87.9
Africa	9.4	304	25	25	9.5
America	11.6	317	30	22	8.7
S.W. and C. Asia	24.4	193	102	59	14.3
Asia (other areas)	51.0	1109	37	40	55.7
Centrally planned	97.6	1228	64		88.6
Asia	57.4	868	53		
Europe, USSR	40.2	360	90		

Column: (1) and (2) : FAO production yearbook 1974. Rome, 1975.
(3) estimated (1)/(2) x 0.80. About 20% is lost as waste or used for seed.
(4) estimated average of nutrional surveys (net intake, edible portion) see table 2.
(5) estimated (4) x (2) x 1.25 see table 2.

Table 4. Composition of some vegetables, compared with pulses and starchy foods. From PLATT (1975). Requirements for an adult man (55 kg) from FAO/WHO standards for East Asia; protein biol. val. 60%

	per 100 g of edible portion										
product	dry matter	energy Kcal	protein g	fibre g	calcium mg	iron mg	carotene mg	thiamine mg	riboflavine mg	niacin mg	Vit.C mg
starchy basic food											
maize	88	362	9.5	1.5	12	2.5	0	0.35	0.13	2.0	0
rice	88	354	8.0	0.5	10	2.0	0	0.25	0.05	2.0	0
cassava	40	153	0.7	1.0	25	1.0	0	0.07	0.03	0.7	30
sweet potato	30	114	1.5	1.0	25	1.0	0.06	0.10	0.04	0.7	30
pulses											
groundnut	55	332	15.0	1.5	30	1.5	0	0.50	0.10	10.0	10
cowpea	90	340	22.0	4.0	90	5.0	0.01	0.90	0.15	2.0	0
vegetables											
dark-green leaves	15	48	5.0	1.5	250	4.0	1.80	0.10	0.30	1.5	100
tomato	6	20	1.0	0.6	5	0.4	0.15	0.06	0.04	0.7	25
okra	10	33	2.0	1.0	70	1.0	0.09	0.10	0.10	1.0	25
green beans in pod	10	34	2.0	1.0	50	1.4	0.12	0.08	0.12	0.5	20
daily requirements		2,530	46.0	-	500	9	1.5	1.0	1.5	17	30

Table 5. Average nutritive value of vegetables. Data from: Food composition table for use in East Asia (FAO, 1972).

type of produce	per 100 g edible portion													ANV per 100 g dry matter
	waste %	DM g	energy Kcal	protein g	fibre g	Ca mg	iron mg	carotene mg	thiamine mg	riboflavin mg	niacin mg	vit.C mg	ANV	
fruit-vegetables														
tomato	6	6.2	20	1.2	0.7	7	0.6	0.5	0.06	0.04	0.6	23	2.39	38.5
eggplant	4	8.0	26	1.6	1.0	22	0.9	0	0.08	0.07	0.7	6	2.14	26.8
sweet peppers	13	8.0	26	1.3	1.4	12	0.9	1.8	0.07	0.08	0.8	103	6.61	82.6
pepper, hot	13	34.6	116	6.3	15.0	86	3.6	6.6	0.37	0.51	2.5	96	27.92	80.7
okra	10	10.4	31	1.8	0.9	90	1.0	0.1	0.07	0.08	0.8	18	3.21	30.9
cucumber	20	3.8	12	0.6	0.5	21	0.4	0.1	0.03	0.04	0.2	11	1.69	44.5
pumpkin	17	8.1	27	0.7	0.8	24	0.7	0.8	0.03	0.04	0.5	14	2.68	33.1
watermelon	37	6.8	21	0.6	0.2	8	0.2	0.1	0.03	0.03	0.2	6	0.90	13.2
melon (white-green)	22	7.6	26	1.0	0.5	18	0.5	0	0.05	0.02	0.4	25	2.33	30.7
bitter gourd	20	6.0	19	0.8	1.0	26	2.3	0.1	0.06	0.04	0.3	57	4.10	68.3
leafy vegetables														
amaranth	40	10.7	26	3.6	1.3	154	2.9	6.5	0.04	0.22	0.7	23	11.32	105.8
kangkong	28	10.0	30	2.7	1.1	60	2.5	2.9	0.09	0.16	1.1	47	7.57	75.7
Chinese cabbage, leaf type	14	5.8	17	1.7	0.7	102	2.6	2.3	0.07	0.13	0.8	53	6.99	120.5
lettuce	26	6.4	20	1.4	0.6	56	2.1	2.0	0.06	0.12	0.5	17	5.35	83.6
white cabbage	15	7.0	22	1.6	0.8	55	0.8	0.3	0.06	0.06	0.3	46	3.52	50.3
cassava leaves	13	19.0	60	6.9	2.1	144	2.8	8.3	0.16	0.32	1.8	82	16.67	87.7
leguminous vegetables														
hyacinth bean (dry)	0	87.9	334	21.5	6.8	98	3.9	0	0.40	0.12	1.8	0	14.03	16.0
Lima bean (fresh)	43	31.5	119	8.4	1.0	25	2.2	0.1	0.16	0.16	1.5	30	4.88	17.9
mung bean (sprouted)	7	9.9	30	4.2	0.9	15	1.2	0	0.11	0.10	0.8	18	2.94	34.2
sprouts, bulbs, tubers, etc.														
onion (dry)	6	11.4	38	1.6	0.7	30	1.0	0	0.06	0.04	0.2	9	2.05	20.0
carrot	17	10.4	37	1.1	0.9	36	1.2	4.2	0.06	0.05	0.7	8	6.48	64.2
bamboo shoots	44	9.0	28	2.5	1.2	17	0.9	0	0.11	0.09	0.6	9	2.55	30.9
mushroom	9	11.3	37	2.7	0.9	8	1.0	0	0.10	0.42	4.8	3	2.10	19.3
taro (as vegetable)	16	24.6	94	2.2	0.8	34	1.2	0	0.12	0.04	1.0	8	2.38	9.7

(vi) The important minerals, calcium and iron are often lacking in diets in the tropics. Calcium deficiency may occur more frequently if the basic food consists mainly of cereals. A high iron intake is important since anaemia caused by malaria, bilharzia and intestinary parasites occurs very frequently. Pulses such as cowpea are rich in calcium and iron.

(vii) Of the vitamins, β-carotene and vitamin C are the most important. Carotene is deficient nearly everywhere in the tropics, with the exception of W. Africa where red palm oil is used in food preparation. The low intake of fat hampers the absorption of carotene in the body. Vitamin C is less abundant in cereal than in tuber-consuming regions.

(viii) Pharmacological substances may also be important, but there is still insufficient data available on the nutritional value of natural plant products.

Several authors have developed formulae for the average nutritive value of vegetables. MacGillivray et al. (1942) suggested a formula, based on a rating of nutrients in 25 vegetable species in the USA. In the present study the formula of Rinno (1965) is used: this is based on the average nutrient requirements in W. Europe, but can also be applied to the tropics, with some exceptions, and special situations. Rinno's formula for the 'Essential Factor of Nutritive Value' here called 'Average Nutritive Value' per 100 g of vegetable is:

$$ANV = \frac{g\ protein}{5} + g\ fibre + \frac{mg\ Ca}{100} + \frac{mg\ Fe}{2} + mg\ carotene + \frac{mg\ vit.C}{40} \quad *$$

Notwithstanding its limitations, the ANV in table 5 presents an acceptable picture of the relative importance of different vegetables. The best estimate for the potentional production of valuable nutrients by various vegetables can be obtained by calculating the ANV per unit of area, per man day per unit input of capital and energy, but adequate data for such calculations are not available. However, an evaluation of the potential production per day of cultivation is presented in table 6 (ANV per m^2 per day). The group of dark-green leaf vegetables has the highest ANV figures, based on both fresh and dry matter; this group is obviously the best nutrient supplier. Sweet peppers rate a high score as producers of nutrients, owing to their high vitamin C content, while carrots are rich in carotene. Either a quantitatively very high production (cucumber) or a short growing season (lettuce) may compensate for a low nutritional value. The group of leguminous vegetables ranks lowest in this classification. Other vegetables with a low production of nutrients are watermelons, eggplants and, although containing a high β-carotene content, pumpkins.

4. ACTUAL CONSUMPTION IN DIFFERENT AREAS

General trends

It has been shown (tables 2, 3) that, in developing countries, the average per caput consumption of vegetables is less than half of that in developed countries. Although many more plant species are suitable for consumption as vegetables in developing countries, very few of the hundreds of

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* When the food is consumed raw, vitamin C is calculated as $\frac{mg\ vit.C}{20}$

If much oxalic acid is present, Calcium is expressed as $\frac{mg\ Ca}{200}$

Table 6. Potential yield of valuable nutrients from vegetables. Average Nutritive Value (ANV) from table 5. Yield data recorded as "high production" in USA (see KNOTT, 1966). For the tropical vegetables (*) records of the Horticultural Centre, Porto-Novo, Benin (W.Africa) have been used.

vegetable	yield t/ha gross	yield t/ha edible portion	ANV	ANV per m^2	duration days	ANV per m^2 per day
fleshy fruits						
tomato	45	42.3	2.39	101[a)]	160	0.63
eggplant	25	24.0	2.14	51	200	0.27
sweet peppers	30	26.1	6.61	173	130	1.33
okra	15	13.5	3.21	43	90	0.48
cucumber	50	40.0	1.69	68	150	0.45
pumpkin	20	16.6	2.68	44	150	0.30
watermelon	40	25.2	0.90	23	120	0.19
leaf vegetables						
*)amaranth	30	18.0	11.32	204	50	4.08
*)kangkong	80	57.6	7.57	436	270	1.61
chinese cabbage	30	25.8	6.99	180	90	2.00
lettuce	20	14.8	5.35	79	50	1.58
white cabbage	40	34.0	3.52	120	90	1.33
*)cassava leaves	60	52.2	16.67	870	270	3.22
leguminous vegetables						
asparagus bean (pods)	7	6.2	3.74	23.0	150	0.15
lima bean (fresh)	9	5.1	4.88	25.0	210	0.12
mung bean (sprouted)	2.5[b)]	20.9	2.94	61.5	110	0.56
*)hyacinth bean (dry)	3	3.0	14.03	42.1	180	0.23
bulbs, tubers						
onion	40	38.4	2.05	78.7	150	0.52
carrot	20	16.6	6.48	107.6	90	1.20
taro	20	16.8	2.38	40.0	120	0.33
turnip	13	10.3	2.03	20.9	80	0.26

a) ANV (for 100 g) x edible portion (t/ha) = total ANV per m^2

b) 1 kg of dry mung bean produces 9 kg of sprouted beans

wild edible species are used, and only a very small proportion of these may be cultivated. Generally, the intake of vegetables increases with modernisation, being more pronounced in urban than in rural areas. In areas with a slow rate of development, the consumption of vegetables may even show a decline. These trends may be due to the following factors:

(a) Urban and non-tribal people change their food habits relatively easily. European-type vegetables, such as tomatoes, cucumbers, cabbage and carrots, have a high social value, compared with the local green leaf vegetables and pulses.

(b) Commercial vegetable growers near the cities and along the access roads produce large quantities of fairly cheap vegetables for city markets.

(c) As a consequence of the introduction of cash crops, rural people have less time for gathering wild vegetables or for vegetable cultivation in family gardens and mixed cropping, resulting in a decreased level of home consumption. Moreover, the areas of natural vegetation, formerly a main source of vegetables, are rapidly decreasing.

(d) The modernisation of agriculture implies the introduction of monoculture systems and hampers vegetable production in mixed cropping with staple food plants.

However, with the economic development of the rural areas, vegetable consumption may rise. For example, in Mexico, the annual intake is 35 kg per head per annum in rural and 45 kg in urban areas, whereas in less developed Honduras, a consumption of 18 kg is recorded for rural and 20 kg for urban people (May et al. 1962).

LATIN AMERICA

In Latin-America, the average annual vegetable consumption is very low i.e. about 22 kg per head or 60 g per day. It is lowest in the tropical regions (Brazil 10 kg) and highest in the temperate southern areas (Argentina 50 kg).

Tomatoes are the most widely cultivated vegetable. Squashes, pumpkins and chayotes are also very popular. Melons and watermelons are frequently used for fresh consumption; they are often classified in statistical records as juicy fruits. Hot pepper is indispensable as a seasoning and onions and garlic are important for flavouring sauces and salads. The European types of vegetable such as carrots, cabbage, lettuce, green peas, cauliflower, broccoli, eggplant and bell pepper are becoming more popular in the cities. Some of these species, particularly cabbage and to some extent, beet leaves and kale are becoming increasingly grown in rural areas, mostly in the highlands. Okra is only important in Brazil. Tropical leaf vegetables are less popular but are often used by communities originating from Africa and India. Many commercial vegetable growers in Latin America originate from either China or Japan and cultivate Asian types of vegetable for their own consumption.

Nutritional disorders are mainly the result of calorie and protein deficiency, but may also be caused by an insufficient intake of vitamins and minerals. Xerophthalmia has been reported frequently and is associated with a low intake of green leaf vegetables. Anaemia is common in many areas, even in maize-consuming areas where the intake of iron is high. This indicates the presence of parasites (such as intestinal worms or malaria); another possible cause is a lack of absorption of the available iron, due to a deficiency of Vitamin C.

In many areas in the southern part of Latin America (S. Brazil, Argentina, Paraguay and Uruguay) it appears that a high intake of meat and dairy products lowers the need for protective nutrients such as carotene from vegetables. However, in the Andean zone, as well as in the tropical part of S. America and in C. America, these products are scarce.

AFRICA

In the Sudanian zone (Mauritania, Senegal, Gambia, Mali, Upper Volta, Chad, Sudan) only 13 kg of vegetables are consumed per capita per year. Okra is widely cultivated and is often sun-dried for use during the dry season. Baobab leaves and the leaves and calices of roselle *(Hibiscus sabdariffa)* are also dried. The locust bean *(Parkia biglobosa)* is widely consumed in quantities varying from 3 to 10 kg per head per annum. Hot peppers are the most common spice and there is a growing interest in tomatoes and onions. Besides calorie-protein malnutrition, vitamins A and C are deficient in these cereal-based diets.

The savanna zones of the Guinean countries of West Africa (Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon) show much the same pattern as the Sudanian zone. In the forest zone of West Africa, about 20 kg of vegetables per caput are consumed yearly. The main vegetables used are local eggplant (Ivory Coast, Ghana, Liberia), okra, tomatoes, hot peppers, onions and shallots, and a wide range of leaf vegetables, 6 - 10 kg being consumed yearly. Gathering of wild vegetables has some importance in areas with a low population density. *Corchorus, Solanum macrocarpon* and taro leaves are important leaf vegetables in the Ivory Coast, Ghana and Togo, whereas amaranth and *Celosia* are more important in Benin and Nigeria. Cameroon and Zaire have a great diversity of leaf vegetables. The weed *Talinum* is consumed everywhere and the leaves of cowpeas, cassava and sweet potatoes are frequently consumed locally. Bitter leaf *(Vernonia)* is important in Benin and Nigeria. Leguminous vegetables such as *Voandzeia*, pigeon pea and Lima beans are frequently consumed, as are the seeds of several cucurbits *(Citrullus, Cucumeropsis)*. European-type vegetables are less important; only the richer people in the cities with a high purchasing power attempt to imitate the European diet (see table 13 chapter 8 for vegetable consumption in Porto-Novo, Benin).

In mountainous regions of Eastern Africa (Ethiopia, Zambia, Malawi, Tanzania, Kenya, Uganda, Madagascar, Zaire, Rwanda, Rhodesia, Mozambique), European vegetables, especially white cabbage and carrots, play an important role next to hot pepper, tomatoes, onions and a local leaf cabbage *(Brassica carinata)*. There is less diversity than in the lowlands of these countries, which are somewhat similar to the West African forest belt zone. Amaranth and *Celosia* are important in the lowlands, whereas consumption in the southern part of Africa is directed more towards the sub-tropical and European vegetable species. White cabbage, cauliflower, cucumber, carrot, lettuce, bell pepper and eggplant are next in importance to tomato, hot pepper and onion.

Nutritional disorders are less common in the lowlands and humid areas than they are in the savanna regions. Vitamin A deficiency is non-existent in areas where red palm oil is used but is common in many other regions. Calcium, iron and vitamin C deficiencies are of frequent occurrence.

ASIA

In the sub-tropical southern part of mainland China and in Taiwan, a wide range of vegetables is traditionally used. The intake is about 50 kg per head per annum. The main species are Chinese and white cabbage, mung bean sprouts, radish, turnip, peas, string beans, tomato, hot pepper, egg-plant, amaranth, kangkong, Japanese bunching onion, melon, gourds, cucumbers and bamboo sprouts. Many other types are used, such as lotus, algae and mushrooms, paddy straw mushrooms being commonly cultivated.

In S.E. Asia (Indonesia, Malaysia, Philippines, Thailand, Vietnam, Lao, Democratic Kampuchea) a large assortment of both tropical and temperate vegetable species are consumed, but the total amounts to only 20-25 kg per caput per year.

Leaf vegetables such as: kangkong, chinese cabbage and amaranth are very important. The production of white cabbage is increasing, mainly at the higher altitudes. Many cucurbits are used, such as pumpkin, bitter gourd, cucumber, loofah, wax gourd and bottle gourd. Hot peppers are important for seasoning food; onions and tomatoes are less important but their popularity is increasing. Garlic, shallots, bunching onion, yardlong beans and mung bean sprouts are also popular. Many wild plants and cultivated shrubs are used as vegetables, the most interesting being the Indonesian leaf vegetables *Gnetum, Sauropus* and the S. Pacific *Hibiscus manihot*. As in Africa and Asia, a trend may be observed towards the increasing use of European types of vegetables such as French beans, cauliflower, cucumber, lettuce and carrots. Apart from common calorie-protein malnutrition, deficiencies of riboflavin, calcium, iron, vitamin C and most of all vitamin A are frequently encountered.

In southern Asia (Bangladesh, Burma, India, Sri Lanka), the vegetable consumption pattern resembles that of the S.E. Asian countries. Many European type vegetables such as cabbage, cauliflower, tomato, endive and spinach may be grown during the cool season. Eggplant, okra, chillies, gourds, amaranth and kangkong are grown during the hot season. Several leguminous vegetables are consumed, such as yardlong bean, hyacinth bean and pigeon pea. *Psophocarpus* is popular in Burma, but is grown more for the fleshy roots than for the seeds. The drumstick tree *(Moringa)* is common and is used for fencing compound gardens; both the leaves and the young fruits are consumed.

5. CONCLUSIONS AND RECOMMENDATIONS

(a) The daily consumption per head of vegetables in tropical countries is approximately 100 g, i.e. only 46% of the quantity which is consumed in many temperate countries.

(b) Nutritional needs in tropical countries differ from those in temperate countries. Apart from protein-calorie malnutrition, vitamin A deficiency appears to be the most common nutritional disorder.

(c) Despite regional differences in the need for protective nutrients from vegetables, an average daily consumption of 150 g per head may be taken as a target for improvement, provided that one third of this quantity is contributed from leaf vegetables.

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An example of a Solanaceous fruit vegetable: Eggplant in a garden in Senegal. This particular garden was included in an effort to better the quality of the local diet.

III. SOLANACEOUS FRUITS

1. GENERAL

In this report, particular attention has been given to tomatoes, sweet and hot peppers and eggplant, which are cultivated for their fleshy fruits. *Solanum* species which are cultivated as leaf vegetables are described in Chapter VIII. Other species which are of minor importance and less widespread, e.g. the tree tomato *(Cyphomandra betacea)* and the cape gooseberry *(Physalis peruviana)* have not been considered.

The three major food crops in this group thrive in tropical climates, although tomato and sweet pepper prefer a somewhat cooler climate than hot pepper and eggplant. All are very susceptible to low temperatures. Within this group, similarities occur regarding plant and seed characters, breeding behaviour, cultural practices and the range of pests and diseases to which they are susceptible. Their nutritional value is rather low when compared to that of leaf vegetables (see table 5). However, they supply minerals and vitamins in the diet and this contribution is significant, when large quantities are consumed. Tomatoes and hot peppers are indispensible flavouring ingredients for most tropical meals.

Data on cultivation and seed production of tomato, peppers and eggplant are presented in table 7.

2. TOMATO

Crop information

Botany

Lycopersicon lycopersicum (L.) Karst is an annual herb, variously called tomato, tomate, jitomate or faan ke'e, and love apple. The hermaphrodite flowers are self compatible and highly self-pollinating in cooler climates, but up to 24% cross-pollination by insections has been reported in tropical clim

At least 600 cultivars are described in seed catalogues. Cultivars are classified on growth habit (determinate or indeterminate); fruit shape; cultivation methods (in the open or under glass); and whether the fruit is to be consumed fresh or processed.

Most of the tomatoes grown in the tropics for home use and local markets are primitive cultivars or local selections.

Well-known cultivars which are grown in the tropics for both the fresh market and for home use include the American cultivars : Bonny Best Campbell, Homestead, Indian River, Manalucie, Manapal, Marglobe, Floradel, Pritchard, Rutgers and BWN 21 hybrid. Cultivers suitable for processing include the Italian cultivars:Piacenza, Roma and San Marzono, and the American cultivar Heinz 1370. In the Far East, Best of All, Early Market and Marglobe are well-known cultivars.

Table 7. Data on cultivation and seed production of tomato, peppers and eggplant.

type of vegetable	cultivation (with transplanting)						seed production							
	seed required	density	harvest period	yield t/ha			mean DM yield	weight 1000 seeds	g per kg of fruits	g per plant	kg/ha			multi-plica-ion factor
				low	high	mean					low	high	mean	
	g/ha	pl/ha x 1000	days(a)				kg/ha	g						kg/kg
tomato (European salad type)	400	20-30	70-160	5	45	20	1,240	3.3	2-5	3-8	30	150	80	200
tomato (local type, wet tropics)	600	20-30	60-120	3	10	6	380	2.5	3-6	6-2	10	50	30	50
bell pepper	400	30-50	50-130	7	30	18	1,440	5.5	3-6	5-10	25	100	60	150
hot pepper	500	10-30	90-270	5	15	8	2,770	3.3	25-100	30-80	300	1200	750	1500
eggplant (*Solanum melongena*)	800	10-30	80-200	4	25	12	960	4.0	8-40	10-30	80	150	120	150
African eggplant (*S. macrocarpon*)	600	20-40	60-300	4	16	10	800	3.3	20-40	8-12	120	300	200	350

(a) days from transplanting to the first and to the last harvest

Harvest time for tomatoes in Mexico. Notice the strip cultivation and the use of maize as windbreaks.

Geography and ecology

Originating from C. America, the tomato is now by far the most important world vegetable by production area, commercial value and consumed quantity. It has become a common vegetable throughout the tropics.

The plant requires moderately high day temperatures (21-28°C) and moderately cool nights (15-20°C) for optimum growth and development. Fruit setting is reduced by temperatures which are either too low or too high and is inhibited below 13°C and above 38°C. The tomato is daylength neutral in respect to flowering, but in relatively long days growth may be improved and the dry matter content of the fruits somewhat higher. The tomato plant cannot tolerate a badly-drained soil or a high relative humidity (80%), both of which favour the development of diseases and there is a high water requirement (8-10 mm/day) during the period of fruit development.

Both tall and dwarf cultivars are available, some are suited for lowlands and others for higher altitude cultivation.

Nutritional importance

In temperate regions, most tomatoes are used in salads, but considerable amounts are also used in the preparation of soups, sauces and beverages. In the tropics, however, the fruits are rarely eaten raw but are usually cooked for flavouring sauces. The nutritional value of the tomato is rather low, although better than that of the eggplant. If level of consumption is high, tomatoes may contribute significant amounts of carotene, thiamin, niacin and vitamin C (see table 5).

Economic importance

The registered annual world production is 36 million tons, cultivated in 1.6 million ha (see table 1) although total consumption figures estimate 38.4 million tons. The leading producers are the USA, USSR, Italy, Spain and Egypt. A proportion of world production, particularly that relating to the tropics, has probably not been recorded.

In the wet tropics, crop yields are much lower (3-10 t/ha) than they are in the drier regions which have lower night temperatures (15-45 t/ha). This has given rise to an important regional trade in fresh tomatoes in these more favourable areas. Also, due to the perishable nature of the fruit and by its restriction to dry season production, the use of tomato paste has become widespread; many countries have now established canning industries in order to reduce the level of imports.

Main limitations to cultivation in the tropics

Production techniques in the tropics are generally rudimentary and many important production aids (fertilisers, pesticides and irrigation equipment) are lacking; consequently the level of production is very low. An average production of about 20 t/ha is obtained in mountainous regions and in the cooler parts of the tropics, but this is reduced to about 6 t/ha in the wet tropics.

Adequate control of pests and diseases is extremely difficult and, in this respect, very few cultivars which are adapted to the climatic conditions of the wet tropics are available. Limited research on production techniques e.g. spacing, staking, pruning, mulching, control of pests and diseases, and the application of growth regulations has been carried out. The most important pests and diseases in the wet tropics are: bacterial wilt *(Pseudomonas)*, leaf fungi *(Alternaria, Botrytis, Cladosporium)*, root knots nematodes and several virus diseases (tomato mosaic and streak, double virus streak, spotted wilt and cucumber mosaic). Many others have been recorded, which are locally or regionally serious.

Breeding and germplasm

Centres of diversity, collections

The primary centre of origin of *Lycopersicon lycopersicum* (L.) Karst (2n = 24) is situated in Mexico and in the mountainous regions of the west coast of South America. The progenitor is probably *L. esculentum* var.*cerasiforme* (Dun.) Alef. In Peru, Ecuador, Colombia and Chile, cultivated tomatoes exhibit spontaneous crossing with *L. pimpinellifolium* Mill., indicating a close genetic relationship. This and other wild species e.g. *L. cheesmanii* Riley, *L. chilense* Dun, *L. hirsutum* Humb. and Bonpl. and *L. peruvianum* (L.) Mill. and some *Solanum* species are now included in breeding programmes since they provide valuable genes for resistance to pests and diseases, such as *Fusarium, Cladosporium, Verticillium, Pseudomonas* and *Meloidogyne*.

Several large germplasm collections, mainly of old and new cultivars selected in the temperate regions, are being maintained for the use of plant breeders (see Annex 2). Primitive cultivars from tropical regions and wild or semi-wild South American tomato species and varieties are not well represented in these collections.

Genetics and breeding

The tomato belongs to one of the genetically best-known genera of plants and many genetic factors have been investigated. A great deal of breeding work has been carried out in developed countries (Europe, North America, Japan) and plant breeders are constantly developing new varieties. During the last ten years F_1 hybrids, showing heterosis and combining resistance to several diseases in addition to other desirable factors, have become more popular. Cultivars are now available which have complete or partial resistance to *Fusarium* and *Verticillium* wilt, bacterial wilt *(Pseudomonas)*, nail-head spot *(Alternaria)*, leaf mould *(Cladosporium)*, corky root *(Pyrenochaeta)*, late blight *(Phytophthora)*, bacterial canker *(Corynebacterium)*, tobacco mosaic virus, spotted wilt virus and root-knot nematodes *(Meloidogyne)*. Breeding work is currently in progress with a view to limiting damage by *Rhizoctonia* soil rot, *Stemphylium* leaf spot and several virus diseases. Breeding for resistance to various pathogens is the main task of the tomato breeders. Improvement in quality (flavour, fruit shape, colour, vitamin C content, β-carotene content), earliness, and potential production are also under consideration. Tolerance to salt, resistance to cracking and good fruit setting at either high or low temperatures are locally important criteria.

Many of the modern high-yielding cultivars appear to be suitable for growing in the mountainous regions of the tropics but not in the tropical, lowlands. Breeding work in the tropics has been mainly limited to cultivar screening and testing of cultivars from temperate regions; suitable cultivars adapted to the hottest seasons or for the wet tropics generally are therefore rare or non-existent. In these regions, local selections are usually cultivated and these are fairly well adapted to high night temperatures and high humidities; they are also often less susceptible to diseases. In some countries (Guadeloupe, Mexico, Ghana, Nigeria, India, Hawaii) these cultivars have been improved by selection and by crossing with exotic introductions. The IRAT station in Upper Volta has developed a high yielding cultivar named Farako-Ba which has a high level of resistance to *Pseudomonas*, by using the Caribbean c.v. Floralou.

The quality requirements of new tomato cultivars suitable for processing are strict concerning colour (bright red pulp), total soluble solids (<4.5%), low acidity and a high content of reducing sugars.

Recommendations

Germplasm

Germplasm of wild and hybrid types from Central and South America and of primitive cultivars present in various tropical and subtropical countries should be collected and conserved for breeding purposes. The loss of primitive cultivars is very real since these are gradually being superceded by commercial cultivars. International cooperation should be used to evaluate and document the material available in collections.

Breeding

Breeding work aimed at producing cultivars which are well adapted to the various ecological zones of the wet tropics should be stimulated. The objectives should include the breeding of true-to-seed or hybrid cultivars which are tolerant to high night temperatures and a high level of humidity, producing good fruit set in hot weather with general resistance to the major tomato diseases, particularly to bacterial wilt *(Pseudomonas)*, leaf fungi *(Alternaria, Cladosporium)* the major virus diseases and root-knot nematodes *(Meloidogyne* spp.).

3. CAPSICUM PEPPERS

Crop information

Botany

Capsicum annuum L. var. *annuum* (Bell pepper, Cayenne, Chili), is an annual herb with self-compatible hermaphrodite flowers and is widely cultivated in tropical areas. Most of the hot peppers and all the sweet peppers belong to this polymorphic cultigen and intercross freely, giving rise to a great range of types varying in fruit size, shape, colour and growth habit. *Capsicum frutescens* L. known as Tabasco or Bird Chili, is a perennial species occuring in a wild state and is generally cultivated as a hot pepper. It does not, however, cross easily with the other species. Several other wild or cultivated species of minor importance have been described such as *C. pubescens*, Ruiz. & Pav., *C. chinense* Jacq. and *G. baccatum* HBK var. *pendulum* Willd. (cultivated) and var. *baccatum* (wild) (Eshbaugh, 1974; Heiser and Pickersgill, 1969; Pickersgill, 1969 and 1971).

The leading sweet pepper cultivar is California Wonder, known for its large, smooth, attractive oblong-shaped fruits. Other popular North American cultivars, bred as pure lines, are: World Beater, Burlington, Yolo Wonder, Keystone, Resistant Giant and Ruby King, all of which have a certain degree of resistance to tobacco mosaic virus. Few cultivars of hot pepper are cultivated outside their regions of origin and nearly all those grown in the tropics are local selections.

Self-pollination in peppers is possible, but, for hot and bell peppers, insect pollination is the general rule. Between 2% and 40% of cross-pollination in areas of pepper cultivation have been recorded, with a mean of 8%, and it is therefore difficult to keep the cultivars true to type.

Geography and environmental requirements

Hot peppers are widely used as a flavouring ingredient in tropical regions. The mild-sweet types of *Capsicum*, the so-called sweet or bell peppers, cultivated since the last century as a summer vegetable in the Mediterranean area and in North America, are becoming more popular both in the tropics and in temperate regions.

Temperature is particularly important and sweet peppers give optimal growth at day temperatures in the range 21 to 25°C. Heat injury, retarded growth and poor fruit setting occur at temperatures above 30°C.

For hot peppers, optimum day temperatures are 24 - 30°C; the limits for heat injury are also somewhat higher than they are for sweet peppers. Small-fruited cultivars are more tolerant to hot weather conditions than the large-fruited ones.

The water requirements of capsicums are similar to those of cotton (450 mm per annum), but the supply must be regular, particularly for bell peppers.

Nutritional importance

The nutritional content of hot peppers is relatively high (see table 5) but the intake per meal is generally low (1-4 g per caput). The ANV is extremely high (27.92), due to the high dry matter content. Calculated on a basis of 100 g dry matter, the ANV (80.7) is similar to that of bell pepper (82.6). Bell peppers can be consumed in much larger quantities, up to 20 g per meal, and constitute a potentially important food source for nutritional improvement, especially with regard to their vitamin C content.

Economic importance

Hot pepper is one of the most important commercially grown vegetables in the tropics, and is probably the most important, after the tomato. It is also exported to temperate countries in a dried form, mainly from India, for use as a spice in flavouring sauces and canned products. However, the greater part is produced for home consumption.

Sweet peppers are grown in some tropical and subtropical areas such as Senegal, Kenya and North Africa during the winter months for export to Western Europe. The greater part of the sweet pepper production is sold in local markets but the general level of production and consumption in the tropics is low.

Capsicum peppers on sale in a market in Bolivia. Peppers are integral in the diet of these settlers who come from the Altiplano to cultivate and live in the lowlands.

Main limitations to cultivation in the tropics

Hot pepper cultivation is hampered by many pests and diseases, although to a lesser degree than the tomato. Tobacco mosaic virus is probably the most serious disease, but bacterial wilt *(Pseudomonas)* and fruit flies are also common problems in pepper cultivation in hot climates. Bell peppers are more susceptible to diseases than hot peppers, especially the wilt diseases such as *Pseudomonas*, *Fusarium* and *Sclerotium*.

Reliable seeds of suitable hot pepper cultivars are either non-existent or not available. Good bell pepper seed may be found, but the popular cultivars are relatively unsuitable for growing in the wet tropics and during the hottest seasons.

Breeding and Germplasm

Centres of diversity, collections

The areas of Meso-America and the Andean zone are the primary centres of *Capsicum annuum*. Since the Columbian era, secondary centres have developed in southern and central Europe, Africa and Asia. The wild variety *minimum* is probably the ancestor of the cultivated variety *annuum*. The centre of origin of *C. frutescens* L.(from *C. chinense* Jacq.) is also located in Meso-America and, as with *C. annuum*, secondary centres have arisen elsewhere.

Interspecific relationships in *Capsicum* and the relations between weedy and cultivated forms have been studied e.g. Eshbaugh, 1970; Pickersgill, 1967, 1971). The variability existing in local populations of *C. annuum* is extensive. Many useful genes have already been identified in hot peppers and are being used in breeding work. Germplasm collections exist (see Annex 2) in many countries, mainly in agricultural stations where breeding work is being carried out. No systematic records of these collections are currently available.

Genetics and breeding

Much breeding work has been carried out on bell-peppers, mostly in the USA, but also in France, Italy, Japan, Brazil, USSR, India and European countries such as Czechoslovakia, Bulgaria, Hungary. Important criteria for selection are a high yield, resistance to virus diseases (tobacco and cucumber mosaic), good fruit shape with a sweet, non-pungent taste, few seeds, and early production with a first harvest approximately 60 days from transplanting. Cultivars such as Allbig give good fruit setting in hot weather. Some cultivars of Hungarian paprika, with an elongated conical shape, have been selected for a high paprika-aroma content, thin skins facilitating drying, and for the production of a bright red powder on dehydratuin. More advanced techniques, such as the application of haploidy, tetraploidy, cytoplasmic male sterility and heterosis breeding are already being used by plant breeders. For mechanised cultivation, types with a compact habit, determinate growth and simultaneous ripening are required.

The breeding of hot peppers is at a much less advanced stage. In the USA cultivars such as Anaheim and Chili Cayenne (both *C. annuum)* and types of Tabasco (*C. frutrscens)* are widespread. The cultivars of *C. annuum* have been selected for early yield, such as 120 days from transplanting to fruit harvest compared with 150 days for normal cultivars, a high capsaicin content (the factor governing pungency), smooth shape for canning and thinwalled furits for drying. Several horticultural stations in tropical countries such as Ethiopia, Ghana,

Ivory Coast, Nigeria, Philippines, Mexico, Puerto Rico, India and Korea have programmes directed towards the improvement of the local hot pepper cultivars, mostly by simple cultivar testing but also by hybridisation. The improvement of disease resistance in the locally preferred types and of types suitable for export as dried hot peppers would appear to be the most important objectives. Donors for resistance to bacterial wilt *(Pseudomonas)*, virus diseases (tobacco mosaic, tomato etch, cucumber mosaic) and *Cercospora* have been found, the hot pepper cv. College No. 9 Chili has been found to possess resistance to *Fusarium annum*. Local West African (thick-walled) hot peppers are not frequently attacked by fruit flies. There exists an obvious resistance to *Sclerotium* (cv. World Beater) and *Phytophthora;* variation in susceptibility to nematodes and *Aphis* has also been noted in several cultivars.

Recommendations

Germplasm

Genetic material may be lost as the primitive and older cultivars of sweet pepper are replaced by newer ones. An inventory should therefore be made of existing germplasm collections. There are fewer risks of genetic erosion occuring in the various hot pepper populations grown in the tropics or in the wild and semi-wild *Capsicum* species existing in Central and South America. However, collecting and testing of this germplasm source is advisable, in order to make it available to plant breeders in other tropical regions.

Breeding

Plant breeders should aim to produce bell pepper cultivars which are suitable for tropical climates; these should combine many types of disease resistance with a high vitamin C and pro-vitamin A content.

Hot pepper cultivars should be selected for resistance to virus and to fruit flies and for high yielding performance.

4. EGGPLANT

Crop information

Botany

The names eggplant, garden egg, aubergine, terong, aikwa and brinjal apply to several *Solanum* species with fleshy fruits, *S. melongena* L. being the most commonly cultivated species. *S. anomalum* Thonn., *S.macrocarpon* L., *S. aethiopicum* L., *S.incanum* L., *S. duplosinuatum* Klotsch. and several other minor species are cultivated in Africa and *S.quitoense* Lam., *S.muricatum* Ait., *S.topiro* Humbo.& Bonpl. in C. and S. America. *S.aethiopicum* and *S.macrocarpon* are cultivated not only for the fruits but also for their edible leaves (see 105). In S.E. Asia small fruits of *S. ferox* L., and *S.torvum* Swartz. are eaten.

S. melongena is self-compatible and highly self-pollinating. In hot, humid climates up to 20% cross pollination from surrounding plants may occur, by insects or by the wind.

Principal cultivars are: Black Beauty, Florida Market (resistant to *Phomopsis* fruit rot), Black Magic (an early hybrid, the first harvest being produced after 72 days), Improved Long Purple, Peradeniya, Florida High Bush and Improved Muktakesu (resistant to *cercospora*). In most countries, however, local cultivars are more common than the high yielding exotic cultivars since they are more adapted to the prevailing ecological conditions and are preferred by the local population. Local cultivars exhibit a wide range of colour forms and shapes. Colour varies from white, yellow, green to purplish-black and shape from short to long and ovoid to sausage-shaped. Many of the other species have much in common with *S.melongena* and are liable to the same pests and diseases.

Geography and ecology

Eggplants are cultivated in most tropical and subtropical areas, also in temperate areas which have a warm summer. Optimum day temperatures range from 25-35 °C and optimum night temperatures from 20-27 °C. Eggplants are more susceptible to low temperatures than tomatoes or peppers and cannot tolerate frost.

Eggplants grow well in the wet tropics. They are less susceptible to diseases than either the tomato or sweet pepper. As far as is known, the primitive African species have the same ecological requirements as *S. melongena* but the South American species prefer a cooler climate. There is no reported daylength reaction.

Nutritional importance

The fruits of eggplants have a somewhat lower nutritional value than those of tomato (see table 5). The intake of eggplant fruits per meal may be relativel high, up to 200 g/caput.

Economic importance

The eggplant is an important vegetable in Central, S. and S.E. Asia and also in some African countries. In the Ivory Coast, for example, *S. macrocarpon* and *S. incanum* are ranked second in the quantity of vegetables consumed (about 4 kg/caput/year), and are placed after okra and before tomatoes and peppers. It is a common market vegetable in most tropical countries but most of the production from home gardens or in mixed cropping with staple food crops is for home use. It is also an important vegetable in the subtropics (India, North Africa, Central America) and in the warm temperate regions (Mediterranean area, Central Asia, America).

Main limitations to cultivation in the tropics

The eggplant is liable to various wilting diseases (*Pseudomonas, Fusarium, Verticillium, Sclerotium*) and is susceptible to root-knot nematodes (*Meloidogyne*. Many other locally important pests and diseases have been reported. Leaf curl is a serious virus disease in many parts of Africa and Asia.

Breeding and germplasm

Centres of diversity, collections

Solanum melongena (2n = 24) probably originated in India and shows secondary diversity in China and S.E. Asia. *S. aethiopicum* (2n = 24), *S. macrocarpon* (2n = (2n = 36?) and *S. incanum* (2n = 24) originate from tropical Africa. *S. quitoense* (2n = 24), *S. muricatum* (2n = 24) and *S. topiro* (2n = ?) all originate from S. America and are mainly cultivated there although limited plantings of *S. muricatu* have been observed in Ethiopia. About 100 old and modern cultivars of *S. melongena* have been collected in seed banks in the USA, USSR and in breeding institutes in Europe. Few collections of either the numerous primitive or more advance local cultivars have been reported but interest is shown in these in Indonesia.

Genetics and breeding

Much breeding work (pure line selection) has been carried out, mostly in the USA but also in India, Sri Lanka and elsewhere. The eggplant withstands inbreeding and shows a limited response to heterosis. Hybrid varieties have been bred, applying male sterility, but these are not yet widely cultivated.

In Hawaii, the high yielding cv. Waimanalo Long has been selected. In India, interspecific hybrids with wild *Solanum* species are used in breeding for resistance to root-knot nematodes and to insect damage by *Leucinodes* (fruit and shoot borers). Resistance to leaf spot *(Alternaria)* has also been obtained. In Brazil, cultivars are selected which are tolerant to *Verticillium* wilt and anthracnose *(Colletotrichum)*. In Japan, *S. integrifolium* (? syn. *S. incanum*) is being used as a parent for the introduction of disease resistance. The Japanese cv. Nihon Nassu possesses resistance to bacterial wilt *(Pseudomonas)* and to anthracnose. In Guadeloupe, a breeding programme for bacterial wilt resistance is in an advanced stage. A cultivar Madinina whith is tolerant to bacterial wilt is already being commercially grown and a tolerant cultivar Bulacan, which is high yielding and contains very few seeds, has been reported from the Philippines. Breeding work on eggplant species other than *S. melongena* is either scarce or non-existent, except for some testing of local cultivars of *S. macrocarpon* and *S. incanum* in the Ivory Coast and Ghana, screening of *S. macrocarpon*, *S. aethiopicum* to diseases in Nigeria, and testing of local cultivars of *S. quitoense* in S. America.

Recommendations

Germplasm

Primitive cultivars of *S. melongena* and of other eggplant species in all tropical countries are being rapidly replaced by more advanced, high yielding *S. melongena* cultivars. Much material is still present in Asian countries but there is noticeable erosion in Indonesia and the Philippines and some danger in Thailand and Malaysia. The collection of other eggplant species for use in breeding is recommended and material should be screened for the presence of genes for disease and pest resistance.

Breeding

Resistance breeding to wilt diseases and root-knot nematodes should have first priority. Useful types for wider distribution may be found within the local eggplant populations, for example, the West African *S. macrocarpon*, which is cultivated for the leaves and fruits in home gardens and in commercial plantings although *S. macrocarpon* is susceptible to *Cercospora*.

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Examples of fleshy cucurbit fruits (marrows). There is a wide range of diversity in these vegetables thoughout the tropics.

IV. CUCURBITS

1. GENERAL

In Chapter II it was shown that cucurbits are an extremely important group of vegetables in both temperate and tropical regions. In this chapter, only the most important species which are cultivated for fruits will be dealt with. However, leaves, flowers, seeds and even the roots of some cucurbits are used as food. Only one species, *Telfairia occidentalis* Hook. f. is cultivated primarily for leaf production and is therefore listed with the leafy vegetables in chapter 8. Several species are cultivated for the dry seeds which are rich in protein and oil and are therefore comparable with groundnut and soya, e.g. the climbing *Cucumeropsis edulis* (Hook. f.) Cogn., *Telfairia occidentalis*, the twining *Citrullus lanatus*, (Thunb.) Mansf., some *Cucurbita* spp. and *Lagenaria siceraria* (Molina) Standl. The most important species in Africa for seed production is *Citrullus lanatus* from which oil is commercially extracted (see 4.2.).

The nutritional composition of some important cucurbits has been presented in table 5. Nearly all the fleshy cucurbit fruits have a poor nutritional composition. Exceptions are the yellow-fleshed pumpkins and melons which have a high B-carotene content and the bitter gourd which has a high iron and vitamin C content. The fleshy cucurbit fruit is appreciated in developed countries as a low calorie flood.

In the tropics, the daily intake of these fruits may be high, their contribution of vitamins and minerals should therefore not be underestimated. Pumpkins (*Cucurbita* spp.) may even serve as a source of carbohydrate. Cucumbers are eaten raw in salads, melons and watermelons are consumed in a ripe state as dessert fruits and either the immature or the ripe fruits of many other vegetable cucurbits are cooked.

The cucurbits form a distinct group of species with many similarities in botany, agronomy, ecological requirements and susceptibility to pests and diseases. Nearly all are monoecious plants with unisexual flowers which are pollinated by insects. Cucurbits grow well at day temperatures between 20 and 35°C; they cannot tolerate frost or strong winds. Low temperatures and a high relative humidity stimulate the development of female flowers. Cucurbits may show a slight photoperiodic reaction to short days. Some tropical cucurbits, such as *Cucurbita moschata* Duch. appear to require short days for flowering. The main species of cucurbits are described in the following sections:

2. *Citrullus lanatus* (Thunb.) Mansf. - watermelon
3. *Cucumis melo* L. - melon, muskmelon, canteloupe
4. *Cucumis sativus* L. - cucumber, gherkin
5. *Cucurbita* spp. - pumpkins, squashes, vegetable marrow
6. *Benincasa hispida* (Thunb.) Cogn. - waxgourd, white gourd, Chinese preserving melon

7. *Lagenaria siceraria* (Molina) Standl. - bottle gourd, white flowered gourd

8. *Luffa aegyptiaca* Mill. - loofah, sponge gourd

9. *Momordica charantia* L. - bitter gourd, calabash

10. *Sechium edule* (Jacq.) Swartz - chayote, guisquil

Many other cucurbit species are cultivated in the tropics for the production of either young or mature fruits but they are of local importance only. Since they have a low nutritional content and no apparent economic value, they are not fully described here. Examples are:

- *Cucumis anguria* L. : West Indian gherkin, (young fruits used raw) New World (See Meeuse, 1958)
- *Coccinia grandis* (L.) Voigt : ivy gourd (Young and ripe fruits and leaves) India, S.E. Asia
- *Cyclanthera pedata* (L.) Schrad.: korila. Young and ripe fruits and shoots. Latin America especially Mexico and the Himalayas
- *Trichosanthes cucumerina* L. : snake gourd (young and ripe fruits) W. Africa, Latin America, India, S.E. Asia.

Notes on cultivation and seed production of cucurbits are shown in table 8.

2. WATERMELON

Crop information

Botany and cultivars

Citrullus lanatus (Thunb.) Mansf. (2n = 22) is a shortlived trailing plant yielding 2-10 kg/annum of heavy, juicy, sweet fruits. It is widely cultivated in the drier lowland regions of the tropics. At least 300 local and modern cultivars have been described. Charleston Gray, Mississippi, Sugar Baby, Chilian Black, Black Diamond, Congo and Crimson Sweet are cultivars which are particularly suitable for growing in the tropics. Many local cultivars are known, most of them occuring in S.E. Asia and India.

In Africa, local cultivars with bitter fruits are widely cultivated for the edible seeds. These seeds, called 'egusi' in W. Africa, are an interesting product of the traditional mixed cropping system, giving an additional crop with a high nutritional value. Very little information on this locally important crop is available. The fruits of several wild types are also used as a stewed vegetable.

Geography and ecology

Watermelons require a relatively dry, warm climate and a dry period is essential for fruit setting. It is a popular dessert fruit in the near East, North Africa, Latin America and S.E. Asia. Commercial cultivation during the dry season, under irrigation, is very common. No specific reaction to day-length has been reported. The optimal day temperature range is between 25 and 30°C.

Table 8. Data on cultivation and seed production of cucurbits.

species, type	maturity when fruit used	cultivation: seed needed kg/ha	density hills /ha x 1000	harvest period a days	yield t/ha low	yield t/ha high	yield t/ha mean	seed production: weight 1000 seeds g	No. per fruit	g per plant	kg/ ha low	kg/ ha high	kg/ ha mean	multi-cation factor kg/kg
Citrullus lanatus	ripe	2-4	5-10	90-120	8	40	12	70	50-250	35	100	400	250	125
Cucumis melo	ripe	2	15	75-120	5	20	8	25	50-500	20	100	600	300	150
Cucumis sativus	young	2-5	10-25	60-150	10	50	30	25	50-250	25	150	800	400	160
Cucurbita maxima	ripe	2	5	90-150	6	20	10	170	100-600	50	200	800	500	250
Cucurbita pepo	young	4	20	50-120	10	30	15	70	50-200	25	200	800	450	110
Benincasa hispida	young	2	8	80-160	10	80	20	70	100-250	30	100	400	250	80
Lagenaria siceraria	young	3	6	100-180	10	30	15	150	50-250	70	200	600	400	130
Luffa cylindrica	young	3	3-15	80-180	8	15	11	90	50-250	30	100	400	250	80
Momordica charantia	few days before ripe	5	40	70-110	5	15	8	60	20-150	10	100	400	250	50
Sechium edule	ripe	500	2	120-360	20	150	60	-	1	-	-	-	-	120

a days from transplanting to the first and to the last harvest.

Nutritional importance

The nutritional value of watermelon is very low, lower even than that of cucumber (see table 5). Seeds are particularly valuable and African cultivars may contain 50% oil and 35% protein with high amounts of essential minerals (Fe, Ca, Zn, P, K, Mn). Amino acid composition compares with soyabean but melon seeds have limited lysine and methionine (Oyenuga and Fetuga, 1975)

Economic importance

Watermelons are highly commercialised and constitute an important product of city markets. The fruits are easily damaged and, in a warm and humid atmosphere, they can be stored for short periods only. This vegetable is not particularly suitable for intensive production and for home gardens since it requires a large area for full development.

Main limitations to cultivation in the tropics

Modern cultivars of the watermelon are extremely susceptible to pests and diseases. Plants are often attacked by aphids, cucumber beetle and other insects. The ripe fruits are often seriously damaged by fruit flies and the melon fly. The main diseases are: *Cercospora* leafspot, anthracnose *(Colletotrichum)*, *Fusarium* wilt, downy mildew *(Pseudoperonospora)*, powdery mildew *(Sphaerotheca, Erysiphe)*, and mosaic virus. The plant is also very susceptible to root-knot nematodes.

Breeding and germplasm

Centres of diversity, collections

The species probably originated in tropical Africa, where numerous wild types are present. It has been cultivated in the Mediterranean area and in Asia for several thousand years where secondary diversity occurs.

Large collections of old cultivars are maintained at the breeding stations and gene banks mentioned in Annex 2; the largest is probably in Beltsville, (USA).

Genetics and breeding

Much breeding work has been carried out on watermelon, mostly in the USA. Japanese breeders developed the first commercial seedless triploid cultivars and, in the USA hybrid cultivars which have been produced using male sterility are becoming popular. Both yield and quality are high. Cultivars with a firm outer skin, useful in long-distance shipping, have also been developed. Resistance to various diseases has been obtained by intensive hybridisation between local and wild types, e.g. resistance to *Fusarium* wilt and different races of anthracnose.

Recommendations

Germplasm

Both wild forms and primitive cultivars should be collected from tropical Africa, although genetic erosion in this African material is not yet widespread. Local cultivars grown in Asia, however, could easily be lost as they become replaced by high-yielding commercial cultivars.

Breeding

High priority should be given to breeding work on this economically and socially important vegetable. Selection of watermelon cultivars with horizontal resistance to many pests and diseases, with a view to successful cultivation in the wetter parts of the tropics, should be initiated. More attention must be paid to research and breeding programmes on the West African types which are grown for their seeds (e.g. cvs. Bara, Serewe and Sofin in Nigeria).

3. MELON

Crop Information

Botany and cultivars

Cucumis melo L. (2n = 24) is a short-lived, twining, monoecious plant with predominantly unisexual flowers, individual plants yielding 0.5 - 2 kg of heavy, juicy fruits. Growth is less vigorous than that of watermelon. Many primitive and modern cultivars are known. In the USA, muskmelons, cantaloups and winter melons are distinguished. Some popular American varieties, cultivated in many countries, are: Hale's Best, Honey Dew, Honey Rock and Smith's Perfect. Each production area has preferred cultivars. In India and S.E. Asia, approximately 100 local and commercial are grown. *Cucumis melo* convar. *conomon* (Thunb.) Greb. is a pickling melon which is cultivated in China and S.E. Asia for the ripe fruits which are used as a cooked vegetable.

Geography and ecology

Melons are mainly grown during the dry season in the subtropics and are difficult to grow in the tropics except in low rainfall regions. They prefer somewhat lower temperatures than watermelons, the optimum growing temperature range being 20 to 35°C.

Nutritional importance

The nutritional value of white-green fleshed melons is higher than that of watermelons, owing to a greater vitamin C content. The deep yellow muskmelons or cantaloupes also have a much higher β-carotene content (1.7 mg/100 g) than the green-white fleshed melons (0-0.1 mg/100 g).

Economic importance

Melons are a more popular fruit vegetable in developed countries than watermelons, but they are much less important in tropical developing countries.

Main limitations to cultivation in the tropics

Melons are affected by the same pests and diseases as watermelons. They are very susceptible to shoot borers and fruit flies and cannot be grown successfully in wet climates. Melons may also suffer serious damage from downy mildew *(Pseudoperonospora)*, powdery mildew *(Sphaerotheca)* and bacterial soft rot *(Erwinia)*.

Breeding and germplasm

Centres of diversity, collections

The melon originated in tropical and subtropical Africa, where many wild types occur. Secondary centres of diversity are the older cultivation areas in Asia (China, India, Iran, USSR: see Leppik, 1966). Working collections are maintained at several gene banks and at stations where breeding work is carried out (see Annex 2).

Genetics and breeding

A great deal of breeding work on melons has been initiated, mostly in the USA. Hybrid varieties with resistance to *Fusarium* wilt and to powdery and downy mildews have been developed. The advanced cultivars combine high yield and quality with resistance to several diseases.

Recommendations

Germplasm

There appears to be no significant risk that the wild and partly wild forms of *Cucumis melo* will disappear from tropical Africa; it is possible that some have genes for disease resistance. Primitive American and Mediterranean cultivars have been collected. There is, however, a danger that local Asian cultivars will be lost.

Breeding

If breeding work for the tropics is considered, increasing the carotene content should be an important objective although the production of cultivars with a high degree of pest and disease resistance should have the first priority.

4. CUCUMBER

Crop Information

Botany and cultivars

Cucumis sativus L. (2n = 24) is a monoecious, annual, climber or creeper. The fruits are used in an unripe state - in temperate regions they are usually eaten raw in salads or pickled, but they are also stewed in tropical regions. Many cultivars of this ancient cultigen exist, often with varying ecological requirements. Cultivars which perform well under tropical conditions include: Tex Long, Ashley, Fengshan Green and Poinset, the latter having a high resistance to powdery and downy mildews. 'Eprix' pickling cucumber has some resistance to nematodes. Southern Cross, Market King and Pixie are recommended for the Pacific Islands.

Geography and ecology

Cucumber is an old cultigen from Asia and the Mediterranean area, cultivated for centuries. It is a typical vegetable of warm temperate and cool tropical areas. The optimum range of day temperatures is between 22 and 30°C. The pickling cucumber cultivars, also called gherkins, prefer a somewhat cooler climate than cucumbers.

Nutritional importance

The calorific and nutritional value of cucumbers is very low (see table 5). It is a popular vegetable in developed countries where there is an excessive calorie intake. Owing to the very high yields obtained (see Table 6) the nutrient production per ha is reasonable.

Economic importance

The cucumber is, after the tomato, the second most important vegetable species in W. Europe, where it is cultivated mainly in glasshouses. In the subtropics and tropics, however, the cucumber is much less important. It is rarely cultivated in tropical Africa and America, but is more popular in Asia, particularly in the cooler areas. The export of cucumbers and pickling cucumbers to temperate areas could become economically important for some regions.

Main limitations to cultivation in the tropics

Diseases of watermelons may also affect cucumbers, but to a more serious extent. During the wet season, many leaf diseases, including mildews, cause a serious loss of production.

Breeding and germplasm

Centres of diversity, collections

The cucumber probably originates from Asia (Himalayas, Burma, and North India) where wild and weedy types of *Cucumis* are present e.g. *C. hardwickii* Royle. Related wild *Cucumis* species occur in Africa. Secondary centres of the cucumber are in China and the Near East. Many collections for plant breeders are available (see Annex 2), comprising both primitive races and more advanced cultivars.

Genetics and breeding

A great deal of work on the breeding and genetics of cucumber has been done. Genetically, it is one of the best known vegetable species. Parthenocarpic and female cultivars have been developed, and hybrids exhibiting heterosis have been produced from female lines. Resistance to many diseases has been obtained by hybridisation, the most important being resistance to powdery and downy mildews, anthracnose, scab *(Cladosporium)*, bacterial soft tot *(Erwinia)* and mosaic virus. Interspecific hydridisation may open new perspectives.

Recommendations

Germplasm

With increases in breeding programmes and commercial seed production,the old cultivars from India, China and other parts of Asia should be collected systematically for conservation, especially since material from secondary centres of diversity are known to be useful in breeding resistance to diseases.

Breeding

Selection work should aim at producing suitable cultivars for the hot and wet tropics but no priority should be given to the cucumber in these areas, as the economic importance is limited and the nutritional value very low.

5. PUMPKINS AND SQUASHES

Crop information

Botany and cultivars

The fruits of *Cucurbita* spp. are called pumpkins, winter squashes, summer squashes or vegetable marrows, but these names give no indication of the relevant botanical species. The most commonly cultivated species are *C. pepo* L., *C. moschata* Duch. and *C. maxima* Duch. Fruits of *Cucurbita* spp. with a hard outer skin, suitable for long storage and used when ripe, are called 'winter squash' in the USA. This latter term also includes the 'pumpkin'; this type is the one most commonly grown in the tropics. Pumpkins are yellow-fleshed and are normally described as belonging to the species *C. maxima*. Some important pumpkin cultivars are: Sugar, Cheese and Cushaw and Baby Delica, Butternut, Blue Kiori are recommended in the Pacific Islands.

Summer squash or vegetable marrow (mostly *C. Pepo*) is the name given to *Cucurbita* spp. consumed when immature. Well-known cultivars are: Long White, Cocozelle and Zucchini, all bush types of Italian origin. Other cultivars have a vine-like growth habit, such as Crookneck and Straightneck.

Winter squash cultivars include: Table Queen and Hubbard. Many local cultivars of pumpkins, marrows and (winter) squash are known in the subtropical and tropical areas, principally in S.E. Asia, and Meso America, less so Africa. The tropical lowland pumpkins are generally referred to as *C. Moschata*.

Geography and ecology

Pumpkins, and to a lesser extent marrows, are popular vegetables in Asia and Latin America, but are less widely grown in Africa. Pumpkins are cultivated in home gardens, on refuse heaps, and also as inter-crops in the fields e.g. together with maize. In addition to the ripe fruits, the flowers and young leaves are also eaten. The bushy type of marrow is cultivated by commercial vegetable growers. Performance is better in wet areas than in dry and they may be grown during the rainy season when melons and watermelons are less successful. Pumpkins and squashes are grown from sea-level up to altitudes of 2000 m.

Nutritional importance

The nutritional value of the *Cucurbita* species with yellow or red flesh is higher than that of cucumber, due to the high carotene content (see table 5). In the unripe state, the nutritional value of the fruits of marrow is much lower. However, their consumption is less widespread than that of pumpkins or squashes, which are generally consumed in the ripe state. Pumpkin leaves are a popular leaf vegetable in Asia (Philippines) and W. Africa.

Economic importance

Pumpkins are sold in tropical markets as a cheap form of produce which is of minor importance. Cultivation is relatively easy and the level of production is high. Pumpkins store well over long periods, especially the hard-rind winter squashes.

Main limitations for cultivation in the tropics

Pumpkins are subject to the same diseases as watermelon, but to a lesser extent. In hot, wet tropical climates, many fruits may be lost due to *Choanephora* wet rot, and *Alternaria* leaf spot may cause moderate infections.

Breeding and germplasm

Centres of diversity, collections

Cucurbita spp. are native to the southern part of N. America, Mexico and C. America south to N. Argentina. *C. lundelliana* Bailey is probably the progenitor of the group of cultivated species and they are related to several other wild or weedy species. *C. Maxima* shows secondary diversity in India.

In parts of S.E. Asia there are very old introductions of *Cucurbita* spp. Breeding stations maintain working collections (see Annex 2).

Genetics and breeding

Breeding problems in marrows *(C. pepo)* have received much attention in the USA. and S. Europe. High yielding hybrid cultivars are now becoming popular. Many interspecific crosses between related cultivated and wild species have been produced and offer interesting possibilities for breeding high disease-resistant cultivars. Amphidiploidy and embryo cultures are useful techniques for creating such species hybrids. In Japan and the USA., commercial cultivars of the hybrids of the three major cultivated species have been developed. Little, if any, work appears to have been done on tropical pumpkins.

Recommendations

Germplasm

Ancient tropical cultivars are in some danger of disappearing with the introduction of modern commercial cultivars, but, to date, the danger appears to be slight.

Breeding

Screening of various tropical cultivars of the yellow-fleshed pumpkins and further improvement by hybridisation is highly desirable. The yield potential should also be improved.

6. WAX GOURD

Crop information

Benincasa hispida is a vigorous, annual, climbing or creeping plant. At least ten different local cultivars are known in S.E. Asia, mainly differing from each other in fruit shape. The fruit weight varies from 1 to 40 kg. Some crops are grown for the production of immature fruits, but the ripe fruits, which can be stored in a cool, dry place for at least six months, protected by their wax outer layer, are more widely used.

Geography and ecology

Benincasa hispida is an important vegetable in southern China, India and all countries of S.E. Asia, being grown from sea-level up to altitudes of 1,500 m. It has been introduced into Cuba and is found in a few regions of America, especially the southern USA, where there are Asiatic communities.

The plant requires a hot and moderately humid climate. In N. India it has been demonstrated that the highest production (20 t/ha) is obtained from sowings from June to August, flowering taking place in October-November; both cool weather and short days during these months stimulate the development of female flowers.

Nutritional importance

Although young leaves, flowers and both immature and mature seeds may be consumed, the main product of the wax gourd is the mature fleshy fruit, the seeds of which are removed before cooking. The food value is very low and is comparable with that of cucumber (see table 5). It contains no pro-vitamin A.

Economic importance

The wax gourd is cultivated in home gardens, with supports, but is also grown as a cash crop in the field without supports. It is a highly commercialised vegetable due to the fact that the fruits can be stored for appreciable periods without deterioration.

Main limitations to cultivation

The wax gourd is not very susceptible to pests and diseases. Fruit flies may damage the young fruits and caterpillars sometimes feed on the leaves. Serious fungal diseases, however, have not been reported. The production level is low, compared with that of the cucumber.

Breeding and germplasm

Centres of diversity, collections

Although cultivated throughout tropical Asia, the origin of this cultigen is probably Indonesia. No wild relatives or ancestors are known. Small working collections are available at horticultural stations in S.E. Asia and India (see Annex 2). There appears to be no urgency in collecting in Thailand, Malaysia or Indonesia.

Genetics and breeding

Some selection work on local cultivars has been reported from India and Japan, where the wax gourd appears in seed catalogues.

Recommendations

Germplasm

The collection of primitive cultivars for plant breeders is recommended but there appears to be no danger of losing such cultivars at present.

Breeding

Selections of highly productive cultivars of good quality, within the available material through variety testing and inbreeding, is advised.

7. BOTTLE GOURD

Crop information

Lagenaria siceraria (Mol). Standl. (2n = 22), the bottle gourd or calabash gourd is a vigorous creeping or climbing annual plant. It is mainly cultivated for the hard fruit skin, which is used in the manufacture of domestic utensils. Other cultivars are grown as vegetables, the young fruits and, occasionally, the ripe seeds, being eaten.

Many local cultivars with various shapes are grown, but commercial varieties are also available.

The bottle gourd is a popular vegetable in China, India, S.E. Asia and Sri Lanka where fruits have been selected which are less bitter. It is grown for the market and for domestic use. The crop is well adapted to a hot, dry climate.

The fruits have a low nutritional value (ANV=1.61), comparable with that of cucumber.

The bottle gourd rarely suffers from diseases and pests although plants are susceptible to anthracnose during the rainy season in India. The production level is low, compared with that of cucumber. The storage life is very limited.

Breeding and germplasm

Several wild species of the genus *Lagenaria* occur in tropical Africa, which may be a centre of diversity. It spread throughout the tropics at an early date and secondary centres are present in tropical America, Brazil, India and S.E. Asia, where the types eaten as a vegetable are to be found. Some material is available in national institutes, particularly in India.

Some research and breeding is carried out in India. Hybrid varieties are still in an experimental stage.

Recommendations

Although not generally in direct danger of genetic erosion (although this is clearly evident in Indonesia) an evaluation of local cultivars could be useful. Since this vegetable is only of minimal economic importance on a world scale and, since the nutritional value is low, a low priority should be given to breeding programmes. The yield potential requires improvement.

8. LOOFAH

Crop information

Luffa aegyptiaca Mill. (2n = 26), the loofah, vegetable sponge, sponge gourd or rag gourd, is a very robust climbing annual cucurbit, widely grown for its ripe fruits which yield a fibrous, spongy material. The young fruits, however, are often used as a cooked vegetable. Special vegetable cultivars of loofah are grown specifically for this purpose and seed is commercially available. *Luffa acutangula* (L.) Roxb., the ridge gourd, is cultivated in the Far East to a lesser extent than *L. aegyptiaca*, but for the same purposes.

The loofah is widespread in the humid tropics, but is only important as a vegetable in India and S.E. Asia. It thrives well in the tropical lowlands and in areas with day temperatures above 2[illegible].

The nutritional value is rather low (ANV= 2.04) which is comparable with that of the wax gourd. It has a short storage life. Loofah is grown mainly in home gardens, where plants are supported by trellises or fences; it thrives well on the poorer sands. It is a cheap vegetable, sold in markets in many regions of Asia.

Breeding and germplasm

Primary gene centres probably occur in tropical India. Some other *Luffa* species also occur here: *L. graveolens* Roxb. the progenitor of both cultivated species and other species probably best regarded as forms of *L. aegyptiaca* and *L. acutangula*. Some testing of local cultivars has been reported from India.

Recommendations

There is no imminent danger of genetic erosion. This vegetable is of minor economic importance and has a low nutritional value. In general, no high priority for breeding work is recommended, although collection and use in breeding of old cultivars in Malaysia and the Philippines are recognised in these countries.

9. BITTER GOURD

Crop information

Momordica charantia L. (2n = 22) is a slender, climbing plant. The bitter young fruits are used as a vegetable and the leaves and tender shoots are also consumed. In addition to bitter gourd, the names bitter cucumber and balsam pear are also used. Commercial cultivars are sold by many seedgrowers and many local cultivars are known. Thick fleshed, less bitter cultivars are grown in Taiwan are reported to produce 20 t/ha in 100 days.

The bitter gourd is a very popular vegetable in India, China and S.E. Asia and is well adapted to hot and humid climates. It is grown in home gardens and market gardens.

The nutritional value of the green, small-fruited types of bitter gourd is surprisingly high for a cucurbit fruit. It has an ANV of 4.10, due to the high iron and vitamin C content (see table 5).

The fruits are an important product in local markets in S.E. Asia and India. Storage possibilities are limited but no serious diseases have been reported, with the exception of fruit flies.

Breeding and germplasm

The origin is probably in India but secondary diversity is seen in China and S.E. Asia. Wild species of *Momordica* are present in many tropical areas. Local cultivars of *M. charantia* are numerous in Asia and rare, but not unknown in Latin America. The variability of cultivars is not known in Africa. The groupings of cultivars relate to geographical areas and ethnic groupings (Williams and Ng, 1976). Selections have been made by seedgrowers in India, Japan and China. In Bangalore (India) the dwarf cv. Arka Harit has been bred, combining high quality with a high yielding capacity.

Recommendations

Local cultivars of bitter gourd may vanish as they become replaced by commercial cultivars. Measures for conserving wild cultivars are recommended especially in Indonesia and China. More information is required on the distribution, variability and use of *M. balsamina* L. and *M. cochinchinenisis* Spreng.

The bitter gourd offers good possibilities of breeding for higher productivity. Within the group of cucurbits, its nutritional value is relatively high; home garden cultivation is therefore recommended. Its economic importance justifies a high priority among the cucurbits, equivalent to that given to melons and pumpkins.

10. CHAYOTE

Crop information

Sechium edule (Jacq.) Swartz (2n = 24) is a vigorous perennial climber. The fleshy fruits contain only one large seed which does not withstand drying and consequently the entire fruit must be planted. In addition to the fruits, the young leaves and the fleshy roots may also be consumed. Chayote is a popular vegetable in many areas of Central America, India and S.E. Asia. Chayote is commonly grown in Africa, only in Sierra Leone, Ghana and Malawi but it could be grown more widely in other areas. It is cultivated in the tropical lowlands but higher yields are obtained at altitudes from 500 up to 1,500 m, where the nights are cooler. It does not withstand drought. *Sechium* produces best in light shade.

The chayote is a very cheap vegetable with a low nutritional value (ANV = 1.81). However, since its production capacity is high and the leaves are edible, it is considered to be a very suitable vegetable for home garden production. The consumption of chayote leaves is very common in S.E. Asia as too is the cooked tuberous starchy root.

Chayotes are commonly found in Latin America markets. For example, the city of São Paulo in Brazil consumes 25 million kg per annum. The chayote is also important as a market vegetable in India and S.E. Asia.

The vines and fruits of a chayote being examined by agricultural students in Mexico. This is a cheap vegetable with high production capacity. Both the leaves and fruits are eaten.

Chayotes are rarely damaged by pests and diseases. High costs are incurred for supports, if the crop is grown on a commercial scale.

Breeding and germplasm

The origin of this cultigen is S. Mexico and Central America. Local cultivars have been recorded here as well as in S.E. Asia but rarely named since they are recognised as white or green, pointed or blunt, spinous or smooth, round or long. Since the chayote cannot be propagated from dried seeds, no commercial cultivars are available. No breeding work has been recorded.

Recommendations

Local cultivars should be collected for variety testing. There is erosion of old cultivars in the Philippines and Indonesia. Although the fruits have a rather low nutritional value, this vegetable is relatively easy to grow in home gardens and has a very high yielding capacity. It is recommended for selection.

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V. ALLIUMS

1.. GENERAL

Allium species (onion, shallot, Japanese bunching onion, garlic, leek, etc.) make up a closely related group both taxonomically and in the cultivation methods used. *Allium cepa* L. the dry or bulb onion, is the most important species of the Allium group. It can be regarded as being the most important single vegetable species of the tropics, after the tomato. The nutritional value of onions is very low (see table 5); nevertheless, they are important for flavouring. Their medical properties are often stressed, garlic, onion and other species are considered to aid digestion and purify the blood. From this group, only the five main species will be considered; several *Allium* species which are only locally cultivated as minor crops are excluded. Some of these minor *Allium* species are:

A. chinense G. Don rakkyo, k'iu ts'oi

A. ledebourianum Roem. & Schult. Asatsuki, siu yuk ts'ung

A. macrostemon Bunge; Chinese garlic

A. nipponicum Franch & Savat.

A. schoenoprasum L. chives, sai ts'ung

A. tuberosum Rottler. Chinese chives, Kau ts'oi

Limited data on the economic importance of these vegetables are available (see table 9). They are sometimes mentioned in food surveys, but they are not used in such large quantities as the onion, shallot, bunching onion, garlic and leek.

2. ONION

Crop information

Botany

Allium cepa var. *cepa* L., (2n = 16), the dry or bulb onion, is one of of the most ancient vegetables in the world. Many commercial cultivars have been selected either for eating raw or boiled, or for dehydration. These cultivars differ in yield potential, quality (shape, colour, pungency, storability), disease resistance and climatic requirements. On the American market, three types are distinguished:

(a) The Bermuda-Granex-Grano short-day type, flat to conical-shaped, mild, early maturing.

(b) Late maturing type, long-day globe onions, mild, e.g. White Globe, Sweet Spanish.

(c) The Creole type, with very strong flavour, e.g. Ebenezer and White Portugal.

The first group is most suitable for cultivation in the tropics. Onions are sometimes cultivated for use as green bunching onions, harvested

Table 9. Data on cultivation and seed production of Alliums.

species type	cultivation						seed production				
	seed needed kg/ha	density pl/ha x 1,000	days to harvest	yield t/ha			weight 1000 seeds g	g per plant	kg/ha		
				low	high	mean			low	high	mean
Allium cepa: globe onions											
- direct sowing	25	300	150	5	80	20	2.9	2	300	1000	600
- transplanting	4		90								
A. cepa: shallots (cloves)	1,100	500	90	4	20	10	-	-	-	-	-
A. fistulosum: Welsh onion transplanting	4	300	120	10	30	20	2.9	1	300	600	450
A. sativum: garlic (cloves)	600	800	100	3	8	6	-	-	-	-	-
A. porrum: leek (transplanting)	3	300	150	8	35	20	2.5	3	300	600	450

when young, with or without a small bulb. Well-known cultivars for this purpose are Evergreen White Bunching and Evergreen. They can be grown successfully in most areas of the tropics which have short days. In general, most of the dry onions cultivated in tropical areas of Asia and West Africa are local selections of fairly primitive cultivars. Most of the onions grown in Latin America and East Africa, however, are exotic cultivars such as Red Creole, Granex, Bombay Red. In West Africa, Red Kano, Red Patna, Texas Grano, Yellow Bermuda and Early Yellow Cape Flat are well known cultivars.

Geography and ecology

Onions are a cool season crop, growing well in day temperatures ranging from 13 to 24°C. They are not particularly susceptible to frost. For bulb initiation, a critical minimum daylength must be reached. The European and American summer onions are "long day" cultivars, not suitable for the tropics but a few early-maturing American cultivars are available in the international seed trade (See page 126). Many local onion cultivars, however, grow well at high temperatures up to 30°C and form bulbs in short days (11 - 12 hours). However, short day cultivars are not short day plants but cultivars which bulb earlier. Bulbing is also stimulated by high temperatures. Flowering normally occurs only if bulb formation is followed by a cool period; the onion in temperate regions is therefore regarded as a biennial plant. In tropical regions with cool nights, bolting of a percentage of young plants of local cultivars, in which bulb formation has started, is a common occurence, resulting in a considerable yield reduction. If the emerging flower stalk is pinched out, however, bulb formation may continue.

Due to its special ecological requirements, the onion is normally cultivated only during the cool season in the subtropics and tropics, but rarely between 10°N and 10°S, except in the tropical highlands above 1,500m. Cultivars which are relatively insensitive to daylength are grown for bulb production only in some lowland areas they rarely produce flowers.

Nutritional importance

In general, the nutritional value of dry onions is low. The ANV (table 5) is only 2.05. Onions are an indispensible part of many diets as a flavouring, and they are consumed regularly in small quantities, being comparable with hot pepper. If the immature bulbs and tops are consumed, the nutritional value will be much higher and the ANV may reach 3.96, with a high vitamin C and calcium content. When used raw in salads, the nutritional value is somewhat higher e.g. for onion 2.30 and green onions and tops 4.69 ANV.

Economic importance

In the wet tropics and in a large part of India and S.E. Asia (Indonesia) the onion is cultivated and consumed to a lesser extent than it is in other countries. In general, the onion is the second most important world vegetable species (after tomato) and the good storage and bulk transport properties of dry onions have facilitated the development of a world-wide trade (see table 1). They are always in demand even in the smallest local markets.

Main limitations to cultivation in the tropics

The primitive local cultivars which are grown in many countries (India, Nigeria, Mexico) often show a tendency to bolting and have a poor keeping quality. High losses due to pests and diseases have been reported, the most important being thrips, onion fly *(Hylemia antigua)* and nematodes *(Ditylenchus dipsaci* purple blotch *(Alternaria porri)*, downy mildew *(Peronospora)*, pink root *(Pyrenochaeta)* and *Colletotrichum* smudge. White rot *(Sclerotium cepivorum)* is a serious disease in some subtropical areas (Brazil). Technical information

concerning onion cultivation in the tropics (density, fertilising, disease and pest control, storage, processing) is very limited.

Breeding and germplasm

Centres of diversity, collections

Allium cepa is a cultigen without wild types, but in its primary centre of diversity (C. Asia) several related wild species have been found, e.g. *A. vavilovii*, Popov & Vved. *A. oschaninii*, Fedtsch. and *A. pskemense*, Fedtsch. Hundreds of locally grown, primitive cultivars exist, mostly in the Near East (which, with the Mediterranean, represents a secondary centre of diversity) and in Central Asia, but also in all the traditional onion growing regions of the tropics.

Large collections of onion cultivars and of wild types are available in Europe and the USA, see Annex 2.

Genetics and breeding

Allium cepa var. *cepa* has been subjected to selection for several thousands of years especially in India and the Near East. In China selection of other species of *Allium* has occurred. Breeding programmes have resulted in the production of high-yielding and high quality cultivars such as Early Yellow Globe which are widely distributed in temperate regions. Breeding work on this crop is relatively easy; the onion plant is a self-compatible out-breeder, pollinated by insects. It can withstand some degree of inbreeding, giving rise to some heterosis when strains of good combining ability are intercrossed. The application of male sterility has made the commercial seed production of hybrids possible and, at present, numerous hybrid forms (F_1) are cultivated, combining uniformity and good quality characters with resistance to several diseases. The area cultivated with hybrid cultivars is about 25% of the total onion area in the USA but only 1% in Europe.

Some modern short-day cultivars frequently cultivated in the tropics are: Texas Early Grano no. 502, Early Yellow Cape Flat, Yellow Bermuda, Red Creole, Tropicana, El Toro and Bombay Red. In a cultivar testing and breeding programme in N. Nigeria (Green, 1973) Texas Grano showed a high yield capacity but a low dry matter content (50 t/ha x 6% DM = 3 t DM) and Bombay Red a lower yield capacity (30 t/ha) but a high DM content (15%) giving 4.5 t DM/ha. Texas Grano, with brown scale leaves, appeared to be of good export quality but had a short storage life, whereas Bombay Red had excellent storage quality but the red colour, popular in local markets, made it less suitable for export. However, the local poor quality cultivars proved to be superior to the internationally grown normal and hybrid cultivarsin yield, resistance to diseases and sometimes also in storage quality. Good results have been reported also from IRAT, Niger. A selection of a local cultivar, 'Blanc de Galmi', produced up to 60 t/ha, with 15% DM and had excellent storage qualities. Similar results have been reported from several countries with a tradition of onion cultivation (Taiwan, Mexico and India).

Local and modern cultivars show important differences in their susceptibility to pests and diseases. A certain degree of resistance or tolerance to thrips, onion fly and nematodes has been reported. Italian Red and local Brazilian cultivars are less susceptible to purple-blotch, a serious disease under wet conditions. Some cultivars are also less susceptible to downy mildew. The commercial cultivars Granex and Excel L 35 show resistance to pinkroot. No data are available on resistance to *Colletotrichum* smudge.

Apart from selecting for yield, storage potential and disease-resistance, several onion cultivars have been selected for use in the food industries i.e. for canning or dehydration. Some of these cultivars contain about 20% dry matter.

Onions grown as a field crop during the cool season in the tropics. This field has been sown with a high-yielding cultivar.

Wild *Allium* species have not yet been used in onion breeding. Up to the present, interspecific crosses have failed, except with *A. fistulosum*. Gene translocation to *A. cepa* might be feasible.

Recommendations

Germplasm, breeding

The primitive onion strains existing in Asian countries, Africa and C. and S. America should be collected, since they are gradually being replaced by modern cultivars.

Breeding work on this economically important crop should be stimulated. Requirements for future selection of onions for the tropics include the following: a high yield ability, combined with a high DM content, good quality for both local and export markets, good storage properties, minimal bolting and a combination of resistance to many diseases and pests. Sterile male lines should be selected for the production of hybrid seed. If further improvement by crossing between local strains and modern temperate cultivars becomes limited e.g. for resistance to diseases, pests and drought, crosses with other *Allium* species e.g. *A. fistolosum* should be considered.

3. SHALLOT

Crop information

The shallot *Allium ascalonicum* L. Usually referred to in this way but more correctly as a form of *A. cepa* (2n = 16) is an onion-type plant which is propagated by cloves. Many clones are known in temperate as well as in tropical regions of Asia and Africa. Clones which flower readily as well as clones which seldom or never flower are known; both are related to onions. Shallots for planting are used locally, but are rarely commercially sold. The seeds are not used for propagation since they usually result in the production of undesirable types.

Shallots are better adapted than onions to cultivation in the tropics. They are widely cultivated in W. Africa (Ivory Coast, Ghana) in the Caribbean countries, and elsewhere in the tropical lowlands of S.E. Asia and C. and E. Africa but thrive best in the drier climates at medium altitudes.

Shallots have a relatively low nutritional value, similar to that of dry onions. Frequently the leaves and young bulbs are consumed, and the value is thereby increased making it comparable to that of green onions. Shallots are often considered to be a luxury, since they have a more pungent flavour than onions.

In the market, shallots command a better price than onions. In the forest zone of S. Ivory Coast, S. Ghana and the Caribbean, they are an important commercial vegetable, often replacing onions. Since the crop is labour-intensive and has a lower yield potential than onions, the shallot is not normally cultivated in cool and dry areas where onions can be grown.

The main problem for shallot growers is the conservation of suitable planting material. In humid regions, this degenerates quickly probably due to factors such as fungus diseases, nematodes, spider mites and virus diseases and has to be renewed after 3-5 generations with material from drier regions. Shallots suffer from the same diseases as onions and are particularly susceptible to *Sclerotium rolfsii*.

Breeding and germplasm

As the shallot is a botanical form of the dry onion, the centres of diversity are identical. No breeding work on shallots in the tropics has been reported and no collection of shallot cultivars are known.

Recommendations

Shallot cultivars could well disappear if they become replaced by onions. Local tropical cultivars should be collected and stored in a germplasm conservation centre for vegetatively propagated vegetables. Testing of local cultivars and improvement by breeding is justified for those regions where shallots are economically important, e.g. W. Africa (Ghana, Ivory Coast).

4. JAPANESE BUNCHING ONION

Crop information

Allium fistulosum L. (2n = 16), the Japanese bunching onion, Welsh onion or spring onion, either develops small elongated bulbs similar to the leek or does not form bulbs. Many local and commercial cultivars are known in the Far East. The bunching onion requires a cool climate and grows well in the tropics throughout the year at altitudes of more than 1,000 m. It appears to be almost as important as dry onions in S. China and Japan although the poor keeping quality is a problem. It is known in East Africa as the 'Kikiyu' onion.

Bunching onions are either cooked or used as a salad onion. The nutritional value is comparable with that of immature onions, having an ANV of 3.27 (table 5). They may also be eaten raw in salads (ANV = 3.77). It is an important vegetable for marketing and for home garden production in S. Japan S. China and to some extent, in S.E. Asian highland areas (Philippines, Indonesia,.

The crop is much less susceptible to pests and diseases than the onion. The main limiting factor to production in the tropics is a temperature in excess of 25°C. Flowering and seed production in the tropical lowlands is rare.

Breeding and germplasm

The origin of this cultigen is S.E. Asia. A wild relative, *A. altaicum* Pall. occurs in Mongolia and hybrids occur with *A. fistulosum (A. x microbulbum)* Prokh., There are several other wild Asian *Allium* species. The breeding behaviour and seed characters are similar to those of onions. Male sterility has been applied in Japan and may lead to the development of hybrid cultivars. No large collection of local cultivars is known.

Recommendations

Asiatic seed companies e.g. in Japan, store a number of high yielding cultivars which are suitable for the cooler regions in the tropics. They expect a gradual loss of valuable local strains. The development of productive strains, intended mainly for the Asiatic tropical lowlands, is recommended.

5. GARLIC

Crop information

Allium sativum L. (2n = 16) is a very pungent species which is propogated by cloves. Many local clones are known, some are well adapted to tropical conditions e.g. high temperatures up to 30°C. Garlic is extensively grown in East Asia, the Mediterranean and in Latin America, but is relatively unknown in Africa although it could be grown much more widely in the drier regions. It is unsuitable for growing in the wet humid areas. The nutritional value is approximately similar to that of dry onions. It is more widely used as spice than a vegetable, and the intake per caput per meal is very low. The plant is very susceptible to *Alternaria* and other pests and diseases which attack onions. Conservation of cloves as planting material for the following year is difficult since they do not store well.

Breeding and germplasm

The ancestor of the old cultigen is possibly *A. longicuspis* Regel (2n = 16) which occurs in C. Asia. Reports on breeding work are very scarce and no international trade in planting material of superior clones is known. No collections have been recorded.

Recommendations

There appears to be little genetic erosion in the local strains. These should, however, be collected for future breeding. Breeding work on this economically important vegetable spice, through cultivar testing, should be carried out, aiming at higher yields and improved disease resistance.

6. LEEK

Crop information

Allium porrum L., (2n = 32) is a temperate leaf vegetable, showing retarded growth and low yield capacity at day temperatures above 24°C. Leek cultivation in the cool season and in tropical mountain regions is possible. Seed production in such areas may be successful after a cool season but is not economically justified. American Flag, Musselburgh and Italian Giant are well-known cultivars. Leek suffers from the same pests and diseases as onions, but to a much lesser degree.

The nutritional value of leek is better than that of all other *Allium* species. It has an ANV value of 6.63 due to relatively high calcium, carotene, iron and vitamin C contents. Although highly regarded by Europeans living in the tropics, this species is of minor importance to the local populations.

Breeding and genetics

Neither the breeding of leeks specifically for tropical conditions nor the existance of local strains of leek in tropical or subtropical countries have been reported except in the Far East. Wild and cultivated *A. ampeloprasum* L. types, related to *A. porrum*, occur in the Near East.

Recommendations

At present no action for the collection of germplasm or the breeding of leeks for tropical regions appears necessary.

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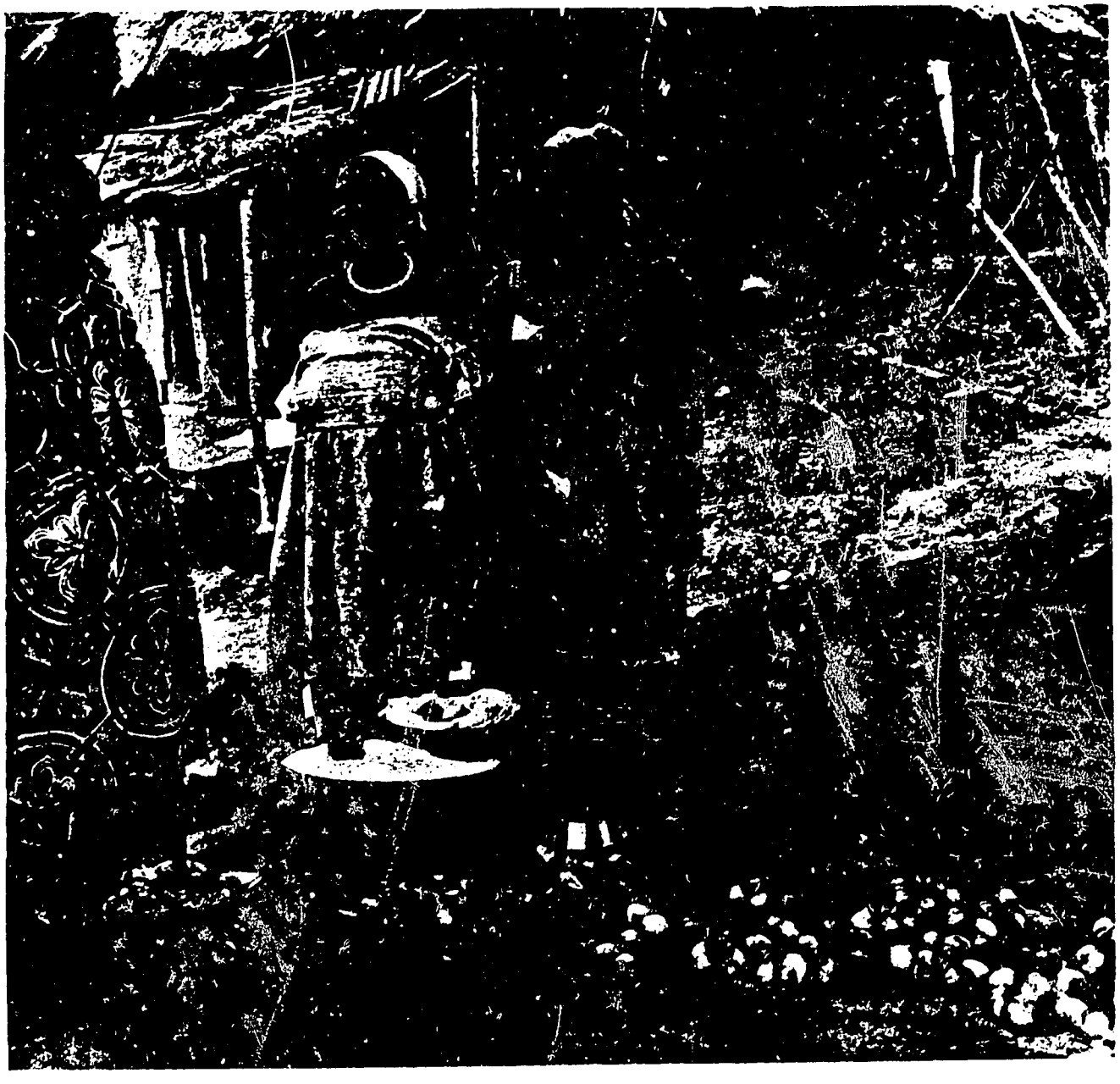

Hyacinth bean or lablab is grown in the Old World tropics. The wild forms are common in tropical Africa and many local cultivars are known. It is frequently grown for fodder in India.

VI LEGUMINOUS VEGETABLES

1. GENERAL

The distinction between grain legumes, cultivated as field crops, and vegetable legumes (referred to in this report as leguminous vegetables), is not always clear. However the most important leguminous vegetables are listed in table 10. The shoots or young leaves of many legumes are occasionally consumed, but this is of minor importance. Only the leaves of the cowpea, which is widely grown as a field crop, are consumed in appreciable quantities (<0.5 g/caput/day), this plant is therefore listed among the leaf vegetables in chapter VIII.

As shown in table 5, the composition of leguminous vegetables varies. Dry beans have a very high ANV, due to their dry matter content, but the ANV calculated per 100 g dry matter is low. Fresh seeds and young pods have a fairly high ANV, sprouted beans a much lower one. The production of valuable nutrients per m^2 per day (table 6) is disappointing, leguminous vegetables showing the lowest production rate of the four groups of vegetables listed. Some average data on cultivation and seed production are listed in table 10. Young seeds, at harvest, weigh approximately twice that of the dried seeds.

The ability of plants of the Leguminosae to fix nitrogen by means of *Rhizobia* is bacteria extremely important for field grown pulses, but is less so for intensive production, since such vegetables are generally well provided with soil organic material. Leguminosae are liable to be affected by many soil-borne diseases such as: *Pseudomonas, Fusarium, Verticillium, Sclerotium* and *Meloidogyne*. The long-lasting or perennial, climbing, deep-rooting tropical leguminous vegetables such as Lima bean, winged bean, hyacinth bean and yardlong bean, together with the non-climbing pigeon pea, are valuable plants for home garden production since they are less susceptible to diseases and are often more drought resistant. Climbing types, planted against fences and hedges, make full use of the available space and light. Climbing types are often used in mixed cropping using the dried stalks of maize, sorghum or castor as a support, or they may possibly be planted against the stems of shrubs remaining in the field after the bush has been cleared. Only a few climbing legumes e.g. the common French bean, Lima bean and winged bean, yield a sufficiently high quantity of seed to justify their cultivation as grain legumes in small gardens.

2. COMMON OR FRENCH BEAN

Crop information

Botany

Phaseolus vulgaris L. (2n = 22) is a species of which many cultivars are grown for pods, green seeds or ripe, dry seeds. Climbing cultivars (pole, snap or French beans) are popular in home gardens and for the commercial production of young pods in the cooler parts of the tropics. At least 200 commercial cultivars of this vegetable are known. The distinction between those grown as vegetables and those grown for dry seeds is not clear and the same cultivars may be used for the production of pods, young seeds and mature dry seeds. Contender and Canadian Wonder are often used as a bush type of snap beans in the tropics, yielding up to 15 t/ha. Canfreezer and Florigreen are suitable cultivars of the pole type. Many local cultivars are grown which are inferior in quality to these cultivars but which have a greater degree of horizontal disease resistance.

Table 10. Data on cultivation and seed production of tropical leguminous vegetables

species	common name	cultivation: seed kg/ha	density hills/ha x 1000	main product (a)	duration days	yield t/ha: low	high	mean	seed production: weight 1000 seeds g	No. per pod	t/ha: low	high	mean	multi-plication factor kg/kg
Phaseolus vulgaris	common bean	50	40	pods [b]	90	2.0	8.0	4.0	290	4-10	0.5	3.0	1.0	20
Phaseolus lunatus	Lima bean	50	30	young seeds [b]	120-270	1.5	6.0	3.2	300	2-4	0.6	2.5	1.0	20
Dolichos lablab	hyacinth bean	40	12	young seeds	120-720	0.8	4.5	2.2	330	3-4	0.4	2.0	0.9	23
Vigna radiata	mung bean	5	80	ripe seeds	70-110	0.3	1.2	0.5	30	6-12	0.3	1.2	0.5	100
Vigna unguiculata	yardlong bean	20	25	pods [b]	150	1.5	9.0	6.0	220	10-30	0.5	2.5	0.7	35
Psophocarpus tetragonolobus	winged bean	20	15	pods [b]	210	2.0	6.0	4.0	500	8-15	0.6	2.5	1.1	55
Parkia biglobosa	locust bean	1	-	seeds +pulp	-	1.2	6.0	3.0	1000	5-25	0.4	2.0	1.0	1000
Canavalia gladiata	sword bean	60	8	young seeds [b]	150-720	0.5	5.0	2.5	4000	6-12	0.3	2.5	1.3	22
Pachyrrhizus erosus	yam bean	30	30	tubers	180	4.0	12.0	8.0	250	6-12	0.3	1.2	0.6	20
Glycine max	soybean	50	120	young seeds [b]	120	1.0	5.0	3.0	670	2-3	0.5	3.0	1.3	26
Cajanus cajan	pigeon pea	15	10	young seeds	270	1.0	7.0	2.4	125	4-5	0.5	3.5	1.2	80
Arachis hypogaea	groundnut	80	200	seeds	120	0.5	3.0	1.0	625	1-3	0.5	3.0	1.0	13
Voandzeia subterranea	Bambara groundnut	40	80	young seeds	120	0.5	2.5	0.8	670	1	0.3	2.0	0.6	15
Pisum sativum	garden pea	80	30	young seeds [b]	100	1.5	5.0	3.0	170	4-8	0.8	2.5	1.5	19
Vicia faba	broad bean	150	100	young seeds [b]	150	2.0	5.5	3.2	1250	5-15	1.0	2.8	1.6	11

a. the pod production is about 3 x and the production of unripe seeds about 2 x that of the weight of the ripe seeds;
b. young leaves used as food;

Western seed companies produce seeds of the bush type of French bean in the upland areas of East Africa which have a suitable warm-temperate climate, where the occurence of halo blight *(Pseudomonas)* is minimal.

Geography and ecology

The common bean is a warm-temperate plant, suitable for cultivation in the tropics at elevations above 1,000 m. In order to obtain a good seed set, the mean day temperature should not exceed 30°C. The plant is indifferent to daylength. In a humid lowland climate, flowering and fruit set is poor, leading to low yields of dry beans and fresh pods. Nevertheless French beans are widely grown for supplying the markets of large cities, due to the extremely high prices paid by the public. In areas of high humidity the plants are subject to several diseases and pests, the main diseases being: dieback and root-rot caused by *Pythium*, *Sclerotium*, *Fusarium*, anthracnose *(Colletotrichum)*, *Pseudomonas* and *Xanthomonas* common (bacterial) blight, *Cercospora* leaf spot and mosaic virus. Important pests are: spider mites, bean flies *(Melanagromyza phaseoli)*, aphids and pod borers.

Nutritional importance

The nutritional value of dry beans is very high, due to the low water content. As a fresh vegetable, the nutritional composition is fairly good; fresh pods are rich in calcium and vitamin C and the young seeds also contain reasonable amounts of calcium, iron and vitamin C (see table 5).

Economic importance

The common bean is the principal grain legume of C. and S. America and of East Africa. As a vegetable, cultivated for the fresh pods (Fresh beans, snap beans) and, to a lesser extent the young seeds, it is extremely important in W. Europe and the USA, but less so in the tropics. Climbing cultivars of French beans are popular in home gardens since they produce pods over a longer period than the bushy cultivars which are more generally grown on a commercial scale. The importance of out-of-season French beans grown in Africa (Senegal, Kenya) for export to W. Europe is increasing, although more recently subject to fluctuation in demand, due to the high air transport costs.

Main limitations to cultivation in the tropics

Cultivation methods used in the growing of snap beans, such as staking, density and the control of diseases and pests are relatively primitive. Fruit setting is often poor and many cultivars are susceptible to drought.

Breeding and germplasm

Centres of diversity, collections

The centre of origin is C. America. Wild *P. vulgaris* and the closely related *P. coccineus* occur in this region as well as hybrids (Rutger and Beckman 1970), and *P. darwinianus* (Hdz. x & Miranda) Smartt (Hernandez et al 1959; Smartt 1973). Many local primitive cultivars are present in the cultivation areas. The IBPGR. Committee on *Phaseolus* germplasm has reviewed the areas of diversity and the needs for collection.

Large collections of bean types have been amassed as an urgent necessity for the use of plant breeders and as a protection against genetic erosion.

Germplasm banks in the USA and also at CIAT in Colombia possess large collections (see Annex 2). The IBPGR has designated CIAT to hold a world collection. Other important material is held at INIA and Chapingo College, Mexico.

Genetics and breeding

A great deal of advanced breeding work has been carried out in the USA and W. Europe on *P. vulgaris*, both as a pulse and as a vegetable. Some work has been reported from C. and S. America. Cultivated types hybridise easily with wild forms and with the related species *P. coccineus*. The latter species has already been used by plant breeders as a donor for many types of disease resistance. The genetic base of bean cultivars, both in Europe and in the USA is narrow and useful combinations may be expected from hybridisation between wild and related species, also with primitive tropical cultivars. Screening and testing of the low-yielding cultivars grown in the tropics in America, as well as Africa and Asia, may give rise to selected types with valuable characters such as resistance to disease and drought and also tolerance to high temperatures. Many local bean cultivars grown in Brazil are more or less tolerant to *Xanthomonas*.

Recommendations

Local cultivars in the tropics may disappear as they become replaced by high-yielding modern cultivars.. Collecting of these cultivars is therefore recommended. The selection of high-yielding cultivars of snap beans adapted to tropical conditions and with a high level of pest and disease resistance is advisable, due to their potentially high economic value.

3. LIMA BEAN

Crop information

Botany

Phaseolus lunatus (2n = 22) is a very variable species. Green-white cultivars are often grown for fresh consumption and commercial dwarf cultivars with large white-green seeds are popular in the USA as canned vegetables. Some perennial, drought and disease resistant types are cultivated in the tropics but the annual types which are of better quality and produce higher yields are more popular. Small-seeded, often red-coloured types are sometimes called sieva beans and are used as a pulse. Lima beans are cultivated as pole beans in home gardens; they are supported by bushes or maize and sorghum stalks when grown as a field crop.

Geography and ecology

P. lunatus grows well in areas with a day temperature range of 22-30°C. Above 30°C, flower shedding may occur. The Lima bean is grown at altitudes up to 1,500 m, but is more commonly cultivated in lowland areas where it produces well during the dry season. Most of the local cultivars are short-day plants, whereas many improved cultivars are day-neutral. It is a popular vegetable in most of the tropical lowland areas of Africa, Asia and Latin America.

Nutritional importance

The dry Lima bean has a high nutritional value (cf. hyacinth bean, table 5). It has a high protein, fibre, calcium and iron content. Fresh seeds are rich in calcium, iron and vitamin C but may contain some HCN which can be adequately removed by cooking. The ANV for dry matter is low.

Economic importance

Lima beans, as green beans, are a very important vegetable for canning in the USA but the crop is of less importance as a pulse (dry seeds) or as a vegetable (young seeds) in the tropics where they are mainly grown for home consumption. Coloured, ripe seeds may contain some HCN which is removed during cooking.

Main limitations to cultivation in the tropics

The yield potential of the Lima bean in the tropics is very low. Many destructive diseases affect the crop in the USA e.g. *Pseudomonas* bacterial spots, *Diaporthe* pod-blight, *Phytophthora* downy mildew and *Colletotrichum* stem anthracnose. These diseases are rarely serious in the tropics, due partly to the higher temperatures which are unsuitable for the development of certain fungi, but also to the higher disease resistance of some primitive, heterogenous local populations. Damage by pod insects and poor fertilisation are some causes of the low yields obtained during the rainy season. Virus and spider mites are sometimes locally important.

Breeding and germplasm

Centres of diversity, collections

Many primitive cultivars are grown in tropical countries, mostly in West Africa, Malagasy and S.E. Asia. These can be considered as secondary centres of diversity and escaped types are sometimes found in the natural vegetation. The primary centre is situated in Central America, from where different cultivar groups had spread to North and South America, in pre-Columbian times. Wild types are present in these areas. The largest germplasm collections are available in the USA (see Annex 2) but CIAT will also hold material at the request of the IBPGR. Other material is held by INIA and at Chapingo College, Mexico.

Genetics and breeding

The Lima bean is a self-pollinating plant, but up to 20% cross-breeding may occur. Primitive cultivars have proved to be useful in breeding programmes; a nemotode-resistant bush cultivar Nemagreen has been selected in the USA after crossing with a semi-wild pole type. Fordhook 242, Henderson, Ventura and several other cultivars are popular bush beans in the USA. Climbing cultivars such as Carolina, Easy Shell and Florida Speckled Butter are popular in home gardens. The American high-yielding Lima beans are now becoming widely cultivated in the tropics.

Lima beans are less susceptible to pests and diseases than are common or French beans; they are, however, often attacked by cucumber virus. Lines with resistance to the Mexican bean beetle have been selected in Mexico.

Recommendations

Germplasm

The risk of loss of germplasm is not yet serious but may become so in the next few decades, when more productive cultivars become available. The collection of local cultivars is not urgent, but is needed for the establishment of breeding programmes.

Breeding

Evaluation of agronomic characters in the hundreds of local types of Lima beans existing in the tropics, and of their wild relatives, will provide a broad base for future breeding work.

4. HYACINTH BEAN

Crop information

Botany

Dolichos lablab L. (syn. *D. purpureus* L., *Lablab niger* Medik.) is either a vigorously growing annual or perrenial pole bean. The plant habit resembles that of the climbing Lima bean *(P. lunatus)*. The seeds have a white, protruding hilum approximately 10 mm long, and may vary in colour from white to red and black, according to the cultivar. Plants require strong supports, due to their prolific leaf and stem production.

Many local cultivars are known in Africa and Asia. In tropical Africa, they are grown in home gardens and are supported by remaining shrubs and trees when grown as a field crop. Commercial cultivars are available, especially in India, Sudan and in the Caribbean area the crop is known as the Seim or Waby salad bean. Cultivars Darkness and Daylight are well-known. Dwarf determinate, early-maturing cultivars, for cultivation as a pulse, are known in Egypt, Sudan and Australia. The hyacinth bean is grown as a fodder crop in India.

Geography and ecology

The hyacinth bean is commonly grown in Africa and Asia in the tropical lowlands up to altitudes of 2,000 m. Local cultivars are mostly short-day or day-length, neutral plants, but long-day cultivars exist in India. The plant is fairly drought resistant.

Nutritional importance

The young pods, as well as the young and ripe seeds, are eaten. The pods and young seeds are fairly rich in calcium and vitamin C.

Economic importance

Hyacinth beans, as dry beans, young pods and unripe seeds, are typically products for home consumption; they are sold in local markets but do not have a high commercial value. The leaves and young pods are also eaten.

Main limitations to cultivation in the tropics

The hyacinth bean is generally resistant to pests and diseases but damage caused by *Agromyza* stem flies, black bean aphids, pulse beetles and *Xanthomonas* bacterial blight has been reported. Local cultivars are often too prolific vegetatively and give very low yields.

Breeding and germplasm

Centres of diversity, collections

The origin of *D. lablab* is probably tropical Africa, with the Hindustani Centre and parts of S.E. Asia as secondary centres of diversity. Several wild types have been described but no large collections of germplasm are known.

Genetics and breeding

The hyacinth bean is mainly self-pollinated, but up to 5% cross-pollination by insects may occur. Selection work has been carried out in Trinidad, where the Waby salad bean has been developed. Dwarf, derminate, early-maturing cultivars have been selected in Sudan, Egypt, and Australia. Most of the breeding work on *Dolichos* as a vegetable has been carried out in India. Resistance to stem fly, aphids and bacterial blight has been found.

Recommendations

Germplasm

The danger of genetic erosion is limited, at present, i.e. as long as no superior cultivars are introduced. The collection of local and advanced cultivars for breeding purposes would be useful.

Breeding

The yield of hyacinth beans should be improved. The crop shows a high potential, both as a field-grown pulse and as a vegetable for home gardens.

5. MUNG BEAN

Crop information

Botany

Vigna radiata (L.) Wilczek, *(Phaseolus aureus* Roxb., *P. mungo* L. var. *aureus* 2n = 22) is a short-duration, erect legume. It is very labour-intensive, since it has to be repeatedly harvested; the dry pods are very dehiscent. Mung beans are often grown after the rice crop and may therefore be considered as a pulse. They are also cultivated in small family gardens, but rarely in home gardens. Yields are very low ranging from 300-600 kg/ha.

Geography and ecology

The mung bean is widely cultivated in India, China and S.E. Asia where the ripe seeds are used as either dry or sprouted beans. At present, they are grown in the USA as a drought-resistant fodder crop and grain legume (cultivars Morden, Lincoln), producing yields of 1-2 t/ha of dry seeds. The mung bean is grown in tropical climates from sea level up to 2,000 m. Flowering and ripening take place during the dry season. In the humid lowlands, fruit setting is generally poor. Most cultivars are indifferent to daylength, only a few showing a short-day reaction. Mung beans are very susceptible to pests and diseases. The most important diseases are: rootrot caused by *Rhizoctonia solani*, *Pythium* and *Fusarium*, powdery mildew *(Erysiphe polygoni)*, *Cercospora canescens* leaf spot and several types of virus; the main pest is the bean fly *(Melanagromyza phaseoli)*.

Nutritional importance

Dry mung beans, when cooked, are a good food for small children. Sprouted mung beans are also a relatively good source of iron, calcium and Vitamin C (see table 5). One kg of dry beans produces about 8 kg of sprouted beans.

Economic importance

The mung bean is highly commercialised in India and S.E. Asia.

Main limitations to cultivation in the tropics

The dehiscence of the dry pods and the high degree of susceptibility to pests and diseases are factors which make the successful cultivation of this legume somewhat difficult.

Mung bean is a plant of ancient cultivation and not known wild. Apart from being esteemed as a pulse, green pods are eaten as a vegetable and bean sprouts are widely used.

Breeding and germplasm

Centres of diversity, collections

Centres of diversity are in India and Burma, where the principal wild form var. *sublobata* (Roxb.) Verdc. occurs. The largest mung bean collection has been established at the AVRDC in Taiwan. Other germplasm collections exist at national institutes in India, S.E. Asia and the USA.

Genetics and breeding

Mung bean is autogamous to a large degree, but the many local types which are cultivated in Asia consist of rather heterogenous populations; this makes selection work relatively easy. Breeding work has been carried out in India and the USA. In India, production potential, resistance to *Rhizoctonia*, reduction of seed shedding, resistance to mosaic, yellow and crinkle viruses and protein content have been considered as important criteria in selection. Interspecific hybridisation with the related rice bean, *Vigna umbellata* (Thunb.) Ohwi & Ohashi, is the main source of resistance used by plant breeders in Taiwan. Resistance to *Cercospora*, *Erysiphe*, *Xanthomonas* and mottle virus has also been detected in the progeny.

Recommendations

Local selections will disappear with the introduction of new high-yielding cultivars. A collection has been established in Taiwan, but representative material from S.E. Asia still requires collection, particularly from Thailand, Indonesia and the Philippines.

Resistance to pests and diseases should be the major breeding objectives, together with a higher yield potential and a decrease of losses during the harvest period.

6. YARDLONG BEAN (Cowpea)

Crop information

Botany

Vigna unguiculata (L.) Walp. cultivar group *sesquipedalis* (2n = 22,24), the yardlong bean, string bean or asparagus bean is a type of cowpea, used as a vegetable. It is cultivated for the very long and tender pods, but the unripe or ripe seeds are also eaten. Some climbing cultivars of *Vigna unguiculata* with short, stiff pods, are also cultivated as a vegetable crop in small gardens and the leaves and pods as well as the young or ripe seeds are used. These cowpea cultivars are common in tropical Africa and are often supported by shrubs and maize or sorghum stalks when grown with other food crops. Bush cowpeas are grown in the USA as green beans and as fodder. Some commercial cultivars of the yardlong bean are available, although local cultivars are most widely grown in Africa.

Geography and ecology

The cowpea is mainly cultivated in regions which have a pronounced dry season during which the pods are harvested, whereas the yardlong bean is more frequently grown in the wet tropics in areas which do not have a significant dry season. The yardlong bean is liable to the same pests and diseases as the cowpea, but to a lesser extent. However, it is more susceptible than the cowpea to extremely high temperatures ($< 35^{\circ}C$) and drought and requires more water, due to

the large leaf surface area produced. All the cultivars are short-day plants or day-neutral. Important diseases are: anthracnose *(Colletotrichum)*, *Sclerotium* footrot, *Fusarium* wilting, *Cercospora* and other leaf diseases and cowpea mosaic virus. Some insects may be serious pests, such as the cowpea curculio *(Chalcodermus)* and the bean fly *(Melanagromyza)*.

The cowpea is the most important pulse of West Africa and it is also widely cultivated in C. America, where it is second in importance to the common bean; it is also grown, to a lesser extent, in Asia (India). The yardlong bean is mainly grown in India and S.E. Asia, but Asiatic immigrants have introduced it into the Caribbean area. It is rarely found in other tropical regions.

Nutritional importance

The nutritional value of yardlong beans and of young cowpea pods is fairly high, approximately equal to that of snap beans (see table 5). The food value of the unripe and ripe seeds is comparable with those of the common and Lima beans.

Economic importance

The yardlong bean is commonly seen in local markets in Asia but is produced mainly for home consumption.

Main limitations to cultivation in the tropics

Both the cowpea and yardlong bean are very susceptible to pests and diseases.

Breeding and germplasm

Centres of diversity, collections

The primary centre is West Africa, with a secondary centre in India. Many local cultivars have been developed in the S.E. Asian countries, where humid conditions promote a certain degree of cross-pollination by insects. The largest collection of cowpea cultivars can be found at IITA in Ibadan, Nigeria and a germplasm catalogue is available. Other collections have been established in India and the USA and at national institutes in the tropics (See Annex 2). Local cultivars of yardlong beans have been given limited attention.

Genetics and breeding

Much research and breeding work on the cowpea has been carried out in the USA, Nigeria and, to a lesser extent, in some other countries (India). Many valuable genes have been identified e.g. for male sterility, high protein and methionine content, resistance to thrips, pod borers, *Meloidogyne*, anthracnose, *Xanthomonas*, *Cercospora*, *Uromyces* and cowpea mosaic virus. Less attention has been given to the improvement of the yardlong bean. Hybridisation with local strains has been reported from India and the Philippines. Bush types which do not need trellis supports have been developed from the climbing local cultivars, e.g. Los Baños Bush Sitao no.1. Well-known cultivars include: Singapore Light Green and Bulacan Dark Purple. The yardlong bean crosses readily with the cowpea and intermediate types are common.

Recommendations

Primitive yardlong bean cultivars should be collected since they are subject to genetic erosion especially in S.E. Asia.

Yield potential, as well as pest and disease resistance are important aims for breeding programmes on yardlong beans. These should preferably be in close collaboration with existing cowpea breeding programmes.

7. WINGED BEAN

Crop information

Botany

Psophocarpus tetragonolobus DC., (2n = 26) also known as the Goa bean is a prolific, climbing, perennial or annual plant. It is a common minor vegetable in S.E. Asia and India and is cultivated mainly in home gardens for the young pods. In Java, it is also cultivated as a pulse on the dykes between rice fields. In Burma, the fleshy roots (yielding 3t/ha) are sold as a delicacy. It is now becoming more widely known in many parts of tropical Africa. The quantity of ripe seeds produced is high and this can be partly explained by the long duration of the growth period. Plants require strong supporting stakes. The winged bean is noted for the high level of *Rhizobium* activity in the root system The seeds are not easily separated from the pod.

Geography and ecology

The winged bean is a tropical short-day plant, well adapted to lowland conditions. It is not drought-resistant and has a high water requirement (8mm/day) for adequate production. It is remarkably free from pests and diseases. The winged bean has been introduced to the Caribbean by Asian immigrants. In Africa, it is not widely cultivated, although it is reported to have been introduced into some W. African countries.

Nutritional importance

The composition of the pods is similar to that of the common bean and the yardlong bean. The ripe seeds have a high protein content, comparable with that of soyabean, but higher than that of the common bean, Lima bean, mung bean, hyacinth bean and pigeon pea. The cooked dry bean is suitable as a protein-rich food for young children, since the testa of the large seeds can be removed very easily. Winged beans are commonly cultivated in home gardens for the immature pods and there is a growing interest in its cultivation as a pulse in tropical lowland areas. The seeds, roots and leaves are also used, in addition to the pods. The roots generally have a high protein content and the leaves are also very rich in nutrients (cf. cowpea leaves, table 14).

Economic importance

The winged bean is of limited commercial importance at the present time since it is mainly cultivated for home production and not for marketing.

Main limitations to cultivation in the tropics

If winged beans are grown as a vegetable for the production of pods, there are no serious problems. For cultivation as a pulse, it requires adequate staking.

Breeding and germplasm

The origin of the winged bean is probably tropical Asia and recent work has indicated that Papua New Guinea may also be a centre of diversity. Local cultivars are available in Papua New Guinea and Indonesia (see Annex 2).

Some testing of local cultivars has been reported from India and S.E. Asian countries. The local cultivars are very uniform and are probably self-pollinating to a high degree. Large and small-podded cultivars are known.

Recommendations

There is some risk of genetic erosion and local cultivars should be collected for plant breeding purposes especially in S.E. Asia. Considerable international interest has recently been shown in the winged bean and it is apparent that it is likely to gain in importance as a vegetable and pulse crop in lowland tropical areas. The breeding objectives can be defined after a study of the available cultivars and cultivation techniques.

8. OTHER LEGUMINOUS VEGETABLES

Locust bean

Parkia biglobosa Benth., is an indigenous fire-resistant savanna tree of West Africa. The fermented pulp and seeds are widely used as a concentrated food. The seeds contain about 32% protein and have a high iron and calcium content. The pods are sold in local markets as a spice, under names such as local cheese, mustard, nere, or soumbala. The pods contain about 20% dry seeds and 40% starchy pulp. Seeds and pulp may be used apart, or in a mixture. The species *P. filicoidea* Welw. and *P. clappertonia* Keay have similar characteristics.

Several wild and cultivated *Parkia* species are used as locust beans in S.E. Asia but to a lesser extent than the African locust bean. In Malaysia and Java, *P. speciosa* Hassk. and *P. javanica* Mer., are planted in compounds. There appears to be little risk of genetic erosion at the present time. The botany and potential agronomy of this valuable tree/vegetable/legume should be studied further, although the National Biological Institute at Bogor has undertaken a preliminary survey.

Sword bean

Canavalia gladiata (Jacq.), DC (2n = 22,44) is a widespread legume in tropical Asia, cultivated for the young tender pods. It is a deep rooting, drought resistant, perennial climber, sown against fences in home gardens and close to tree stumps and shrubs when grown as a field crop. The dry beans are coarse-skinned and are not very appetizing, but they have a high nutritional value, similar to that of other dry beans. The unripe seeds are more palatable. The seeds generally contain some HCN which is removed by cooking.

The sword bean originates from the Indochinese-Indonesian centre with probably a secondary centre in tropical Africa. The wild *C. gladiolata* Sauer of Burma is probably its ancestor and *C. polystacha* Schweinf. of China is closely related.

Hybridisation between the sword bean, which is partly cross-pollinating, and the S. American jack bean *C. ensiformis* (L.), DC (2n = 22), a forage and cover crop of minor importance, may be possible. No important pests or diseases have been recorded, other than spider mites. In wet regions, production is low and many young pods are heavily damaged by pod borers.

The degree of variation which may exist in the various local cultivars is not fully known although there are distinct botanical varieties. No breeding work has been reported. There is some danger of genetic erosion and the crop should be studied further. This drought resistant plant could become a valuable vegetable legume or pulse in hot dry areas.

Yam bean

Pachyrrhizus erosus L. Urban (2n=22) is a minor vegetable in China, S.E. Asia (Indonesia), India and E. Africa. The tubers are sometimes consumed raw but are mostly eaten as a cooked vegetable. The young pods are also eaten, but the ripe seeds are poisonous. It is a popular vegetable in Malaysia where several cultivars are known, some of which require staking; some wild types have been recorded in parts of Asia. The nutritional value of the tubers is rather low, they have an ANV of only 2.60.

C. America is the main centre of diversity and wild plants and some cultivated types are to be found in C. and S. America, e.g. Colombia. There are no serious risks of genetic erosion except of old cultivars and weedy forms in S.E. Asia and S. China. The yield potential and possible wider use in home gardens or markets should be studied.

Soyabean

Glycine max L., (2n = 40) is the world's most important oil and protein crop. It is extremely important as a pulse in S.E. Asia but is only recently becoming more widely known in Africa and Latin America. Dry soyabeans are used as sprouted beans, but to a lesser extent than mung beans. Soyabean cultivars, grown for the production of young seeds and pods, are very popular in Japan and S. China. A great deal of research on the soyabean is being carried out and large collections of germplasm are held e.g. at the AVRDC in Taiwan and by the INTSOY Consortium. Details are therefore being omitted from this report but it should be recorded that much collection is still very necessary in order to conserve the genetic variability of this crop.

Pigeon pea

Cajanus cajan (L.), Mill. (2n=22) is probably the most important pulse of India, after the chick pea. This area is a secondary centre of diversity, the main centre being tropical Africa. It is well-known throughout the tropics. The principal region of pigeon pea production is in the West Indies (Puerto Rico) where the young seeds are canned. Pigeon peas are grown in most tropical regions which have a long dry-season, usually as a field crop due to its soil improving qualities, but it is also frequently grown in home gardens.

The pigeon pea grows well during the dry season but is less suitable for the humid tropics since the pods are often seriously attacked by insects. Several cultivars of this mainly self-pollinating species are known, and breeding work has been carried out in India and the Caribbean countries. *Cajanus* breeding is a main research topic at ICRISAT, Hyderabad, India and at several national research institutes in the tropics, therefore it is not treated here in detail.

Groundnut

Arachis hypogaea L. (2n=40) is a major field crop in the tropics, cultivated mainly as a pulse for local consumption and as an oil crop for export. Although it is widely grown in small gardens as a vegetable legume, details of the crop are not included in this report, since a great deal of attention is being paid to the groundnut in research programmes at both national and international re-research institutes (e.g. ICRISAT).

Bambara groundnut

Voandzeia subterranea (L.), Thou. (2n=22) is cultivated in the drier areas of Africa especially on poor soil and is an important pulse in Zambia. It is a

widespread but minor vegetable, cultivated for its young seeds in India, S.E. Asia and S. America; the commercial value of the crop is low. Several local cultivars have been described but little research has been carried out on this crop. The risk of losing genetic material is not serious and a fairly low level of priority should be given to breeding work. IITA (Nigeria) is assembling germplasm.

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Cabbage as a field crop in Senegal. This is a temperate plant becoming more and more widely grown in tropical uplands.

VII BRASSICAS

1. GENERAL

The genus *Brassica* includes a number of popular vegetables. Most of these species are biennial, cold-resistant, temperate plants, requiring a cold period for flowering and seed production. Some Brassicas are indigenous in the tropics. The taxonomy, especially of the cultivated types, is very difficult and includes many synonyms; clear descriptions of species, subspecies and botanical varieties are rarely available. The more important Brassicas grown in tropical areas are below and data on cultivation and seed production in table 11.

(a)	White cabbage	*B. oleracea* L. var. *capitata* L.
(b)	Chinese cabbage	
	- paak-tsoi (leaf type)	*B. campestris* L. subsp. *chinensis* (L.) Makino
	- pe-tsai (heading type)	*B. campestris* subsp. *pekinensis* (Lour.) Rupr.
(c)	cauliflower	*B. oleracea* var. *botrytis* L.
	broccoli	*B. oleracea* var. *italica* Plenck.
(d)	mustard (tropical leaf)	*B. carinata* A. Br. *B. integrifolia* Schultz
	cabbages	*B. juncea* (L.) Coss. *B. tournefortii* Gouan
(e)	Kale, collards (temperate leaf cabbages)	*B. oleracea* var. *acephala* (DC.) Alef

Turnips, Brussels sprouts, kohlrabi and swedes are occasionally grown as minor vegetables in the tropics, but they have not been included in this report; the red and Savoy cabbages, which can be considered as belonging to the same cultivar group of *B. oleracea* as white cabbage, have also been omitted. Many *Brassica* vegetable types of minor importance occur in S.E. Asia and the Far East and it appears possible that, in the future, they may be useful in programmes aimed at improving the more commonly cultivated *Brassica* vegetables.

Although the genus *Brassica* is very polymorphic, all its vetetable species have similar cultivation and ecological requirements and are susceptible to the same types of pests and diseases. All species are out-breeders, pollinated by insects. Inbred lines, if crossed with each other, give rise to heterosis. Hybrid seed is relatively easy to produce with the aid of self-incompatible mother plants. Cauliflower is an exception, in that a high percentage of selfing is normal and inbreeding does not lead to genetic depression. Many interspecific crosses, amphidiploids and allopolyploids have been recorded and are used in plant breeding programmes. The commercial cultivars have usually been selected from old local cultivars by mass selection, but are gradually being replaced by hybrid cultivars.

Table 11. Data on cultivation and seed production of Brassicas.

Brassica type	cultivation [a]						seed production					
	seed needed kg/ha	pl/ha x 1000	harvest period days [b]	yield t/ha			1000-seeds weight g	g per plant	kg/ha			multi-plication factor kg/kg
				low	high	mean			low	high	mean	
white cabbage	0.6	30	60-100	8	60	20	4.0	20	200	1200	600	1000
Chinese cabbage paak-ts'oi	2.0	200	50-80	5	30	15	3.0	15	200	800	500	250
Chinese cabbage heading	0.6	60	40-100	8	50	20						800
cauliflower	0.3	35	55-70	5	25	10	3.0	5	100	300	150	500
broccoli	0.3	30	60-150	4	10	6	3.0	15	400	800	500	1600
mustard, collard, kale & trop. leaf cabbages	1.0	100	50-90	8	35	20	2.0	20	200	900	600	60[illegible]

a) with transplanting, except paak-ts'oi

b) days from sowing or transplanting to the first and to the last harvest.

2. WHITE CABBAGE

Crop information

Botany

B. oleracea var. *capitata* (2n = 18) is a temperate biennial plant, one of the most ancient and widely cultivated European vegetables. Some 280 cultivars are grown in W. Europe, differing in shape and size of the head, the shape and colour of the wrapper leaves, resistance to diseases, earliness and storage quality. Late types (90-120 days from transplanting) such as Glory of Enkhuizen produce large heads of 2-5 kg whereas early types such as Golden Acre and Copenhagen Market produce small heads of 1-2 kg in 60-90 days. The early types are more popular in the tropics than are the late types. A local, vegetatively propagated, white cabbage is grown in Indonesia, at medium elevations. After the heads have been harvested, the young lateral shoots which arise from the remaining stem are used as new planting material. Due to its poor quality, it is gradually being superseded by cultivars propagated from seed.

Geography and ecology

White cabbage is commonly cultivated in all tropical upland regions. Its optimum day temperature requirement is low, between 15 and 20°C. Good heads may be obtained at temperatures up to 28°C, but a longer growing season is necessary. In recent years, some Japanese early cultivars have been introduced; these perform well under tropical lowland conditions. Cabbage is not daylength sensitive and flower initiation is mainly determined by temperature. Bolting occurs after a period of some weeks if the temperature falls below 10°C. Nearly all the cabbage seed used in the tropics is imported from temperate regions, but cultivars have been developed which will flower at higher temperatures, giving rise to local cabbage seed production industries (Brazil, Venezuela). Bolting cabbage cultivars also occur in Indonesia.

Nutritional importance

White cabbage has a fairly good nutritional value with an ANV of 3.52 (see table 5). It cannot, however, compete with green, leafy vegetables. The calcium and iron content of cooked cabbage can be readily absorbed by the human body.

Economic importance

The importance of cabbage in the tropics is increasing rapidly, one of the main reasons being that it is a high prestige vegetable which can be fairly easily produced in considerable quantities; it is not liable to damage during transport and can be stored for several weeks. It is in demand for the city markets, where it often replaces the green leafy vegetables used in traditional dishes. In contrast to this development, the importance of white cabbage in developed countries is gradually decreasing since it is being replaced by cauliflower and other vegetables.

In the Philippines, 10% of the budget spent on vegetables is used in the production of cabbage which is a very popular vegetable. Cabbage is also important in the upland regions of Indonesia and East Africa (Kenya, Tanzania), in Northern India, and in Meso- and S. America.

Main limitations to cultivation in the tropics

Apart from high temperatures, the main limiting factor is its great susceptibility to pests and diseases. Black rot *(Xanthomonas campestris)*, clubroot

Cabbages are in great demand at the market due to their prestige value.

(Plasmodiophora brassicae), bacterial softrot *(Erwinia)* and *Fusarium* and *Sclerotium* wilts appear to be the most serious diseases. Caterpillars such as *Plutella* and *Pieris* cause severe damage in many areas and many other pests and diseases have also been reported. *Alternaria*, anthracnose *(Collectotrichum)* and downy mildew *(Peronospora)* are occasionally serious.

Breeding and germplasm

Centres of diversity, collections

The origin of the white cabbage is either the Western part of the Mediterranean area or Asia Minor. The cultivated species *B. oleracea* is presumed to have several wild ancestors. The heading types may have arisen, by selection, in W. Europe in the early Middle Ages. Many working collections and germplasm collections of wild and primitive types of white cabbage and other Brassicas useful for breeding purposes are already available (see Annex 2).

Genetics and breeding

White cabbage is one of the most intensively studied vegetables regarding its genetic and breeding behaviour. Most of the older cultivars are the result of mass selection. Modern cultivars have been selected from crosses involving high quality parents. Hybrid cultivars which combine a high degree of uniformity, a high yield capacity and other desirable factors are becoming increasingly popular. The most important development in this field is the selection of tropical types by Japanese breeders, such as K-Y Cross and K-K Cross; these are suitable for hot climates and mature in 60 days.

In wet tropical climates the level of infection by bacterial and fungal diseases is very high (from 30 to 70%). These diseases are difficult to control by cultivation methods but good results have already been obtained in breeding programmes aimed at introducing resistance to some pathogens. In Indonesia, hybrids between Glory of Enkhuizen x Pudjon are reported as being resistant to blackrot. In Brazil, a local cultivar Louho has been selected, this shows a high level of resistance to blackrot and also gives good seed production at high temperatures. Many cabbage cultivars are resistant to different physiological races of clubroot.

Recommendations

Germplasm

The collection of germplasm in the Mediterranean area and in W. Asia has already been given much attention by plant breeding institutions. The danger of losing wild Brassica types is not great and there appears to be little need for immediate action. The existing collections of local Asiatic white cabbage cultivars should be revised.

Breeding

High priority should be given to breeding cabbage cultivars which give high yields in hot climates, produce fertile seed and combine many kinds of disease resistance. Attention should also be paid to those types which have a high nutritional value.

3. CHINESE CABBAGE

Crop information

Botany

The hundreds of cultivars of *Brassica campestris* widely grown in the Far East under the names of Chinese cabbage or Chinese mustard can be roughly classified into two main groups:

(a) subsp. *chinensis:* paak-ts'oi, spoon cabbage Chinese white cabbage. these are generally non-heading, warm-weather plants with prominent white, fleshy petioles and upright glabrous leaves which form a loose rosette, as in Swiss chard.

(b) subsp. *pekinensis:* pe-tsai, Shantung cabbage, Chefoo cabbage, celery cabbage. Generally grown in cooler climates.Many types form loose or solid heads which resemble white cabbage or cos lettuce; many types have a very broad, flat midrib and petiole.

Common cultivars of type (a) are: Taisai, and of type (b) Wongbok and Michihli. Many cultivars have characteristics which are intermediate between (a) and (b).

Geography and ecology

Chinese cabbage is one of the main vegetables of the Far East and S.E. Asi The popularity of the leaf types (paak-ts'oi) as a summer vegetable in temperat zones (USA, W. Europe) and as an all the year round leaf vegetable in some humi tropical areas, particularly in Africa and S. America, is increasing. The heading type (pe-tsai) appears to be less well adapted to high temperatures. It is less well-known outside China and rarely cultivated in the humid tropics. Paak-ts'oi flowers and sets seed very easily at high temperatures, but pe-tsai requires cool weather for seed production. Long days are favourable for flower initiation in both types.

Economic importance

In the Far East and S.E. Asia, Chinese cabbage is produced in family garde for home use and by commercial vegetable growers for city markets. The heading type is more important for market production than the leaf type.

Nutritional importance

The green, leafy types have a high nutritional value. The ANV rating in table 5 is 6.99 i.e. twice that of white cabbage. The heading types, however, have very little chlorophyll in the inner leaves and therefore have a much lowe ANV (3.56). The white, thickened petiole has a low food value, compared with that of the green leaf blade, so the large petiole types have a somewhat lower nutritional value than the leafy ones.

Main limitations to cultivation in the tropics

Chinese cabbage suffers from the same range of pests and diseases as the white cabbage but its susceptibility to diseases appears to be much lower.

Breeding and germplasm

Centres of diversity, collections

The main source of diversity of Chinese cabbage is the Chinese-Japanese centre. A large collection of germplasm exists in Taiwan; working collections have also been established at some institutions involved in breeding work (see Annex 2).

Genetics and breeding

A large number of commercial cultivars of Chinese cabbage are found in the Far East. Japanese companies have developed hybrid cultivars from self-incompatible lines; these are uniform high yielding with good keeping qualities and have some resistance to wilt diseases, root-knot nematodes, virus and soft rot. These cultivars differ from each in other shape, colour, earliness (60 to 90 days), keeping quality and sensitivity to high temperatures. The AVRDC is developing heat-tolerant cultivars with multiple disease resistance (at least for soft rot, downy mildew and mosaic). A mutant with a high vitamin C content has been reported from the USSR.

Recommendations

Germplasm

Local cultivars are in some danger of erosion as they become replaced by modern high yielding types. A second priority is collecting, bearing in mind that the AVRDC in Taiwan has already assembled a large collection.

Breeding

Breeding work on both heading and leafy types suitable for hot weather should be stimulated. The breeding programme of the AVRDC only includes the heading type.

4. CAULIFLOWER, BROCCOLI

Crop information

Botany

Cauliflower *(Brassica oleracea* var. *botrytis)* and broccoli *(B. oleracea* var. *italica)* are closely related annual plants with very similar characteristics. The main difference between the two varieties is that the white cauliflower is harvested only once whereas the small green broccoli heads may be cut from the same plant over an extended period. Cauliflower heads should be compact and white, whereas the green broccoli inflorescences or curds have a loose structure. Mechanised harvesting is more practical with cauliflower than with broccoli.

In the tropics, the main cauliflower cultivars are the late-maturing European ones which are adapted to short daylengths but those are being replaced by Indian and Japanese cultivars such as Early Patna and Snow Queen, which are adapted to warm climates. The tropical cultivar Pua Kea has been selected in Hawaii. Calabrese is perhaps the most common of the many broccoli selections.

Geography and ecology

Cauliflowers and broccoli are both cool weather crops. Cauliflower, in particular, is more difficult to grow in warm climates than white cabbage but broccoli is better adapted to high temperatures. No satisfactory curd formation takes place in cauliflower at temperatures higher than 25°C and heat injury or scald is a frequent phenomenon. Seed production of cauliflower in warm climates is either non-existent or very poor but broccoli gives a good seed yield at higher elevations.

Nutritional importance

The nutritional value of cauliflower is good (ANV=4.12), due to a high vitamin C content. Broccoli has a very high value (ANV=6.5) due to a high calcium, carotene and vitamin C content.

Economic importance

The popularity of these vegetables in city markets is increasing. They are already important in the cooler parts of Latin America, India and the Far East.

Main limitations to cultivation in the tropics

Both cauliflower and broccoli are susceptible to the same pests and diseases as white cabbage, but to a lesser degree. The main limiting factor is the poor formation of curds in cauliflowers grown in high temperatures.

Breeding and germplasm

Centres of diversity, collections

The origin and main centre of diversity is in the Mediterranean. Working collections of old and modern cultivars are available at breeding stations (see Annex 2).

Genetics, breeding

The Indian selection Patna and, within the past few years, the Japanese hybrid cultivar Snow Queen are early, tropical cauliflowers which have been developed by modern plantbreeding techniques. The genetic constitution and breeding methods used with both cauliflowers and broccoli are similar to those of white cabbage. Early, uniform, one-head broccoli hybrids have been developed both in the USA and Japan. In Campinas (Brazil) the local cauliflower cultivar Piracicaba, which produces seed, has been selected.

Recommendations

The collection of germplasm has no high priority for the tropics. Resistance to serious diseases is a much more important requirement. More attention should be paid to broccoli, which is easier to cultivate and has a better nutritional value than cauliflower.

5. VARIOUS LEAF CABBAGES

Crop information

Brassica juncea (2n=36), Indian mustard, is a popular leaf vegetable in the Far East. Unlike Chinese cabbage, the petioles have no wings and are not swollen, but the dentate leaf blades are thin with prominent veins; they have

a somewhat bitter taste. Local mustard cultivars are used as leaf vegetables in many tropical areas such as Indonesia (cv. Sawi), India, Sierra Leone and Guinea. *B. carinata* (2n=34) is an important leaf vegetable, cultivated in Ethiopia and elsewhere in E.Africa. A vegetatively propagated leaf cabbage from Kenya probably belongs to this species, or possibly to *B. tournefortii* or *B. integrifolia*, which are also cultivated in the humid regions of W. Africa. The latter two types could also be subspecies of *B. juncea*; the taxonomy of these tropical Brassicas is very confusing. In the Far East, a number of other mustard greens are grown, such as *B. perviridis* (2n=20), called spinach-mustard. The local leaf cabbages are usually tall-growing plants, the leaves being harvested singly as they mature. Some of the Asian cultivars are cultivated for the consumption of young plants cut at ground level. The African types are well adapted to high temperatures, they flower easily and produce large quantities of seed.

The temperate leaf cabbage types: kale, collard and thousand-headed kale, *B. oleracea* (2n=18) are cultivated in the cooler areas of Latin America and East Africa. 'Thousand-headed kale' also refers to a perennial plant, propogated by shoots, which is cultivated in East Africa. *B. alboglabra* Bailey (2n=18), Chinese kale, is probably a subspecies of *B. oleracea* and is a popular vegetable in S. China.

All the leafy cabbages have a very high nutritional value comparable with that of the leafy types of Chinese cabbage (see table 5). The economic value is low. Leaf cabbages are much less susceptible to diseases than the white cabbage.

Breeding and germplasm

The main centres of diversity of the tropical leaf cabbages correspond with the main cultivation areas. Collards and kale originated in the Mediterranean area. Almost no breeding work on these crops has been reported from tropical areas.

Recommendations

Local cultivars should be collected and studied particularly in E. Africa. Breeding should begin with cultivar testing and it is necessary that leaf Brassicas should be improved in areas where they are important in human nutrition.

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There are several types of amaranth grown in the tropics as typical leaf vegetables. The example shown in the picture is taken from Zaire.

VIII LEAF VEGETABLES

1. GENERAL

Classification and characteristics of leaf vegetables

In the tropics, numerous wild and cultivated plants are in use as leaf vegetables. Martin and Ruberte (1975) listed about 1,000 and Terra (1967) mentioned about 700 species with edible leaves, belonging to some 125 different plant families.

All dark-green vegetables are more or less similar in their nutritive values and methods of consumption and preparation. White or light-coloured leaves and sprouts, such as bamboo and white cabbage, are not listed in this group, since their nutritional value is much lower. Approximately 80% of the more popular dark-green leaf vegetables are wild plants and are mainly gathered for home consumption. These 600-800 species constitute only a very small part, probably far less than 10%, of the total quantity of leaf vegetables consumed. Interest in them is declining, with increases in population density, changes in the wild vegetation and the increase in urbanisation associated with economic development. Only the most important of these wild plants i.e. *Talinum* and baobab leaves, are discussed in the section.

Some 50 species of food or ornamental plants have edible leaves, such as maize, taro, cassava, sweet potato, hot pepper, okra, papaya, groundnut, cowpea, radish, carrot, sesame, bitter gourd, pumpkin and chayote. Only the more important food crops in this group, i.e. cassava, taro, sweet potato and cowpea are described in this section. Selected cool weather leaf vegetables such as: New Zealand spinach, lettuce and endive which are grown in some tropical upland areas have also been mentioned.

Of the numerous perennial plants (shrubs, trees) used as leaf vegetables, only the following most common species have been mentioned: drumstick, *Leucaena*, bitter leaf, *Gnetum* and *Sauropus*. The great advantage of these perennial plants which are commonly grown in home gardens, is that they produce young leaves during the dry season and do not require a great deal of attention.

Geography and ecology

The most important leaf vegetables in the main tropical areas are listed in table 12; this indicates that a large number of perennial plant species are used as leaf vegetables. In table 13, Porto-Novo, Benin, is cited as an example of a city in which the population traditionally consumes a large amount of leaf vegetables; only five species are considered really important, since together they constitute 96% of the total quantity of leaves marketed. The remaining 4% is contributed by not less than 20 species. In the rural areas around Porto-Novo, this group of minor leaf vegetables includes some 50 species which constitute about 20% of the total quantity consumed. Amaranth is the most important annual leaf vegetable in Benin and Sierra Leone, *Celosia* is the most important one in S. Nigeria, *Solanum* in S. Togo, taro and *Solanum* in Ghana and *Corchorus* in S. Ivory Coast and Liberia. This illustrates the great diversity of locally important leaf vegetables which can be found within a limited area.

In the tropical lowlands, the very expensive European type vegetables are consumed only to a limited extent by the more affluent sector of the population and are not consumed in rural areas. In the cooler tropical regions, more European type vegetables may be consumed.

Table 12. Important leaf vegetables used in tropical areas. Blanched leaves, such as those of white cabbage, are not included.

Areas	Important leaf vegetables	Moderately important leaf vegetables
S. Asia, S.E. Asia, Pacific, Far East	Chinese cabbage, kangkong, amaranth, leaf cabbage (mustard), spinach beet, drumstick tree	cucurbits, *Sauropus*, sweet potato, basella, taro, lettuce, yardlong bean
Ethiopia, E. Africa	leaf cabbage, amaranth, cassava, jute	lettuce, endive
C. Africa, W. Africa	jute, amaranth, roselle, *Solanum* spp. bitter leaf, *Talinum*, cowpea, baobab, taro	cassava, *Cucurbita*, basella
Meso-America	leaf cabbage, *Xanthosoma*, *Cucurbita*, spinach beet, chaya	cassava, celery, endive, Talinum
Brazil, Andean Zone	leaf cabbage, lettuce, spinach beet, endive, spinach	cassava, *Cucurbita*, celery, parsley

Table 13. Vegetable sales in the markets of Porto-Novo (Benin) in 1973. Adapted from Vermeulen (1974).
For 80,000 inhabitants. Consumption as purchased. F = francs CFA.

	ton	F/kg	g/caput per day	F/caput per day
tomatoes	724	90	24.8	2.23
hot pepper	413	140	14.1	1.97
onions	300	92	10.3	0.95
okra	387	54	13.3	0.72
european vegetables (lettuce, carrots, french beans, cabbage etc.)	70	±500	2.4	1.20
tropical leaf vegetables :	1,662	21	56.9	1.19
33 % *amaranth*				
27 % *Celosia*				
19 % *Corchorus*				
12 % bitter leaf				
5 % *Solanum*				
4 % rest: *Basella*, *Talinum* cowpea etc.				

Table 14. Nutritional value of 24 tropical leafy vegetables. Values from FAO Food Composition Tables for Use in East Asia, 1972 (1) and for Africa, 1968 (2). Vegetables ranked on dry matter content. Values per 100 g of edible portion. Waste in % of the product as purchased

	type of leaves	waste %	DM %	protein g	fibre g	calcium mg	iron mg	-car. mg	vit.C mg	ANV fresh	ANV DM	Source
1.	Chinese cabbage (paak-ts'oi)	14	5.8	1.7	0.7	102	2.6	2.3	53	6.99	120.5	1
2.	lettuce	26	6.4	1.4	0.6	56	2.1	2.0	17	5.35	83.6	1
3.	Ceylon spinach *(Basella alba)*	43	6.4	1.6	0.6	106	1.6	3.5	86	7.90	123.4	1
4.	spinach *(Spinacia)*	24	7.0	2.4	0.7	62	3.9	3.6	56	8.44	120.6	1
5.	spinach beet	10	7.4	1.8	0.9	70	2.9	1.7	22	5.31	71.8	1
6.	waterleaf *(Talinum triangulare)*	33	7.6	1.9	0.6	90	4.8	3.0	58	8.28	108.9	1
7.	mustard	10	8.2	2.4	1.0	160	2.7	1.8	73	8.06	98.3	1
8.	New Zealand spinach	39	8.5	2.8	0.8	178	3.8	3.5	27	8.33	98.0	1
9.	chayote		8.8	4.0	0.8	62	1.4	1.5	24	5.02	57.0	1
10.	kangkong *(Ipomoea aquatica)*	28	10.0	2.7	1.1	60	2.5	2.9	47	7.57	75.7	1
11.	amaranth *(Amaranthus tricolor)*	40	10.7	3.6	1.3	154	2.9	6.5	23	11.27	105.3	1
12.	pumpkin		10.8	4.0	2.4	477	0.8	3.6	80	13.97	129.4	2
13.	yardlong bean	44	11.6	4.2	1.7	108	4.7	2.4	35	9.25	79.7	1
14	sweet potato	18	13.3	3.2	1.6	86	4.5	2.7	21	8.58	64.5	1
15.	roselle		13.6	1.9	1.3	116	1.5	7.6	34	11.04	81.2	1
16.	cowpea	5	15.0	4.7	2.0	256	5.7	8.0	56	17.75	118.3	2
17	jute *(Corchorus olitorius)*	34	15.9	5.6	1.7	266	7.7	7.9	53	18.56	116.7	1
18.	amaranth *(Amaranthus cruentus)*	24	16.0	4.6	1.8	410	8.9	5.7	64	16.52	103.3	2
19.	African eggplant *(Solanum)*		17.9	4.8	2.4	523	6.0	6.4	67	19.67	109.9	2
20.	taro	20	18.6	4.1	1.2	162	1.0	5.5	63	11.20	60.3	1
21.	cassava	13	19.0	6.9	2.1	144	2.8	8.3	82	16.67	87.7	1
22.	drumstick	39	22.4	7.4	1.2	297	3.6	8.9	167	20.53	91.7	1
23.	*Sesbania grandiflora*	60	24.0	8.7	2.2	404	5.0	6.2	58	14.13	58.9	1
24.	*Gnetum gnemon*	11	24.6	3.8	2.6	128	2.7	3.6	113	12.42	50.5	1
	mean	27	12.9	3.8	1.3	187	3.7	4.5	57	11.37	92.3	

Nutritional importance

Dark-green leaf vegetables have already been mentioned for their high nutritional value, especially their content of calcium, iron, β-carotene and vitamin C (see section 2.3). These vegetables are also rich in other protective nutrients such as phosphorus, vitamin B complex and folic acid. From the details of the nutritional values of 24 leaf vegetables (table 14) the following conclusions may be drawn:

(a) The dry matter content of the fresh product varies considerably between different species. However, it has been proved that this content also varies within each vegetable species. In Amaranth leaves, the DM content ranges from 8 to 21% depending on the cultivar, the climatic conditions, soil type, fertilisers applied, irrigation, degree of maturity, method of harvesting, transporting and handling.

It is better to consider the nutritional value of the dry matter of the vegetable than that of the fresh product. Moreover, leaves with a low DM content lose water during cooking whereas leaves with a high DM content take up some water. Unfortunately, data on the nutritional value of cooked vegetables are very scarce.

(b) Proteins (29.5% of the DM) are generally high in sulphur-containing amino-acids and consequently they improve the biological value of the main protein-supplying food types (cereals, tubers, pulses).

(c) Records of nutritional values show a great variation in the vitamin and mineral contents. This may be due to the different methods of analysis, but the growing conditions of the vegetables may also influence the quality. For example, it has been proved that a high level N-fertilisation increased the -carotene content of amaranth from 17.0 to 40.0 mg per 100 g DM. Available data on nutritional values should therefore be interpreted with some caution.

(d) There is no evidence to show that tropical dark-green leaf vegetables have a much higher nutritional value than dark-green temperate leaf vegetables. The only advantage of the former is that they are better adapted to cultivation in a tropical climate. All dark-green young leaves have about the same nutritional composition, including leaf lettuce and leaf cabbage.

(e) There is also no evidence to indicate that some wild tropical vegetables have a higher nutritional value than the commonly cultivated ones. The only difference is the higher DM content, if leaves of long-lived plants (shrubs and trees) are taken into account.

Economic importance

Leaf vegetables generally have a low economic value and social prestige and are more commonly consumed by the less affluent sectors of society. Many leaf vegetables are produced for domestic consumption and leaves are

easy to grow without much attention. Many perennial leaf vegetables may be found in home gardens, such as *Cnidoscolus* in C. America, *Sauropus* in Malaysia and S.E. Asia, drumstick tree in India and S.E. Asia and bitter leaf in W. Africa. These deep rooting and highly drought-resistant vegetatively propagated shrubs are of low economic importance. The successful market products among the leaf vegetables are those which are easy to grow in gardens, give high yields with a short growth period, are easy to harvest with a minimum of labour and have a widely acceptable taste. The most important are Chinese cabbage, amaranth, jute, taro, kangkong, *Solanum* and two European type vegetables i.e. spinach beet and lettuce (cf. table 15).

Main limitations to production and consumption

Several of these species may suffer seriously from pests and diseases and seeds or planting material of good cultivars are seldom or never available. The main limitation, however, is the lack of any knowledge of the nutritional value of leaf vegetables among the public in general. The short storage capacity of fresh leaves, which demands a well-organised marketing system is also a serious handicap.

2. COMMON ANNUAL LEAF VEGETABLES

Species dealt with below exclude the leaf types of *Brassica* which are described in Chapter VII, *Allium* (see Ch. V) and vegetables which produce edible flowers and shoots (see Chs. IX and X).

AMARANTH

Crop Information

Amaranthus spp. are widely distributed, short-lived weeds, the leaves of which are frequently used as pot-herbs. Some species are cultivated in home gardens and for marketing, i.e. *A. tricolor* L. (2n=34) mostly in East Asia, *A. cruentus* (L.) Sauer (2n=32) mostly in Africa and *A. dubius* Mart. ex Thel (2n=64) in the Caribbean area. These are probably the most important leaf vegetables of the lowland tropics of Africa and Asia, but are scarcely known in S America. The nutritional value is high, although the high oxalic acid content slightly decreases the ANV rating (see table 14 No.11 and 18.) A considerable amount of research has been carried out on amaranth in those regions where it occurs as a serious weed, and it has been included as a test plant in physiological research. Amaranthus is a plant with a C-4 cycle photosynthetic reaction which makes it an efficient producer of cabohydrate. Some Indian cultivars are markedly short-day plants; market growers plant them in the beginning of the summer and harvest them over several months by repeated cutting until the beginning of flowering at the end of the season. The cultivation method is either by sowing directly, or transplanting seedlings raised in a nursery. When the plants are pricked out, either dense spacing (10X10cm) with one single harvest by uprooting, or wide spacing (25X25cm) with several harvests by repeated cutting is practised.

Amaranth is a suitable plant in a crop rotation since it is not affected by the more common soil diseases and pests (nematodes, *Fusarium*, *Sclerotium*, bacterial wilt). Serious pests and diseases are: damping off *(Pythium)*, wet-rot *(Choanephora)*, caterpillars *(Hymenia)* and stemborers *(Lixus)*. Early flowering may occur as a consequence of a short daylength or may result from a short period of water stress.

Breeding and germplasm

Amaranth species show centres of diversity in C. and S. America, India, S.E. Asia and secondary diversity in W. Africa and E. Africa. Many local cultivars and wild forms occur especially in Africa. Some cytogenetic work has been carried out in India. Crossing with related wild species or with grain amaranths is possible, but not between the three vegetable species mentioned. All are monoecious plants with wind-pollinated, unisexual flowers. However, abundant pollen production leads to a high degree of self-fertilisation. Commercial cultivars exist in India, Taiwan, the Caribbean and the USA; these are remarkably uniform. Considerable differences exist between the three main species. The African cultivars of *A. cruentus* were originally grain-amaranths; they have long stems, a high DM-content in the leaves and bear large inflorescences. Cultivars of *A. dubius* and *A. tricolor* have a much lower seed production; their habit is similar to spinach, with short stems and succulent leaves. The wide variation between local cultivars within each species in growth habit, disease resistance, taste and quality implies possibilities for future breeding. Small collections of local cultivars are kept at AVRDC in Taiwan, Coimbatore and other institutes in India, and also at national research institutes.

Recommendations

Local cultivars should be collected since they are apt to disappear rapidly with the introduction of modern cultivars in India and S.E. Asia. Breeding work should be stimulated, with a view to the selection of high-yielding cultivars with resistance to wetrot and stemborers, with a good cooking quality and low oxalate content.

CEYLON SPINACH

Crop Information

Basella alba L. (2n=48) is a climbing perennial plant, mostly cultivated as an annual vegetable against supports in home gardens but in some areas as a vine-like market vegetable which is not staked. It is a short-day plant, with a C4-cycle photosynthetic pathway similar to that of amaranth. Flowering is precluded at a day length of more than 13 hours but water stress promotes early flowering. *Basella* is known as a minor vegetable in all tropical lowland areas. It is often called Ceylon spinach or Malabar nightshade. Three main types are in cultivation. The most common has dark-green, oval or nearly round leaves. a less popular type, often referred to as *B. rubra*, has red oval round leaves and red stems and a third, less commonly grown type has cordate-shaped, dark-green leaves. Ceylon spinach is a succulent and slightly mucilaginous vegetable; it is very susceptible to root-knot nematodes but is seldom or never attacked by insects, due to its very thick leaf cuticle. Red spots on the leaves and stems, caused by *Cercospora* and *Acrothecium*, are rarely serious. Market growers in Asia normally use cuttings as propagating material whereas, in Africa, seeds are usually sown.

Breeding and germplasm

Basella has its origin in S. Asia but is widely cultivated in tropical Asia, Africa and the New World. No references to breeding work have been encountered. Indian seed catalogues offer *Basella* seeds. No collections germplasm are known.

Table 15. Data on cultivation and seed production of leaf vegetables.

type of vegetable	cultivation						seed production						
	seed needed kg/ha	density pl/ha x 1000	duration days e)	yield t/ha low	high	mean	mean DM yield kg/ha	weight 1000 seeds g	g per plant	kg/ ha low	high	mean	multiplication factor kg/kg
Amaranthus cruentus	1 a)	250	20-80	10	40	20	3200	0.3	40	800	3000	1500	1500
Amaranthus tricolor	2 b)	500	30-90	10	40	25	3000	0.7	15	300	800	500	250
Basella alba c)	10 b)	50	60-180	10	80	50	4000	40	25	1000	2000	1200	120
Beta vulgaris	20 b)	1000	40-100	10	40	20	1600	16	10	400	800	600	30
Celosia argentea	1 a)	250	40-90	10	30	20	2400	1	12	200	700	450	450
Colocasia esculentum d)	-	30	60-270	3	9	6	1000	-					10
Corchorus olitorius	5 a)	250	45-80	3	10	8	1600	2	2	200	400	300	60
Hibiscus sabdariffa	6 b)	20	120-180	10	25	16 f)	2600	25	20	200	600	400	70
Ipomoea aquatica c)	5 b)	120	60-360	8	120	80	7000	40	15	100	500	300	60
Ipomoea batatas d)	-	120	90-180	5	20	15	2000	-					20
Lactuca sativa	5	200	30-60	5	30	15	1100	1.1	2	100	400	200	400

Manihot esculenta d)	-	100	60-270	30	90	50	8000	-					10
Spinacia oleracea	150 b)	1500	45-60	8	25	12	1000	10	6	300	1200	900	30
Solanum macrocarpon	1 a)	90	60-120	15	35	25	4000	3.3	30	120	300	200	350
Talinum triangulare	5 a)	250	60-180	10	60	45	3600	0.3	4	100	300	200	400
Vigna unguiculata	200 b)	500	30-60	5	15	10	1500	250	20	600	3000	1200	6
Zanthosoma sagittifolium d)	-	20	60-270	10	30	20	4000	-					10

a) transplanted

b) direct sown

c) may be propagated by cuttings

d) propagated only vegetatively

e) days from sowing or transplanting to the first and last harvest

f) about half of this quantity being calices

Inflorescence of an amaranth *(Amaranthus cruentus)*. Seeds are collected from such heads in Guatemala and other parts of C. America for grain. In Africa leaves are used as a vegetable.

Celosia argentea an important vegetable in limited parts of Africa. Several closely related species are used for medicinal purposes.

Recommendations

Ceylon spinach is a very productive leaf vegetable which is suitable for both home gardens and market production in the low humid tropics. It shows a remarkable resistance to pests and diseases. There is no danger of genetic erosion. Collecting of local types and screening for high yield capacity is advisable but is of low priority.

BEET

Swiss chard, spinach beet or leaf beet, cultivars of *Beta vulgaris* L. (2n=18) are temperate annual vegetables widely cultivated in the Mediterranean area, but becoming increasingly popular in cool tropical areas. The stalk type, the real 'Swiss chard' which is popular in the Mediterranean area, has a much lower nutritional value than the leafy types. Dark green Lucullus, Fordhook Giant, Large Rib and Rhubarb Giant are well-known leafy cultivars. Since only the large, outer leaves are harvested, the harvest period is prolonged and the level of production high. Swiss chard is a very important vegetable in N. India and, to a lesser extent in the cooler parts of S. America. Diseases and pests are identical with those of the sugarbeet i.e. nematodes, aphids, yellow mosaic virus and *Cersospora* leaf spots.

Some breeding work on Swiss chard has been undertaken in India, resulting in the introduction of new commercial cultivars. These, together with local cultivars from India, Hongkong and S. China, show a better yield than cultivars introduced from temperate regions and produce viable seed in the tropics. Collections of both cultivated and wild *Beta* species and cultivars from the centre of diversity, i.e. the E. Mediterranean area, and secondary centres in Asia and N. Africa are kept by sugarbeet breeders in W. Europe and N. America but are inadequate for the improvement of the tropical spinach beets.

The genus *Beta* has a high priority for IBPGR since the local S.W. Asian cultivars and wild species are rapidly disappearing. Material collected for breeding work with the sugarbeet can also be used for spinach beet programmes. This vegetable merits more attention as a suitable market vegetable for the cooler parts of the tropics.

SOKOYOKOTO

Celosia argentea L. (2n=72) (Amaranthaceae), occurs in Africa and Asia both as a weed and as a cultivated vegetable resembling *Amaranthus*. It is the most important leaf vegetable of S. Nigeria, where it is known as Sokoyokoto, and is popular in Benin, Zaire and Indonesia. It is often considered as a variety or type of *Amaranthus*, since the growth habit and cultivation methods used are very similar. However, in contrast to amaranth, *Celosia* has a C3-cycle photosynthetic pathway. It is susceptible to root-knot nematodes, *Cercospora* leaf spots and spider mites. It is a short-day plant which grows well on marshy soils and the shoots can be harvested over a period of 3-5 months, even when flowering has started. It is less suitable for harvesting by uprooting since juvenile development is slower than that of amaranth. The nutritional value is comparable to or somewhat lower than that of amaranth. The oxalate content is very high.

Celosia argentea originated in the Hindustani centre but *C. trigyna* L. and other species originated in tropical Africa. From a local, broad-leaved and high-yielding cultivar, with a red anthocyanin spot on the leaf blades, a completely green strain has been selected in Benin. No further breeding work or collections have been recorded.

Celosia cultivars should be collected and investigated, together with amaranth, since it is an important African vegetable for home garden production and marketing. It is a potentially suitable vegetable for all tropical lowland areas.

TARO

Taro, dasheen or cocoyam, *Colocasia esculenta* (L.) Schott is a root cro originati g from South East Asia and is important also in the tropical lowlands of the Pacific area and the West Indies. It is of minor importance in West Africa, South America and other parts of Asia. The consumption of the young leaves is popular in the West Indies and West Africa, especially Ghana. Many cultivars exist and propagation is by small side tubers or suckers. Olde leaves may contain crystals of calcium oxalate which do not dissolve during cooking. Virus diseases, *Phytophthora* blight and root rot are common probler Special cultivars, suitable for leaf production have not been recorded (See *Xanthosoma*, a leaf vegetable related to *Colocasia*).

Taro is included in the research programme on tropical tuber crops of th IITA, Ibadan, Nigeria. No special priority for this plant as a vegetable is necessary. A collection is held in Papua New Guinea and a more modest one in Indonesia.

JUTE MALLOW

Corchorus olitorius L. Jew's mallow, jute mallow or jute (2n=14) is wel known as a fibre crop but selected types with shorter and more branched stems are frequently cultivated as a leaf vegetable. The cultivation methods are very similar to those of amaranth. It is a short-day plant, self-pollinating with up to 10% of outbreeding. Seed yields are rather low and germination is often very poor, owing to dormancy (which can be overcome by soaking in hot water). Leaf production is also low (see table 15), but the leaves have a high dry-matter content; the stalks are not edible. Jew's mallow is a most important leaf vegetable in Egypt, where it is cultivated from March to November. It is one of the leading leaf vegetables in lowland West Africa and is often stored in a dry condition. It is also commonly grown in Malaysia and parts of Latin America. The plant thrives best in the hot, wet, lowland tropics. It is very susceptible to damage by spider mites and root-knot nematodes and is also attacked by caterpillars which feed on the leaves.

Corchorus, as a vegetable, has received very little attention from plant breeders. There are numerous cultivars, varying in stem colour, height, pubescence and fruit shape. The primary centre of origin is S. China and it wa taken at an early date to India. In many places it has become weedy.

This important leaf vegetable is not yet in great danger of genetic erosion but collecting is recommended and selection of cultivars should rate a high priority.

ROSELLE

Roselle is a self-pollinating, annual plant with woody branches, grown t a large extent in the drier parts of West and Central Africa and in India. I is a short-day plant. Harvesting of the fleshy, green or red calices takes place in December-January; they are usually dried and stored for use during t dry season. The leaves are eaten fresh or dried, they have a higher nutritio value than the calices. In India and the USA, special cultivars with sweet, calices are used in the preparation of a jelly. In the Sahel zone, roselle i widely cultivated as a mixed crop under the name of "dah". In monoculture,ab

8 t/ha of fresh calices and 10 tonnes of leaves may be harvested per annum. *Lixus* beetles damage the stems and plants are generally susceptible to the same pests and diseases which attack cotton. Roselle is very attractive to insects belonging to *Hemiptera* (plant bugs, aphids and mealy bugs).

The origin of roselle, *Hibiscus sabdariffa* var. *sabdariffa* (2n=36 or 72) is tropical Central Africa. Many local strains and wild types are known. In India, some commercial cultivars are available, as are also those of *H. cannabinus* L. kenaf, which is also used as a leaf vegetable in West Africa and elsewhere. No collections are known.

The high degree of drought resistance and its suitability for drying makes roselle an interesting vegetable. Some risk of genetic erosion is present in India but not in Africa. Breeding of high-yielding cultivars is recommended and cultivar testing should yield early results.

KANGKONG (*Ipomoea aquatica* Forsk.)

Kangkong or water cabbage (2n=30) is a trailing, tropical lowland plant, related to the sweet potato. Two main botanical varieties are distinguished: var. *aquatica* and var. *reptans*. The former is an aquatic plant, widely grown in the southern part of India and South East Asia; it is propagated by cuttings and grown in fish ponds and water courses. The latter is an upland vegetable, cultivated on dry or marshy land and is propagated by either cuttings or seeds. Var. *aquatica* is often used as a fodder for pigs. The upland type is an important market vegetable in Malaysia, Indonesia and other South East Asian countries; the species has not become widely distributed outside this region. Pests and diseases are similar to those found on sweet potato, i.e. caterpillars and virus diseases.

Various clones and cultivars propagated by seed are available in South-East Asia and India. The danger of genetic erosion is apparently small, nevertheless, a detailed study of this very important Asiatic vegetable, including the collecting and testing of all the available genetic material, is strongly recommended as a priority.

SWEET POTATO

The leaves of the sweet potato *Ipomoea batatas* (L.) Lam. are used as potherbs in South East Asia, the Pacific and locally in Latin America. It is an important source of food for the highland population of Papua New Guinea where many interesting local selection are grown. Since the sweet potato is an important research subject in both national and international institutes in the USA and in developing countries, it is not specifically included in this study. No special action is recommended except to support the need for the collection of germplasm in Papua New Guinea.

LETTUCE

Lettuce, *Lactuca sativa* L. (2n = 18) is one of the most important vegetables grown in temperate regions. It has a high social significance for affluent people in developing countries but its nutritional value - although fairly good - is often highly exaggerated. Europeans commonly consume it raw although it may be an important cause of intestinal infections in hot climates. It is more popular in Latin America, Africa and the Near East than in India and South East Asia, where it is often consumed cooked as a spinach substitute.

Lettuce is an important market vegetable in the tropics, especially in Latin America and Africa. This beautiful crop of lettuce was photographed in Senegal.

In the tropics, lettuce is principally a market vegetable, home consumption being generally limited. Many hundreds of cultivars have been produced. In the wet tropics, butter-head cultivars are less successful than the crisp-head cultivars such as Great Lakes. In southern China, local cultivars of leaf lettuce and stem lettuce are popular and growers produce seed of these cultivars. *L. indica* L. and *L. denticulata* Maxim. deserve more attention. *L. sativa* var. *angustana* grown in China for its fleshy stem is eaten raw or cooked. Leafytypes have a higher nutritional value than the heading ones.

Seed production of this crop is possible in the tropics in dry regions, since flowering is stimulated by high temperatures. The bolting of young lettuce plants grown at high temperatures may be somewhat retarded by shading and frequent watering. High temperatures frequently induce a bitter taste.

Some cultivars have a light requirement for breaking of dormancy. Apart from the high level of cultivation required, the main problem of growing lettuce in the tropics is its susceptibility to pests and diseases. Root-knot nematodes and rots caused by *Sclerotium* or other fungi, are the main problems.

Lactuca sativa L. is an old cultigen derived from *L. scariola* L. which grows wild in the Near East. It is a highly self-pollinating species and modern cultivars cross readily with primitive cultivars or related types. It is one of the best studied temperate plants. Several large collections of germplasm are already available but lack the types from China and S.E. Asia. Heat-resistant cultivars such as Slobold have been bred but cool nights (less than 23°C) are necessary for these types to mature properly.

Lettuce cultivation can be recommended as a spinach-type leaf vegetable, due to its increasing economic value. Cultivar testing and local seed production of suitable cultivars should be stimulated.

CASSAVA *(Manihot esculenta* Brantz.)

Cassava leaves are eaten in many tropical lowland areas. Special clones have been selected, e.g. in Nigeria, which form very few tubers but which have a high production of palatable leaves, free from virus. Cassava is an important leaf vegetable in Zaire, Indonesia, Malaysia and parts of South America (Brazil) where it is known as manioc. It is suitable for growing in home gardens; a plot of cassava occupying 10 m^2 of a fertile soil produces about 2 kg of young leaves per week during the wet and 1 kg per week during the dry seasons.

Cassava, as a leaf vegetable, is more commonly grown for home production than for marketing. The nutritional value is high, due to the high dry-matter content (table 14). The high level of hydrocyanic acid is no drawback to consumption since this poisonous substance disappears during cooking.

If the leaves of a cassava crop intended for tuber production are harvested, there will be a subsequent decrease in tuber production. The method of propogation by cuttings, rather than by seed, has limited the distribution of numerous cultivars.

Since cassava, as a tuber crop, is an object of research at IITA in Nigeria, CIAT in Colombia and also in many national research institutes, no further details are given here. In breeding cassava, the selection of high protein-content leaf types and virus-resistant cultivars should not be ignored. The collection of germplasm is apparently adequate, at present.

AFRICAN EGGPLANTS

Apart from the formation of fruits, many kinds of African eggplant have glabrous, dark-green, succulent edible leaves. In some regions of West Africa (Ivory Coast, Ghana) the consumption of the fruits is more important, (see

Chapter III). However, some cultivars with small fruits are cultivated in West Africa, (Ghana, Togo, Benin, Nigeria) as a leaf vegetable, the fruits being rarely consumed. The taxonomy of local *Solanum* spp. used as vegetables is confused. *S. macrocarpon* L. (2n=36) is characterised by the long calyx which surrounds the fruits. *S. aethiopicum* L. (2n=24) is a related species which occurs in the wild but is not commonly cultivated. Both the dark-green leaves and the small, bitter fruits are eaten. *S. macrocarpon* is an important market vegetable in West Africa, the fruits are sold in the Ivory Coast and Ghana, but the leaves are more widely used in other areas. The black nightshade, *S. nigrum* L. is collected from the wild as a pot herb in many parts of the world and is sometimes cultivated in Africa; two main forms, Ogunmo and Odu are grown in Nigeria and Sierra Leone (Epenhuijsen, 1974).

The origin of *S. macrocarpon* and *S. aethiopicum* is tropical Africa. Some selection work on local cultivars has been carried out in the Ivory Coast and Benin. Pests and diseases which affect *S. melongena* (see III) but is less these species. They are very susceptible to virus, bacterial wilt, *Fusarium*, *Sclerotium*, root-knot nematodes and stemborers.

S. macrocarpon is an excellent leaf vegetable for the regular harvesting of the leaves over a long period. The risk of disappearance of the local cultivars, used for both fruits and leaves, exists (see III) but is less serious for the types which are grown exclusively for their leaves. Collecting and screening of local cultivars is strongly recommended.

WATERLEAF

Talinum triangulare (Jacq.) Willd., waterleaf, is a common weed in most tropical areas but is frequently grown in home gardens and market gardens as a leaf vegetable. It has a C4-cycle photosynthetic pathway, similar to that of *Amaranthus* and *Basella*; this results in a high level of dry-matter production provided the temperature is high and soil fertility, light and water availability are optimal. The DM content of the leaves is as low as that of *Basella*. It is a soft, mucilaginous vegetable, with a high oxalate content.

It is propagated by seeds or, occasionally, by cuttings. It possesses a remarkable degree of drought resistance. No serious pests and diseases are known. Plants may continue to produce edible shoots for more than a year. Waterleaf is a minor vegetable with some economic importance in West Africa, Java, and Brazil (Amazon). The small seeds are difficult to collect which is a drawback to regular cultivation.

The origin of *Talinum* (2n=48,72) is not precisely known; it probably comes from Central Africa, but tropical South America could also be a possible centre of diversity. No breeding work has been described. There is no risk of genetic erosion but some broad research and breeding of this interesting vegetable is recommended.

COWPEA AND YARDLONG BEAN

The leaves of both the cowpea and the yardlong bean (see VI) are frequently consumed. African farmers believe that the removal of the young growing points of the cowpea (about 2 t/ha during the flowering period) stimulates fruit setting and seed production, but this has not been proved. If a considerable proportion (more than 4 t/ha) of the leaves is removed, the yield of dry beans will be seriously affected. In West and Central Africa, cowpeas are traditionally grown both during the dry and rainy seasons as a leaf vegetable. The 3-week old plants are cut at ground level or uprooted, either for home consumption or for marketing. It is not known whether special leaf types

have been selected. The consumption of cowpeas as a leaf vegetable should be given some attention in international cowpea research and breeding programmes. The yardlong bean (see VI) is less important as a leaf vegetable.

COCOYAMS

Xanthosoma brasiliense (Desf.). Engler is an important leaf vegetable grown widely in south Brazil and the Pacific and known as calalou or yautia. It is propagated by small corms. All the leaves are used; they contain oxalates, but these are not the same as the sharp calcium oxalate crystals which are found in the older leaves of the tanier, *X. sagittifolium* (L.) Schott. This is often called cocoyam, but only the unfolded young leaves are used, in addition to the starchy corms. This species originates from tropical South America and is popular in most tropical lowland areas. Many cultivars (clones) are known, some of them being especially cultivated as leaf vegetables. *Xanthosoma* may suffer from virus diseases or from wilting and rotting, probably caused by nematodes.

No breeding work on *Xanthosoma* as a leaf vegetable is recorded. Local cultivars are available at national institutes and in Nigeria at IITA, where breeding work on the tuber crop is in progress (see *Colocasia*). This adaptable vegetable should be given some attention in horticultural research programmes. There is no immediate risk of losing local cultivars.

3. SHRUBS AND TREES

The leaves of many wild trees and shrubs are used as vegetables, some woody species being specially cultivated for this purpose. The most important of these species are briefly described. Their advantage over annual vegetables is that they produce over a long period, require very little attention, and are more drought resistant and less susceptible to pests and diseases. The disadvantage is that the harvesting is less convenient, and the time from sowing or planting to the first production is much longer.

Adansonia digitata L. the baobab, is a common, wild, protected tree from the Sahel zone in West Africa to Tanzania and Malawi in East Africa. The leaves are used fresh or dried in soups. It is not cultivated.

Cnidoscolus chayamansa McVaugh, the chaya or tree spinach, is a shrub grown on compounds in the Caribbean and Central America. It is propagated from cuttings and planted as hedges.

Gnetum gnemon L. is a shrub or small dioecious tree, grown in South East Asia (Indonesia) for the seeds and leaves. It is propagated by seed. This and related *Gnetum* species used as leaf vegetables can be found in the spontaneous vegetation of lowland areas in Asia.

Leucaena leucocephala De Wit is a common leguminous shrub used for mulching and as a forage plant in tropical lowland areas. It occurs as a weed in cash crops. The young shoots are sometimes used as a minor vegetable in Asia, e.g. in the Philippines. Seed production is very high but non-seeding clones, propagated from cuttings, are known. An annual dry matter production of *Leucaena* leaves of 25 t/ha has been recorded in Hawaii.

Moringa oleifera Lam., the drumstick tree or horse-radish tree, is very popular in S.E. Asia and West Africa. In addition to the young fruits, the leaves are commonly used as a vegetable. The small leaflets are easily stripped from the petioles. Various clones are known in India. *Moringa* is propagated by cuttings with a length of more than 1 m which are planted in fences for the protection of home gardens. They provide a light shade and are useful as stakes for climbing vegetables.

Sauropus androgynus Merr. is a small shrub which is popular in India, Malaysia and Indonesia as a leaf vegetable in home gardens. It is propagated by cuttings and is often planted in hedges or around vegetable beds as a soil conservation measure. The first harvest is after 3-4 months, cutting begins when the plant reaches 60 cm. It has an exceptionally high pro-vitamin A content.

Vernonia amygdalina Del., bitter leaf, is a popular vegetable in West Africa. It is propagated by cuttings and planted in hedges in home gardens or in plots for commercial production. About 4 kg fresh leaves per m^2 per year may be obtained. The shrub suffers from *Lixus* beetles and *Sclerotium* wilting. Other wild or cultivated *Vernonia* species are known in the tropical lowland areas of Asia, Africa and America.

Recommendations

The use, cultivation and genetic variability of the perennial woody leaf vegetables should be studied, especially *Adansonia*, *Cnidoscolus*, *Moringa*, *Sauropus* and *Vernonia* which are promising species. There is no immediate danger of genetic erosion.

4. MINOR WILD AND CULTIVATED LEAF VEGETABLES

Some of the many hundred species other than the 18 annual vegetables listed in VIII and the seven trees and shrubs of section VIII are worth mentioning in brief:

Apium graveolens L., celery, is a temperate vegetable of increasing importance in subtropical and cool tropical areas of Latin America and the Far East. Leafy types and cultivars with fleshy petioles are grown.

Chrysanthemum coronarium L., is an annual leaf vegetable or a spice plant locally grown in Malaysia and other South East Asian countries and in the Far East as a cool-weather crop.

Crassocephalum spp., erect or climbing plants, are wild or cultivated annual vegetables in West Africa, especially in South Nigeria. They grow well in heavy shade, in contrast to almost all other tropical leaf vegetables.

Emilia sonchifolia D.C. is known as both a weed and a cultivated annual vegetable in tropical Africa.

Gynandropsis gynandra Briq. (*Cleome gynandra* L.) is a wild or cultivated vegetable sometimes grown in compounds in tropical Africa.

Hibiscus manihot L., is a popular South Pacific leaf vegetable propagated by cuttings. Its habit resembles *H. sabdariffa* (see VIII). It is very suitable for home gardens.

Nasturtium officinale L., the watercress, is found wild and is also cultivated in some tropical areas. Its popularity is increasing (Indonesia). Propagated from cuttings or by seeds.

Petroselinum vulgare Hill., parsley, is a popular vegetable of the temperate regions. It is frequently grown as a leaf vegetable in Brazil. It is used as a spice, a green leaf vegetable or salad seasoning in almost all subtropical and tropical areas. Parsley grows best in moderately cool, humid and shady conditions.

Pluchea indica L. Less. is a shrub occurring in the wild or planted by cuttings in compounds in Indonesia. The young leaves are a popular vegetable.

Physalis peruviana L., the Cape gooseberry, is found wild in the lowland tropics. It is sometimes cultivated for the leaves in South America, tropical Africa and Asia. Propagation is by seed.

Portulaca oleracea L. and other *Portulaca* species occur as weeds in most tropical and subtropical areas. Purslane is a popular winter vegetable in North India. Propagation is by seed.

Sesbania grandiflora Pers., is a small tree used for shade in compounds in South East Asia and India. The flowers and sometimes also the leaves are eaten. Propagation is by seed.

Spilanthes spp. are collected in the wild or grown as leaf vegetables in compounds in Central Africa and in Indonesia; they are propagated from seed.

Telfairea occidentalis Hook. f., is an annual cucurbit, native of tropical Africa, grown as a leaf vegetable in home gardens in Nigeria. It is propagated by fresh seeds and is fairly drought resistant but grows better in the humid regions. Female plants produce leaves for longer periods than male plants.

5. GENERAL RECOMMENDATIONS

(a) Leaf vegetables are very important in human nutrition (see II.3 & VIII.1) especially regarding their content of pro-vitamin A. However, data on the utilization, cooking and net nutritional value of the consumed product are inadequate. Research in these areas should therefore be encouraged.

(b) Leaf vegetables show many parallels in their growth and the cultivation methods used. The photosynthetic resources of plants are significantly reduced by repeated harvesting of the leaves. Leaf vegetables rapidly exhaust the soil fertility and there is a need for more extensive agronomic research and growth analysis of the more widely used species.

(c) The collection of primitive germplasm of the more important species mentioned in this chapter should be undertaken, both for conservation and for immediate breeding programmes. A first priority has been attributed to amaranth, jute mallow, kangkong, chaya, drumstick tree and *Sauropus*.

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IX OTHER WARM WEATHER VEGETABLES
(okra, sweet corn, palm cabbage, bamboo, arracacha, mushrooms)

1. INTRODUCTION

In the preceding chapters, numerous vegetable species which are grown in the tropics have been discussed. They belong to five families: Solanaceae, Cucurbitaceae, Alliaceae, Leguminosae, Cruciferae and one group which includes miscellaneous leaf vegetables. Six species, which are more or less important warm weather vegetables and which have not been mentioned previously are discussed in this chapter, i.e. okra, bamboo, palm cabbage, sweet corn, arracacha and mushrooms. Many other tropical or subtropical vegetables of minor importance are listed in section 8 but are not fully described.

2. OKRA

Crop information

Botany

Okra is an annual erect, poorly or non-branching herb, cultivated for its young fleshy fruits. Some 6 kg of seed/ha is sown in hills, 2-5 seeds per hill, at 30-60 cm intervals in the row and with 60-120 cm between rows, depending on the growth habit of the cultivar; seedlings are later thinned to 2 or 3 plants per hill. Harvesting is from 2-4 months for the modern early dwarf cultivars and 4-12 months for many local tall-growing types. Clemson Spineless, Louisiana Green Velvet, Ladyfinger, Perkins Spineless and Emerald are well-known American cultivars of the short-duration type. Pusa Sawani is a popular Indian cultivar. In the USA 7 t/ha of young fruits may be harvested i.e. 5-10 fruits per stalk. The okra crop in the humid tropics generally yields less than 2-3 t/ha. The ripe pods contain 30-80 seeds; the weight of 1000 seeds is 50 g. One ha of okra may produce 1500 kg of seed, but 400 kg of viable seed is a good average yield in the tropics. Soaking the hard-skinned, fatty seeds may improve their germination.

Many local cultivars occur in Africa and India, differing from each other in growth habit (branching or non-branching, large or dwarf, late or early, hairy or glabrous, light-green, dark-green or red) and fruit characteristics (upright or pendulous, slender or wide, with 5 to 10 ridges). The skin may be soft or hard, varying in specific gravity and dry matter content. Okra is often cultivated on marshy land at the end of the rainy season, in monoculture or in mixed cropping with maize, sorghum or upland rice.

Geography and ecology

Okra is a hot weather, tropical lowland crop, susceptible to drought and low night temperatures. It grows well at day temperatures between 25 and 40°C with night temperatures over 22°C. Most tropical cultivars are short-day plants.

Nutritional importance

Okra has a good nutritional value. It is a very popular, tasty, gelatinous vegetable, used in a number of local dishes. The extremely high calcium content is particularly valuable (see table 5). Okra is widely grown in the Sahel area as a food crop for the dry season. The fruits, cut into slices and dried in the sun, can be stored for long periods. The leaves are also used as a vegetable and may be dried.

Women in the Ivory Coast harvesting a crop of okra. There are many local cultivars grown in Africa.

Economic importance

Okra is a typical market vegetable. After harvesting, it can be easily transported in bulk and stored for several days without much loss of quality. Considerable differences in keeping quality exist between cultivars. Okra is not as cheap as the leafy vegetables because the yield potential is low, and the consecutive harvests are time-consuming. Dried okra slices are an important market product in the Sahel zone. Fresh okra is important in Brazil, W. Africa, India and in many other regions in the tropics. It is also a popular vegetable in the Near East and the southern part of the USA.

Main limitations to cultivation in the tropics

Okra is very susceptible to powdery mildew *(Oidium abelmoschi, Erysiphe cichoracearum)*, *Verticillium* and *Fusarium* wilts virus (yellow vein virus), root-knot nematodes and many insect pests (*Heliothis* caterpillars, leaf beetles, bugs). Apart from these biological drawbacks the yield potential is also low.

Breeding and germplasm

Centres of diversity, collections

Hibiscus esculentus L., (Syn. *Abelmoschus esculentus* (L.) Moench, is a cultigen originating from tropical Asia., or it may originally have been present in Africa and India as a polyphyletic species. A semi-wild ancestor, *A. tuberculatus*, occurs in India. Collections are present in genebanks in the USA and India.

Genetics and breeding

The scarce data on okra breeding have recently been reviewed by Joshi & Hardas (1975). The flowers of okra are self-fertile but usually up to 20% cross-pollination occurs by insects. Varying chromosome numbers between 2n=72 and 144 have been reported. Hybrids between Indian and African cultivars appear to be partially sterile. These are being studied in India for resistance to yellow-vein mosaic. A popular Indian early cultivar with very long fruits, Pusa Sawani, has some tolerance to virus. Sources of tolerance to *Fusarium, Verticillium* and root-knot nematodes have been reported. American seed companies have selected attractive cultivars such as Clemson Spineless, Louisiana and Emerald for the fresh market and special short-fruited cultivars like Goldcoast for canning. National research institutes in Ivory Coast, Ghana and Benin have carried out some testing of local cultivars. Hybrid varieties of okra may be developed in the near future. In India, it was shown that crossing inbred lines gives rise to heterosis and male sterility could be obtained by chemical induction. In Japan, amphidiploids have been obtained from interspecific crossings with the related wild species.

Recommendations

Germplasm

Collections of local Asiatic and African cultivars should be made both for direct breeding purposes as well as for the conservation of the germplasm. The danger of genetic erosion is great as a consequence of the growing popularity of the early, high yielding Indian and American cultivars.

Breeding

African farmers need long-duration cultivars which are suitable for their traditional cultivation methods. For the fresh market, however, growers require early-maturing cultivars possessing a high level of disease resistance, with special emphasis on mildew and virus. The yield potential of okra is far too low but screening of the many local cultivars would be the first step to improving the okra crop.

3. SWEET CORN

Roasted or sautéd maize cobs are a popular dish in areas where maize is grown as a staple food. In most instances no special cultivars are grown, but the young cobs of the local maize types are used for this purpose. Cultivars of the botanical variety *Zea mays* var. *saccharata* have been bred as vegetable maize of sweet corn. Although sweet corn is a hot climate plant, most American cultivars do not perform well in the tropics since they are not sufficiently adapted to short-day conditions and are too susceptible to diseases such as *Helminthosporium*. Golden Bantam (USA), Supersweet (Hawaii), Branco (Brazil), Cubana (Brazil), Puerto-Rico 50 and many other cultivars can be grown under tropical conditions, yielding 10-15 t/ha of marketable ears.

Sweet corn as a cooked vegetable has a certain importance in tropical America, Malaysia and India. A great deal of research on maize as a cereal crop has been carried out in several parts of the world and large collections have been established. The caloric value of sweet corn is fairly high, but it has a low rating (ANV=2.4) as a vegetable. No special action or priority for research or for the collection of germplasm of this vegetable is necessary.

4. PALM CABBAGE

The growing points of many palm species such as pejibaye *(Guilielma)*, coconut and several wild palms are used as a vegetable in the humid tropics. The cultivation of palms for harvesting the growing points has not yet been shown to be economic but could possibly be initiated with branching palms such as pejibaye. Palm cabbage is very popular in Brazil and in the rain-forest areas of Africa where it leads to a destruction of the forest. The nutritional value of this luxury vegetable is low. There is little risk losing the many types involved, so no high priority should be given.

5. BAMBOO

The young shoots of bamboo *(Dendrocalamus, Bambusa, Phyllostachys)* [illegible] popular vegetable in S.E. Asia and the Far East. The nutritional value is rather low (see table 5). Bamboo is often cultivated in dense plantings especially for the harvest of shoots, and is therefore a suitable plant for large compounds. Very little data exist on the cultivation of this vegetatively propagated vegetable and no important pests or diseases have been recorded. Bamboo thrives best at low elevations in humid tropical areas. There is no danger of genetic erosion.

6. ARRACACHA

Arracia xanthorrhiza Bancr. Arracacha, apio or Peruvian parsnip, is a popular vegetable grown at high altitudes in the Andean Zone and in Meso-America. *Erwinia* bacterial rot has been reported as a serious disease in Venezuela. Cultivars with white or yellow tubers are known. Some attention to research and breeding of this rather widespread, vegetatively propagated vegetable of tropical America appears to be justified. A small collection is held in Campinas (INTA), Argentina. There is no danger of genetic erosion.

7. MUSHROOMS

Mushrooms are popular in most tropical areas. They are gathered among the wild vegetation, perhaps most frequently in C. and W. Africa. In S. and S.E. Asia and the Far East, the cultivation of mushrooms *(Volvaria volvacea)* (Bull.) Guel. on paddy-straw is widespread. *Agaricus bisporus*, the common ten perate mushroom, is cultivated at high altitudes in the tropics. The nutri- tional value of mushrooms is very low (ANV = 2.44). However, they show a fai ly high content of some vitamins (thiamine, riboflavin and niacin) which are not incorporated in the ANV formula.

The labour input of a small-scale production unit in Asia is about 1 mar day per 2 m^2 of bed per cycle. A yield of 2-10 kg per m^2 may be obtained. Taiwan is a very important mushroom exporting country. In temperate countrie much research and breeding work on mushroom growing has been carried out.

In tropical areas the cultivation of mushrooms is expected to increase i the near future. Some attention to this vegetable via international researc is justified. There is no danger of genetic erosion.

8. VARIOUS SPECIES OF MINOR IMPORTANCE

Coleus tuberosus Benth. is cultivated for the tubers in S.E. Asia.

Nelumbium nelumbo Druce, lotus, is an aquatic plant cultivated in the F East for the consumption of its flowers, seeds and rhizomes.

Oxalis tuberosa Mol., oca, is cultivated in the Andean Zone at high al- titudes for the consumption of the tubers.

Trapa natans L., water chestnut, is cultivated in the Far East for its seeds.

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X OTHER TEMPERATE VEGETABLES

1. INTRODUCTION

A number of temperate vegetables grown in the tropics have already been discussed: sweet pepper (Ch.III); onion, Welsh onion, garlic, leek (Ch.V); common bean (Ch.VI); white cabbage, Chinese cabbage, cauliflower, kale and other Brassicas (Ch.VII); spinach beet, lettuce, spinach, celery and parsley (Ch.VIII). Some other typical temperate vegetables are of some regional importance in tropical areas, i.e. carrot, radish, asparagus and beetroot. Other temperate vegetables, of minor importance, which are grown locally in the tropics, e.g. salsify an artichoke, have not been discussed.

2. CARROT

Crop information

Carrot *Daucus carota* (L.) (2n=18) is a biennial temperate vegetable and many cultivars exist. Some of them e.g. Danvers Half Long and Intermediate are suitable for cultivation in upland regions of the tropics, and others e.g. Chanteney, Early Nantes and Cape Market are suitable for low to medium altitudes. Imperial Long, Scarlet, New Kuroda, Chantenay and Egmond Gold are recommended for the Pacific Islands. Seed sown at the rate of 3-4 kg/ha will give a density of 200 plants/m^2. After 100 to 150 days, the crop may yield between 5 t/ha (low) to 30 t/ha (high). Carrots are usually cultivated as a cool season crop. A high day temperature, above 25°C, causes a slow growth rate and blanched yellow-white roots of poor quality are produced. Flowering and seed setting are successful only in cool regions with a mean day temperature below 20°C (Brazil); yields of about 200 kg seed per ha may be obtained.

The ANV rating referred to in table 5 is 6.48; this very high value is due to a β-carotene content of 4.2 mg/100 g. The carotene content of carrots in temperate regions is assessed as 6.00 mg/100g, normally resulting in an ANV of 9.00. It is known that high temperatures and short-day conditions decrease the β-carotene content.

Carrots are important market vegetables in many areas in the tropics, especially Brazil, Venezuela, Nigeria and Indonesia.

Alternaria leaf blight and root-knot nematodes are the major cultural problems in the tropics. Carrot seedlings are easily washed out by heavy rains and many fungi or bacteria may cause rootrot, e.g. *Erwinia, Stemphylium, Sclerotium, Fusarium*.

Breeding and germplasm

Carrots have their origin in S.W. Asia from where they spread to China and the Mediterranean area. Several wild annual forms occur in these regions. Much breeding work has been undertaken in W. Europe (the Netherlands, France), Japan and the USA. The present cultivars are selections from the old landraces, selected for carotene content, colour, shape, earliness, yield, resistance to cracking and decreased bolting. The canning and storage quality, which is related to the dry matter content, is also important. Inbreeding induces a reduction of vigour. Hybrid cultivars, however, are not yet in general cultivation. Local carrot cultivars from Brazil include: Kuroda and Piracicaba.

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Recommendations

The preservation of old local strains from temperate regions should be ensured by the developed counties. The risk of the disappearance of wild germplasm is not imminent. In order to promote the cultivation of this very nutritious vegetable, cultivars should be bred which are suitable for tropical conditions.

3. RADISH

Radish, *Rapharus sativus* L. (2n=18) is a shortlived annual which is grown throughout the tropics. Seed production of temperate and Asiatic subtropical types is successful in cool areas. The Japanese radish (daikon) forms large, long or round, white roots instead of the small red, round European type. Seed sown at a rate of 40 kg/ha yields 10-40 t of fresh roots after 30 - 70 days with a seed yield of 800 kg/ha. Radishes are fairly resistant to pests and diseases. Blackrot *(Aphanomyces)* and *Alternaria* have been mentioned. The nutritional value of the radish is low (ANV =3.22).

Much breeding work on radish has been done in developed countries, but only a few reports, mainly from India, are available on the results of breeding in tropical countries. Germplasm of wild radish types and species is abundant in Europe and the Mediterranean.

No high priority to germplasm collection and breeding need be given, but more information is needed on the diversity in the Chinese or Japanese radish.

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XI CONCLUSIONS

1. PRODUCTION AND CONSUMPTION

Using a large number of nutritional surveys and the scarce statistical data on vegetable production, an outline of tropical vegetable production and consumption has been presented (Ch.II). It is indicated that the registered production included in the FAO Production Yearbook and the Trade Yearbook (1974) represents only a part of the total production. This is due to incomplete statistical data for commercial production and a high proportion of non-registered small-scale cultivation for home use.

The average daily per caput consumption of vegetables in the developing countries is about 100 g, i.e. only 46% of the quantity consumed in developed countries. From the nutritional surveys, it can also be concluded that the nutritional needs in the hot zones differ from those in temperate zones. Special emphasis should be given to vitamin A deficiency, hence the need for leaf vegetables in particular. Although large regional differences exist in the nutrient requirements from vegetables, in addition to the basic food, it can be concluded that an average daily per caput consumption of 150 g of vegetables would be sufficient, if one-third of this quantity consisted of leaf vegetables.

2. GROUPS AND SPECIES OF VEGETABLES

The economic and nutritional importance of different vegetable species at the present level of research and breeding, and comment on the risk of loss of genetic material as well as recommendations for priorities (Ch.III-X) are summarised in table 16. The principal conclusions concerning the different crops are as follows:

Tomato

Research and breeding programmes should be directed towards the cultivation of this crop in the tropical lowlands. The collection of germplasm has already been given much attention, tomato being a main project subject of the AVRDC, Taiwan.

Peppers

Sweet pepper is an important vegetable in both tropical and subtropical areas, whereas hot pepper is more important in the tropics. Both have a high vitamin C and carotene content. Breeding of hot pepper for higher yields must have first priority.

Eggplant

The eggplant is relatively easy to cultivate and produces high yields although it has a rather low nutritional value. A high priority should be given to its collection since many tropical strains are likely to disappear.

Watermelon

In tropical Asia, especially India, many valuable local cultivars are being replaced by commercial cultivars. The collection of germplasm therefore deserves a high priority.

Table 16. Importance and priorities of vegetables cultivated in tropical areas.[a]

Vegetable type	general economic importance	nutritional importance		present level of research & breeding	priority for		priority areas
		actual	potential		collection of germplasm	research & breeding	
Solanaceous							
tomato	1	3	3	1	2	1	M. America, Andean Zone
sweet pepper	3	4	2	2	2	2	Medit.
hot pepper	1	4	3	4	2	1	M.America, Andean Zone
eggplant	2	4	3	3	1	2	S.Asia, S.E.Asia, C. Asia, S.W. Asia
Cucurbits							
watermelon	1	5	4	3	1	1	S. Asia, C. Asia
melon	3	4	3	2	3	2	S. Asia, C. Asia
cucumber	4	5	5	1	4	3	S. Asia
pumpkins and squashes	3	3	2	3	2	1	M. America
waxgourd	2	4	3	4	3	2	S. Asia, S.E. Asia
bottle gourd	2	5	5	4	4	3	S. Asia, S.E. Asia
loofah	4	5	5	4	0	4	S. Asia, S.E. Asia
bitter gourd	2	3	2	4	2	1	S. Asia, S.E. Asia
chayote	3	4	4	3	2	2	Brazil, M. America, S.E. Asia
Alliums							
onion	1	4	4	1	1	1	S.W. Asia, C. Asia, W. Africa
shallots	3	5	5	4	3	2	W. Africa, Ethiopia, S. E. Asia

a) for meaning of the ranking numbers see footnote on page 123

Vegetable type	general economic importance	nutritional importance		present level of research & breeding	priority for		priority areas
		actual	potential		collection of germplasm	research & breeding	
spring onion	2	4	4	3	2	2	Far East
garlic	2	5	5	4	3	2	C. Asia, Medit.
leek	4	4	3	3	0	4	Medit.
Leguminosae							
sword bean	5	4	3	5	4	4	Africa, S.E. Asia, S. Asia
hyacinth bean	5	4	2	4	2	1	S. Asia
yam bean	5	5	5	5	4	0	S.E. Asia, Andean Zone
locust bean	3	4	2	5	3	2	W. Africa, S.E. Asia
Lima bean	4	3	2	4	2*	1	M. America, W. Africa, Ethiopia
mung bean	3	3	3	2	2	2	S.E. Asia, S. Asia
common bean	4	4	4	1	3*	3	America, E. Africa
winged bean	5	4	2	4	2	1	S. Asia, S.E. Asia, Pacific
yardlong bean	3	3	3	2	2	1	S.E. Asia
Bambara groundnut	5	4	3	5	4	3	Africa
Brassicas							
white cabbage	1	2	2	1	3	1	E. Africa, America
cauliflower, broccoli	3	3	3	2	4	2	America, Medit., S.W. Asia, S. Asia
Chinese cabbage	1	1	1	2	2	1	S.E. Asia, Far East
kale, mustard	3	3	2	4	3	3	America, Asia
tropical leaf cabbage	3	3	2	5	2	2	E. Africa, Ethiopia

* but priority 1 for field crops

Vegetable type	general economic importance	nutritional importance		present level of research & breeding	priority for		priority areas
		actual	potential		collection of germplasm	research & breeding	
Leaf vegetables							
amaranth	3	1	1	4	2	1	Africa, S. Asia, S.E. Asia, Pacific
Basella	4	4	2	5	4	3	S. Asia
Swiss chard	3	3	2	3	3	2	S.W. Asia, C. Asia, S. Asia, America
Celosia	4	3	2	5	3	3	W. Africa
jute mallow	3	1	1	3	2	1	W. Africa, M. America, Medit. (Egypt)
roselle	4	3	2	3	2	2	W. Africa S. Asia
kangkong	3	1	1	4	2	1	S. Asia, S.E. Asia
lettuce	2	4	3	1	2	2	E. Africa, Far East, Medit., Andean Zone
cassava leaves	4	3	2	3	2	2	Brazil, W. Africa, S.E. Asia
spinach	2	2	2	1	3	3	Medit., Andean Zone, C. Asia, S. Asia
Solanum spp.	3	2	1	5	3	2	W. Africa, Ethiopia
Talinum	4	3	2	5	4	3	Brazil, M. America
Xanthosoma	4	3	2	4	3	2	M. America, Brazil, W. Africa
chaya	5	3	2	5	2	1	M. America
drumstick tree	4	3	2	4	2	1	S. Asia, S.E. Asia, W. Africa
Sauropus	4	3	2	5	2	1	S.E. Asia
bitter leaf	4	3	2	5	3	2	W. Africa

Vegetable type	general economic importance	nutritional importance		present level of research & breeding	priority for		priority areas
		actual	potential		collection of germplasm	research & breeding	
Other warmweather vegetables							
okra	1	3	2	3	1	1	W. Africa, Brazil, S. Asia, S.E. Asia
sweet corn	2	4	3	2	4	4	M. America
palm cabbage	3	4	4	4	4	3	Brazil
bamboo shoots	3	4	3	4	4	3	S.E. Asia, Far East
arracacha	4	4	3	4	3	3	Andean Zone
mushrooms	2	5	5	4	4	3	S.E. Asia
Other temperate vegetables							
carrot	2	2	1	2	2	1	S.W. Asia, Medit.
radish	3	4	4	3	4	4	S.W. Asia, Far East

a. Ranking numbers, used in the table:

- economic or nutritional importance, present level of research:
  1 = very high, 2 = high, 3 = medium, 4 = low, 5 = very low;

- priorities for the collection of germplasm or for research and breeding:
  1 = first, 2 = second, 3 = third, 4 = fourth, 0 = no priority

Pumpkins, melon, bitter gourd

Pumpkins and yellow or red melons merit attention due to their high carotene content and bitter gourd for its high vitamin C and iron content.

Wax gourd, chayote

A high priority for research should be given to the wax gourd, since it stores well, and also to the chayote, because it is very suitable for cultivation in home gardens in humid areas at medium altitudes and its leaves also are eaten.

Onion, Japanese bunching onion

Primitive onion strains in Asian countries (India), W. Africa and S. America are gradually being replaced by commercial, modern cultivars. They should therefore be collected. Japanese bunching onion also seems to be in danger of genetic erosion.

Shallots, garlic

A high priority for research should be given to shallots and garlic which are both locally very important. Shallots are particularly important for cultivation in the tropical lowlands, as a substitute for onions.

Hyacinth bean, Lima bean, winged bean, yardlong bean

A first priority for research and breeding should be given to the hyacinth bean, Lima bean, winged bean and yardlong bean. Climbing types of these four species are suitable for cultivation in home gardens in the high rainfall areas of the tropical lowlands.

Common bean, mung bean and other leguminous vegetables

The common or French bean is a main subject of research in national institutions in temperate countries and at CIAT in Colombia since it is widely grown as a vegetable or as a pulse. The vegetable type of this species has little importance for the tropics. The mung bean is an important subject for research at the AVRDC in Taiwan. When used as sprouted beans, this pulse can also be regarded as a vegetable. The groundnut (oilcrop), soyabean (pulse, oilcrop) and pigeon pea (pulse) have not been discussed in detail, although they are also used as vegetables.

White Cabbage

The production of white cabbage is rapidly increasing, especially for supplying to markets, where it is replacing the traditionally grown, local leaf vegetables. The underlying reasons are that this crop is relatively easy to grow. It is also high yielding, transports well and stores for some time. The availability of Japanese heat-resistant cultivars supports this trend.

Chinese cabbage, tropical leaf cabbages

The heading type of Chinese cabbage is a main subject of investigation at the AVRDC in Taiwan. More attention must be given to the leafy types of Chinese cabbage and to tropical leaf cabbages, the nutritional value of which is much higher than that of heading Brassicas.

Tropical leaf vegetables

Species of leaf vegetables should have special attention since they are so important in diets in less affluent areas. They are early, highly productive and inexpensive vegetables, mainly grown in compounds and in small family gardens for home consumption. There are more than 1,000 tropical plants with edible leaves but only about 10% of these are currently cultivated. Approximately 25 species have been identified as the most important tropical leaf vegetables, based upon the fact that they constitute at least 90% of the total consumption of green leaf vegetables. Several minor species are quite important regionally; e.g. *Chrysanthemum*, *Rumex*, *Portulaca* and *Hibiscus manihot*. The risk of genetic erosion in these plants does not appear to be serious. The same comment is also applicable to the more commonly cultivated leaf vegetables. However, for research and breeding programmes, collections of germplasm should be made.

A first priority for research and breeding has been allocated to annual crops such as amaranth, jute mallow and kangkong and to the shrubs or trees baobab, chaya, drumstick tree, *Vernonia* and *Sauropus*. The first three are widely cultivated annual vegetables, suitable for both home gardens and market production. The trees and shrubs are valuable plants for home gardens in the wet tropics.

Lettuce, spinach beet

The consumption of lettuce and spinach beet in the tropics is increasing, especially in urban areas. Raw lettuce, consumed as a salad, has a high social meaning for the higher income groups. There is, however, a danger that unwashed leaves may carry infections such as intestinal diseases. Local cultivars in the Far East and in S.E. Asia are mainly used as cooked vegetables. Research and breeding of lettuce and spinach beet (cultivars suitable for hot climates) should be given a high priority due to their economic and nutritional importance.

Okra

Okra is one of the most important tropical vegetables grown in Africa, America, S.W. and S. Asia. Primitive cultivars are in danger of being lost, as high-yielding commercial cultivars become popular.

Carrots

Carrots are becoming popular in many tropical upland regions. Primitive and wild types occur in S.W. Asia. Carrots are potentially important for their high carotene content; for this reason they deserve a high priority in research and breeding programmes.

Other vegetable species

Many other tropical vegetables (mushrooms, bamboo shoots, palm cabbage) and some temperate vegetables such as radish and sweet corn are locally of some importance. No high priority for research and breeding should be given to these crops.

3. THE AVAILABILITY OF VEGETABLE SEEDS IN THE TROPICS

The lack of highly selected modern cultivars and of an efficient seed production and distribution system in nearly all tropical countries is a serious

hindrance to the improvement of vegetable cultivation. The following remarks on vegetable seed production and distribution in the tropics can be made:

(a) A local seed industry (practical breeding, multiplication, processing, distribution) is non-existent in most countries and rudimentary in others. In this field, Egypt, Kenya, India and Taiwan are the most advanced.

(b) In most countries, there is no official control over the genetic and physical quality of both the locally-produced and the imported vegetable seeds.

(c) Seeds of local cultivars are produced by the grower himself or obtained from local dealers.

(d) Commercial seeds of European-type vegetables grown for marketing are mostly imported. Many cultivars offered by international seed companies are not usually adapted to local tropical conditions and are often inadequately protected from the effects of high atmospheric humidity.

(e) The seeds of species with poor seed setting in the tropics (onion, cabbage, cauliflower, lettuce) have to be imported each season.

(f) Vegetable growers tend to produce their own seed from the imported varieties which set seed easily, viz. cucurbits, solanaceous fruits, leguminous vegetables. They renew these seeds only occasionally.

(g) Effective seed storage techniques are not widely understood and local seed distributors rarely use desiccators or cool storage.

Some government horticultural institutions (e.g. those in Egypt), listed in Annex 2, produce and distribute vegetable seeds. Others (India) provide nucleus seed to private companies for multiplication and wider distribution of certified seed. Most horticultural institutes are only active in cultivar testing, resulting in information which can be passed to growers about the most suitable commercial cultivars. A considerable amount of good breeding work which results in the production of suitable local cultivars is lost through the lack of follow-up propagation and distribution.

Most of the vegetable seeds which are commercially available in developing countries are produced in and imported from developed countries. The European companies are most active in Africa, C. and S.W. Asia. India is largely self-supporting, and so too is Taiwan. S.E. Asia imports most of the seed required from Japanese or Australian companies but, in the Philippines, American vegetable seeds are more common. Latin American supplies of vegetable seeds come mainly from companies in the USA.

All these companies use skilled plant breeders. Most of these practical plant breeders, however, remain relatively unknown, since they do not normally publish their work; their names do not therefore appear in the list in Annex 2 The commercial seed companies are gradually becoming more aware of the specific plant characters required for the tropics, in particular with respect to the commercial production of vegetables.

A N N E X I

NOTES ON COLLECTING VEGETABLE GERMPLASM

NOTES ON COLLECTING VEGETABLE GERMPLASM *

1. INTRODUCTION

From the numerous vegetables, approximately 90 in number, discussed in this report, two groups require special consideration as far as the collection and maintenance of germplasm is concerned. The first group includes crops which are commonly propagated by vegetative means rather than by seeds, such as: shallots, garlic, thousand-headed kale, some kangkong cultivars, *Colocasia* and *Xanthosoma*, chaya, drumstick tree, *Sauropus*, bitter leaf, bamboo and leaf cassava. The second group includes those species of which the seeds do not tolerate desiccation and consequently cannot be stocked such as chayote and *Telfairea*; cultivars or types of these can only be maintained in a live collection. Transport of plant material may give rise to serious problems due to very stringent plant quarantine regulations and retention of viability. Modern techniques such as tissue culture could be used to solve some of these problems. Most vegetable species, however, are propagated by seeds and these offer no special problems of transportation and long-term storage, provided they are dried and stored in conditions which are compatible with the retention of maximum viability.

2. SITES FOR THE COLLECTING

A collector usually investigates the region in which the required vegetable or its wild relatives may be expected to occur, collecting the whole range of material which he is able to detect. He must be familiar with the region as well as with the botanical characteristics of the vegetable species in question. He would be well advised to seek the assistance of government officers who have appropriate local expertise. The material should preferably be sampled in the field where appropriate notes can be made. Leguminous vegetables, cucurbits and solanaceous vegetables can also be collected in the markets, but exact data on the site of cultivation and the characteristics of the plant are then more difficult to obtain.

3. SAMPLE SIZE

The number of individual plants from which seed should be collected to form a genetically representative sample depends on the breeding system and the degree of genetic variation within the population. This also applies to plants which are being collected as live specimens. Information on this is rarely available, however. Most modern cultivars are genetically narrow-based and a few seeds from a few plants may be representative of the entire population, but more numerous seeds and plant specimens will be necessary if primitive cultivars are collected.

Highly self-pollinating plant populations may be well represented by some ten seeds from a few specimens, whereas collections from cross-pollinating populations should be made from a much greater number of individuals. As a general rule, seed from about five plants will be representative for a modern self-pollinating cultivar, 20 for a primitive self-pollinating cultivar and not less than 50 for a primitive, outbreeding cultivar (and often many more are recommended).

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* Advice can be obtained from the Unit of Crop Ecology and Genetic Resources, Plant Production and Protection Division, FAO of the UN, 00100 Rome, Italy.

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Seeds of the various plants at any given site may be mixed in a bulk sample. The collector may prefer to keep the individual plant samples separately if he aims at collecting certain special types. Nevertheless samples for long-term conservation should aim to be representative of the populations.

For long-term storage, the IBPGR recommendations concerning the collection of cereals may also be applied to vegetable crops. The IBPGR offers an optimum model containing 18,000 seeds per accession, divided into 45 sub-samples of packets of 400 seeds. In practice, the collector may not be able to collect this quantity. The weight of 18,000 seeds may vary according to the seed weight mentioned in the tables of the previous chapters, from 6 g for amaranth to 72 kg for swordbean. Either the optimum seed quantity to be stocked should be reduced or the sample may be multiplied before it is finally prepared for long-term storage.

4. DOCUMENTATION*

For each sample, the maximum data available in the form of condensed notes, should be recorded, preferable following accepted procedures. The notes should include descriptors and descriptor states covering (a) geographic and ecological collection data (b) morphological characteristics, (c) cultivation data. Representative plant specimens should be collected for drying and preservation in an herbarium; these will provide reference speciments.

5. SEED EXTRACTION

Vegetable types may be divided into two major groups, i.e. (a) those which produce seeds within fruits which mature and dry on the plants in the field and (b) those which produce fleshy fruits with seeds enclosed in a pulpy mass.

Group (a) includes leguminous vegetables, *Allium*, *Brassica*, okra and the majority of the leafy vegetables. The dry pods can be picked and cleaned by hand. Small sieves may be useful for this operation.

Group (b) includes fleshy fruits typical of the families *Solanaceae* and *Cucurbitaceae*. This group may be subdivided into two categories: soft, fleshy fruits and the more leathery types. Fully ripe fruits of the soft-fleshed types (tomato, cucumber, melon, watermelon etc.) are cut into pieces and allowed to ferment in an open container for 2-5 days, until the seeds become separated from the pulp. The seeds are then rinsed and dried. A rapid method which is useful for small samples is to squeeze the fruits or to cut them into halves. The seeds, with the adhering pulp, are then removed and dried on an absorbent surface. For larger quantities 1 ml of 40% hydrochloric acid is added to 100 g of the pulped ripe fruit. This is then rinsed after 30 minutes and the seeds are separated from the fruit tissue. The leathery type of fruit such as those of peppers, eggplants, wax gourd and bitter gourd, are cut into halves and the seed separated from the pulp by washing and rubbing by hand. For these vegetables, i is especially important to use over-ripe fruits in order to obtain good seed qua quality. Cucurbit fruits may be stored for several weeks before the seeds are extracted.

6. DRYING

In low humidity areas, seeds may be dried in the open on a moisture-absorbing type of material such as newspaper, linen or mats. In areas of high atmospheric humidity, seeds must be dried artificially. This may be done in a number

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* Advice can be obtained from the FAO Unit or the IS/GR Program, University of Colorado at Boulder, USA.

of different ways e.g. by using a small dryer which is heated by gas or electricity. The seeds are spread on a sieve which is sufficiently shielded from the direct source of heat to ensure that the temperature does not exceed 45°C; a small fan may be used to accelerate the drying. Seeds may also be dried in an air-conditioned room, in a heated room or under an electric lamp.

If possible, seeds should be dried to a moisture content (on dry weight basis) of not more than 10% for small seeds and seeds containing oil, and not more than 12% for beans, okra, large cucurbit seeds and other large seeds. This is approximately the average equilibrium moisture content of seeds when exposed to a relative air humidity of 65%. This R.H. is regarded as safe, since the growth of moulds will be inhibited and seed respiration will be reduced to a minimum, even at room temperatures.

Measurement of the moisture content of seeds under local circumstances is often difficult or impossible. It is therefore advisable to store the seeds with a desiccant such as silica gel. This inert chemical can be re-used if it is dried by heating between treatments. For small samples, the seed can be mixed with dry silica gel in an airtight container and separated out after several days, using a sieve. For seeds with a moisture content of 20% (on a dry weight basis) at least 1 g of dry silica gel per g of seed will be required to reduce the moisture content to 10% within two days.

7. DISINFECTION

It is necessary to disinfect all seed samples immediately after drying with a fungicide/insecticide treatment. Diazinon, DDT, lindane or dieldrin may be used for insect control and thiram or a mercury-containing chemical as a fungicide. It should first be ascertained that these treatments are in accordance with plant quarantine regulations regarding the transport or export of the samples. On arrival at a genetic resources centre, the seed will probably be disinfected by fumigation as a routine precaution. Before sowing, seeds of certain vegetables may be treated for virus and nematode infection by a warm water treatment.

8. STORAGE FOR TRANSPORT

Before reaching the safe storage conditions of a genebank dried seeds are required to maintain a high level of viability for several months in unfavourable climates.. Seed samples should therefore be kept in air-tight containers which include a desiccant. Glass jars are generally too heavy and too bulky for this purpose but heat-sealed plastic bags of good quality are ideal. Bags of paper, linen or non-sealable plastic may be used for small samples, if they are stored together within a large, airtight container with a desiccant (silica gel), the desiccant itself being in a linen bag or a jar with a perforated cover. Aluminium laminated multiwall paper bags may also be used.

In addition to the humidity, temperature is also a very important factor and, if possible, packaged samples should be kept in an air-conditioned room or refrigerator, pending transport. The collected seed must reach the genebank in the shortest possible time.

9. LONG TERM STORAGE

In the seed bank, the seed must be kept under conditions which are suitable for long-term conservation, e.g. at -20°C and in a R.H. of 20% which is in equilibrium with a moisture content of 5%. For IBPGR, the minimum standards are +5°C

and 7% moisture content. In section 3, it has been stated that the IBPGR advises that each sample (accession) should be divided into 45 subsamples or units of some 400 seeds each:

- 1 subsample is intended for a germination test
- 29 subsamples to be stocked in long-term storage; some of these will be available for exchange
- 15 subsamples to be used as duplicates, for storing in another gene-bank for safety.

If the collected quantity of seeds is too small or if the viability is too low for long-term storage, the material should be multiplied immediately. This gives the added advantage of evaluating the characteristics of the sample.

The long-term storage programme of a seed bank, the evaluation and final documentation of the material as well as methods of distribution to plant breeders and propagation techniques must be carefully planned in advance by the managers of these institutions.

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ANNEX II DIRECTORY OF INSTITUTIONS INVOLVED WITH BLE GERMPLASM RESOURCES

		Page
A.	Institutions	
1.	Regional and national organisations	137
2.	Institutions dealing with vegetable germplasm	139
B.	Research workers	157
C.	Seed growers	183

Note: It is emphasised that these data should not be taken as being complete, amendments and additions would be much appreciated. Exact data on the number of accessions, storage conditions and methods of evaluation of material are also urgently required.

A. INSTITUTIONS

REGIONAL AND INTERNATIONAL ORGANISATIONS

ASHS

American Society of Horticultural Science
North Carolina State University
Raleigh
North Carolina 27607, USA

EUCARPIA

European Association for Research on Plant Breeding
PO Box 128
Wageningen
The Netherlands

FAO

Crop Ecology and Genetic Resources Unit
Plant Production and Protection Division
FAO
Via delle Terme di Caracalla
Rome 00100, Italy

ISHS

International Society for Horticultural Science
Bezuidenhoutseweg 73
The Hague
The Netherlands

Commission on Tropical and Subtropical Horticulture of the ISHS:

Chairman: H.D. Tindall, Nat. College of Agric. Engineering, Silsoe, Bedford, U.K.

Vice Chairmen:

West Africa J.C. Norman, Dep. of Horticulture, Fac. of Agriculture, Univ. of Science and Techn., Kumasi, Ghana

Latin America O. Quarte, Dep. of Horticulture, U.N.A., La Molina, Lima, Peru

South India Dr. G.S. Randhawa, Hortic. Society of India, 255 Upper Palace Orchards, Bangalore 6, Mysore State, India

North India Dr. B. Choudhury, Division of Vegetable Crops and Floriculture, Indian Agric. Research Inst., New Delhi 12

Australia H.M. Groszmann, Dep. of Primary Industries, William Street, Brisbane, Que. 4000, Australia

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S.E. Asia Dr. R.L. Villareal, Dep. of Pl. Breeding,
Asian Veg. Res. & Development Centre, P.O.B. 42, Shandav,
Tainan, Taiwan (741)

Regional Liaison Secretary:
East Africa: Prof. C.L.M. van Eijnatten,
Crop Production, University of Nairobi,
P.O. Box 30197,
Nairobi, Kenya

Addresses of horticultural research institutions (ISHS):

HORTICULTURAL RESEARCH INTERNATIONAL 1973

Directory of horticultural research institutes and their activities in 54 countries: 538p
Pudoc, Wageningen

ISTA
International Seed Testing Association
P.O. Box 68
N-1432 Aas-NLH
Norway

INSTITUTIONS DEALING WITH VEGETABLE GERMPLASM

ALGERIA		
Alger	Inst. Nat. Rech. Agrom.	tomato
ARGENTINA		
Bella Vista, Corrientes	Dept. Fitotechnica	tomato, peppers
Campinas	Inst.Nac. Tecnol. Agropec. (INTA)	beans,cassava
Castelár	Inst. Nac. Tecnol. Agropec.(INTA) Bella Vista	peppers
Rio Negro	Exper. Inst. Agr.Alto Valle de Rio Negro	tomato
Tucuman	University of Tucuman Agron. y Zootecnia	tomato
AUSTRALIA		
Canberra	CSIRO, Div. Pl. Industr.	tomato
Indooroopilly	Qld. Dept. Primary Ind.	common bean
Merbein	CSIRO, Div. Hortic. Res.	amaranth
Rydalmere NSW	Dept. Agric., Biol. & Chem. Res. Inst.	common bean
St. Lucia	Univ. Queensland. Dept. Bot.	tomato
BANGLADESH		
Dacca	Bangladesh Agric.Res.Inst.	tomato,eggplant, onion, cowpea
Mymensingh	Bangladesh Agric.Univ.	cauliflower, eggplant
BELGIUM		
Antwerp	Bedrijfsvoorlichtingsdienst Tuinbouw	tomato
Gembloux	Fac.Sciences Agron.	cowpea
BENIN		
Porto-Novo	Centre de Form.Hort. et Nutr. (CFHN)	amaranth,*Corchorus*, *Solanum* spp.,(seed production),okra, tomato, peppers
BRAZIL		
Belo Horizonte, Minas Gerais	Inst Agron.	common bean
Campinas, São Paulo	Inst Agron.	tomato,peppers, eggplant,melon, common bean,okra lettuce,garlic
Manaus	Inst.Nac.de Pesquisas da Amazonia	vegetable variety trials
Jaboticabal, São Paulo	Dept.Fitotecnia,Fac. Medicina Veterinaria e Agron.	cucumber,pumpkin, onion, okra

BRAZIL (cont'd)		
Pelotas	Empresa Bras.de Pesq. Agropec.(EMBRAPA)	common bean
Piracicaba, São Paulo	Univ.São Paulo,ESALQ.	pumpkin,chayote, onion, okra
Recife Pernambuco	Inst.Pesquisas Agropec. Nordeste (IPEANE)	common bean
Rio de Janeiro (a)	Inst.Pesquisas Agropec. Centro Sul (IPEACS)	cabbage, common bean, lettuce
Rio de Janeiro (b)	Univ.Fed.Rural,Rio de Janeiro (UFRRJ)	eggplant, okra, cucumber, garlic,
São Paulo	Inst. Biol.	peppers
Sete Lagoas	Inst.Pesquisas Agropec. Centro-Oeste (IPEACO)	tomato
Viçosa, Minas Gerais	Univ. Fed.de Viçosa, Esc.Superior Agric.	tomato, common bean, okra
BULGARIA		
Lom	Acad.Agr.Sciences Exp. Res. Sta.	peppers
Plovdiv	Maritsa Inst. Veget.	tomato,onion, cabbage,cucumber, peppers (coll.)
Ruse	Inst.Cereal & Legume Crops Obraztsov Chiflik	common bean
Sofia (a)	Inst.Genet. & Pl. Breed	tomato, peppers, common bean,(coll.
Sofia (b)	G. Dimitrov Higher Inst. of Agric.	common bean
CAMEROON		
Yaoundé	Ecole Nat. Sup.Agric. (ENSA)	leaf vegetables, leguminous vegetables
CANADA		
Charlottetown Prince Edward Isl.	Agric.Canada,Res.Sta.	broccoli
Deschambault Lake Saskatchewan	Sta. de Rech. Agric.	tomato,cauliflower common bean
Guelph Ontario	Univ.Guelph. Dept.Hort. Sci.	okra, tomato(coll. 9000) (gene bank)
Montreal	McGill Univ.,Macdonald Coll.	carrot
Ottawa, Ontario	Ottawa Res. Sta.	(nat. gene bank)
St. Jean Quebec	Reg. Res. Sta.	onion
Simcoe Ontario	Hort. Exp. Sta.	cucumber,peppers

CHILE		
Chillan	Inst.Invest.Agropec. (INIA) Est.Exp.Quilamapu	common bean
Santiago (a)	Inst.Invest.Agropec (INIA), Est. Exp. La Platina	tomato,common bean,melon,lettuce
Santiago (b)	Univ.Chile,Fac.Agron.	tomato
COLOMBIA		
Cali	Centro Intern.Agric.Trop. (CIAT)	legumes e.g. *Phaseolus* (Coll. 10,000; int. gene bank)
Manizales	Univ. Caldas	*Brassica*
Pasto Narino	Univ.Narino,Fac.Agron.	common bean
COSTA RICA		
Turrialba	Trop.Agric.Res.& Training Center (CATIE), Inter-American Inst.Agric.Sci. (IICA)	common bean (gene bank)
CUBA		
Habana (a)	Inst. Invest.Trop.,Acad. de Ciencias de Cuba	tomato, garlic
Habara (b)	Inst.Mejoram.de Plantas, Acad. de Ciencias de Cuba	pumpkin
CZECHOSLAVAKIA		
Bratislava	Slovak Acad. Sciences	peppers
Olomouc	Palacky Univ., Res. Inst. Veget. crops	tomato, peppers, cabbage,lettuce, garlic (coll.50)
Prague- Ruzyne	Res. Inst. Crops	tomato, onion, cucumber,lettuce, *Brassica*
CYPRUS		
Nicosia	Min.Agr.Nat.Resources, Agric.Res.Inst.	tomato,common bean, cucumber,squashes
EGYPT		
Alexandria	Univ.Alexandria,Fac.Agric.	cucurbits,spinach
Assiut	Assiut Univ.,Coll.Agric.	okra
Cairo (a)	Ain Shams Univ.,Fac.Agric. Dept. Hortic.	tomato,common bean, melon, cucurbits
Cairo (b)	Al-Azhar Univ.,Fac.Agric.	common bean
Cairo (c)	Univ.Cairo,Fac.Agric.	common bean,okra, spinach
Cairo (d)	Field Crops Res.Inst., Agric.Res. Centre	common bean

EGYPT		
Cairo (e)	Univ.Cairo,Desert Inst. Bot.Res. Lab.	okra
Dokki	Veg. Res. Sta.,Min.Agric.	carrot,cabbage, melon,squash
Minia	Dept.Hortic.,Fac.Agric.	common bean,melon
EL SALVADOR		
Santa Tecla	Centro Nac.Technol. Agropec.	tomato
ETHIOPIA		
Addis Ababa	Haile Selassie I Univ.	peppers
FIJI		
Suva	Res. Div.,Dept.of Agric.	vegetable variety selection
FRANCE		
Avignon	Sta.Technol.Produits Veg. Centre de Rech.d'Avignon	eggplant
Montfavet	Sta. d'Amel. des Plantes maraicheres,Centre de Rech. Agron. du Sud Est	radish,tomato, eggplant,peppers, melon
Paris	Inst. de Rech. Agron. Trop. (IRAT)	peppers
Versailles	Sta. Genetique & d'Amel. des Plantes, Inst. Nat. Rech. Agron. (INRA)	onions
GAMBIA		
Cape St. Mary	Dep. Agric.	tomato,peppers, onion,common bean, melon,carrot
GERMANY D.R.		
Greifswald	Ernst Moritz Arndt.Univ.	tomato
Quedlinburg	Inst.fur Züchtungsforschung	onion,cucumber, cabbage,Chinese cabbage
GERMANY F.R.		
Berlin	Fed. Biol.Inst.Agric. & Forestry	Brassicas,radish, cucumber,spinach
Braunschweig	Inst. fur Pflanzenbau & Saatforschung	*Solanum*,(European gene bank field crops)
Freiburg	Asgrow GmbH Breed & Genet. Sta. Ebnat.	common bean

GHANA		
Kumasi	Univ. Sci. & Technol.	tomato, leaf vegetables
Legon	Univ. Ghana, Dept. Crop Science	wing bean, cowpea, okra
GUADELOUPE (Lesser Antilles, West Indies)		
Petit Bourg (a)	Inst. Nat. Rech. Agron. (INRA)	cauliflower, tropical leaf vegetables
Petit Bourg (b)	Sta. de Bioclimatologie, Centre de Rech.Agron.des Antilles & de la Guyane	cowpea
Petit Bourg (c)	Sta. d'Amel. des Plantes, Centre de Rech. Agron. des Antilles & de la Guyane	cucumber, melon
HUNGARY		
Budapest (a)	Kertészeti Kutató Intézet (Hort. Res. Sta).	peppers,tomato, cucumber,onion, common bean
Budapest (b)	Nat. Inst. for Agric. Var. Testing	peppers, common bean, onion
Debrecen	Univ.Agrar.Sci.,Dept.Bot.	tomato, peppers
Kecskemet	Veg. Crops Res. Inst.	
Tapiószele	Nat. Inst.Agrobotany	common bean, peppers,tomato
INDIA		
Akola, Maharashtra	Dept.Hort. P.K.V.	radish
Annamalainagar, Tamil Nadu	Annamalai Univ.,Fac. Agric.	eggplant,okra, melon
Aurangabad, Maharashtra	Marathawada Univ.	cauliflower, cabbage, radish
Bangalore, Hessaraghatta	Ind. Inst. Hort.Res.	tomato,eggplant, okra,pumpkin,melon, watermelon,cauliflower,amaranth, onion,radish,peppers bitter gourd,(coll. nat.gene bank, nucleus seed)
Bhubaneswar, Orissa	Utkal Univ.	amaranth
Bhuntar	Dept. Pl.Breed. en Genet. Himachal Pradesh Univ.	common bean
Calcutta	Univ. Calcutta	cabbage
Chaubattia, Uttar Pradesh	Govt.Hill. Fruit Res. Sta.	*Cucurbita pepo*, tomato

INDIA		
Coimbatore (a) Tamil Nadu	Tamil Nadu Agric. Univ.	eggplant,okra, peppers,pumpkin,wax gourd,amaranth,cow-pea,hyacinth bean, green gram
Coimbatore (b) Tamil Nadu	Ind. Agric. Res. Inst. (IARI),Reg. Res. Sta.	pepper
Coimbatore (c) Tamil Nadu	Agric. Coll. Res. Inst.	melon,hyacinth bean
Delhi	Univ. Delhi	okra
Dharwar	Univ. Agric. Sci.,Coll. Agric.	okra
Gwalior, Madhya Pradesh	Coll. Agric.	bottle gourd, loofah, snake gourd
Hebbal (a) Bangalore	Agric. Coll.	tomato,eggplant, cowpea
Hebbal (b) Bangalore	Univ. Agric. Sci.	eggplant
Hissar, Haryana	Haryana Agric. Univ.	tomato,peppers,okra, mung bean,cowpea, cabbage
Hyderabad (a) Andhra Pradesh	Inter. Crops Res. Inst. for Semiarid Tropics ICRISAT	pigeon pea (int. gene bank)
Hyderabad (b) Andhra Pradesh	Agric. Univ.	tomato
Jabalpur, Madhya Pradesh	Jawaharlal Nehru Krishi Vishwa Vidyalaya	tomato,mung bean, peppers
Jaipur, Rajasthan	Univ. Rajasthan	lettuce
Jaipur	Durgapura Govt. Res. Sta.	water melon
Junagadh, Gujarat	Coll. Agric.	mung bean, cowpea
Kanpur, Uttar Pradesh	U.P. Inst. Agric. Sci.	eggplant,common bean,hyacinth bean, mung bean
Lucknow, Uttar Pradesh	Nat. Bot. Gardens	carrot,amaranth
Ludhiana, Punjab	Dept.Hort. & Dept.Pl.Path, Punjab Agric. Univ.	tomato,peppers,egg-plant,water melon, mung bean cowpea, spinach beet, onion, okra
Madurai (a) Tamil Nadu	Tamil Nadu Agric. Univ.	watermelon
Madurai (b) Tamil Nadu	Agric. Coll. Rest. Inst.	eggplant

INDIA

Meerut, Uttar Pradesh	Meerut Univ.	okra
Muzaffarnagar, Uttar Pradesh	DAV Coll	melon, bitter gourd
Nadia, Kalyani, West Bengal	Univ. Kalyani	mung bean
Nagpur, Maharashtra	Univ. Nagpur, Coll.Agric.	bitter gourd
New Delhi (a)	Div. Vegetable Crops, Indian Agric. Res. Inst.	tomato,peppers, eggplant,water-melon,bitter gourd, pumpkin *(C. moshata)* radish,turnip, carrot,peas,cowpea, spinach beet (coll).
New Delhi (b)	Vegetable Res. Sta. (Katrain)	cabbage,cauliflower, French beans,pumpkin, *(C. pepo)*,tomato,pea, radish,cucumber, carrot (coll.)
New Delhi (c)	IARI Pulses Breed.Sta. (Katrain)	common bean
Patna, Bihar	Patna Univ.	cucumber,radish, bitter gourd
Pantnagar, Uttar Pradesh	G.B. Plant Univ. Agric. & Techn.	eggplant
Rewa, Madhya Pradesh	Govt. Coll. of Sci.	melon
Simla, Himachal Pradesh	Cent.Potato Res. Inst.	peppers
Shrinagar, Kashmir	Kashmir Univ.	onion
Trivandrum	Univ. Kerala	bitter gourd
Udaipur, Rajasthan	Univ. Udaipur, Agric. Exp. Sta.	tomato, eggplant
Vallabhnagar, Rajasthan	Univ. Udaipur,Res. Farm	watermelon, eggplant
Varanasi, Uttar Pradesh	Banaras Hindu Univ.	loofah
Vellayani, Kerala	Agric.Coll.Vellayani	peppers,eggplant
Warangal, Andhra Pradesh	Osmania Univ.	peppers

INDONESIA		
Bogor	Nat. Biol. Inst.,	grain legumes, local leaf vegetables,e.g. *Sauropus Gnemon*. Regional gene bank prepared for jack bean,lablab,yam; nat.gene bank prepared for soyabean, winged bean
Jakarta	Ministry of Agric.	tomato, garlic
IRAN		
Karaj	Univ. Teheran, Coll.Agric.	common bean, mung bean
Teheran	Pl. Pest & Diseases Res. Inst. Evin	onion
ISRAEL		
Bet Dagan	Agric. Res. Organiz. Volcani Center	eggplant cucurbits,onion, peppers
Neve Ya'ar	Exp. Sta.,Agric.Res. Organiz.	melon
Rehovot	Hebrew Univ. Jerusalem, Fac. Agric.	tomato,melon, cucumber
ITALY		
Bari	Univ. Bari, Inst. Agron. & Inst. Vegetables, Assoc. with CNR Laboratorio del Germoplasma	artichoke,beet, lettuce,turnip, peppers, cucurbits, (European gene bank)
Bologna (a)	Inst. Sperimentale per le Colture Industriali	tomato
Bologna (b)	Univ. Bologna, Inst. di Genetica	eggplant, peppers
Bologna (c)	Univ. Bologna, Inst. di Agronomia	spinach,peppers, melon
Catania	Inst. di Agronomia,Consiglio Naz. delle Richerche	common bean
Milan	Inst. Sperimentale per l'Orticoltura di Salerno, Sezione di Montanaso Lombardo	tomato,watermelon, pumpkin
Minoprio	Inst. di Richerche Orticole	tomato
Perugia	Univ. di Perugia, Inst. di Allevamento Vegetale	peppers
Pisa	Univ. Pisa, Inst. di Genetica	cauliflower

ITALY		
Rome	Plant Prod. Protection Div. FAO	leguminous vegetables
Salerno	Inst. Sperimentale per l'Orticultura (ISPORT)	tomato, pepper, eggplant, squash
Torino (a)	Univ. Torino, Inst. di Orticoltura e Floricoltura	eggplant, carrot, peppers
Torino (b)	Univ. Torino, Inst. ed Orto Botanica	peppers
Torino (c)	Univ. Torino, Inst. di Produzioni dei Sementi per Orticoltura e Floricoltura	
IVORY COAST		
Abidjan	ORSTOM, Adiopodoumé	okra
JAPAN		
Fukuoka	Veg. & Ornam. Crops Res. Sta. Kurume	melon
Funajuka-cho, Miyasaki-shi	Miyazaki Univ.	tomato
Hyogo	Univ. Agric.	cucurbits
Kagoshima	Kagoshima Univ.,Fac. Agric.	radish
Kamihama-cho, Tsu-shi	Mie Univ.	melon
Kanagawa-ku, Kyoto	Kanagawa Res. Inst. Kyoto Univ.,Fac. Agric. Pl. Germplasm Inst.	broccoli Solanaceae incl. peppers, *Citrullus*, *Cucumis* a.o.cucurbits, *Brassica*, *Raphanus*, *Phaseolus*, (nat. gene-bank)
Mishima (a)	Kihara Inst. Biol. Res.	peppers
Mishima (b)	Nat. Inst. of Genetics	peppers
Niigata	Hokuriku Nat. Agric. Exp. Sta., Joetsu	(nat. gene bank)
Sapporo Hokkaido	Nat. Agric. Exp. Sta.	cucumber
Sendai	Tohoku Univ., Fac. Agric.	Brassicas
Takamatsu-shi, Kagawa-ken	Univ. Kagawa	peppers
Tokachi, Hokkaido	Tokachi Agric. Exp. Sta.	common bean
Tokai-kinki	Nat. Agric. Exp. Sta., Tsu, Mie	cucumber
Tokyo	Tokyo Univ., Fac. Agric.	*Brassica*
Tokyo	Tokyo Univ. Dept. Int. Agric. Devel.	cabbage
Tsu	Veg. & Ornam, Crops Res. Sta., Ishinden-Ogoso	melon, tomato, eggplant, cucumber
Yamagata City	Yamagata Univ.,Fac. Agric.	tomato, melon

KENYA		
Thika	Nat. Hort. Res. Sta.	vegetable var. testing
S. KOREA		
Seoul	Dong-Kook Univ.	radish
Suweon	Hortic. Exp. Sta.	peppers, carrot
Iri	Jeanbuk Prov. Office Rural Development	garlic
LIBYA		
Tripoli (a)	Min. Agric., Dept. Pl. Prod.	cucurbits
Tripoli (b)	Univ. Libya, Coll. Agric.	watermelon
MALAWI		
Lilongwe	Univ. Malawi, Bunda Coll. Agric.	common bean
MALAYSIA		
Kuching	Dept. Agric.,Res. Branch	tomato, peppers, leek,cabbage, cauliflower
Serdang, Selangor	Malaysian Agric. Res. & Devel. Inst. (MARDI)	veg.National coll. winged beans proposed
MARTINIQUE		
Fort de France	Inst. de Rech. Agron. Trop. & de Cultures Vivriéres (IRAT)	eggplant tomato
MEXICO		
Chapingo (a)	Coll. Postgraduados, Escuela Nac. de Agricultura	tomato, *Phaseolus* (nat. gene bank to be developed)
Chapingo (b)	Inst. Nac. de Invest. Agric.	tomato, *Phaseolus*
NETHERLANDS		
Amsterdam	Roy. Trop. Inst., Dept. Agric. Res.	leaf vegetables (amaranth),documentation tropical vegetables
Naaldwijk	Glasshouse Crops Res. Exp. Sta.	tomato,eggplant, peppers,cucumber
Wageningen (a)	Inst. Hort. Pl. Breeding, IVT	tomato,onion, cucumber,cabbage, spinach,lettuce (coll.),common bean

NETHERLANDS		
Wageningen (b)	Dept. Trop.Crops, Agric. Univ.	amaranth, *Xanthosoma*, kangkong
NEW CALEDONIA		
Noumea Cedex	South Pacific Commission	vegetable variety testing
NEW ZEALAND		
Christchurch	Dept. Sci. & Industr. Res. (DSIR)	tomato
NIGER		
Niamey	Inst. de Rech. Agron. Trop. (IRAT)	onion
NIGERIA		
Ibadan (a)	Univ. Ibadan, Dept. Agric. Biol.	cowpea,rosell
Ibadan (b)	Intern. Inst. Trop. Agric. (IITA)	tomato,(coll.2000), peppers,okra,melon, Chinese cabbage, amaranth a.o. leaf veg.,cucurbits,cowpea,winged bean, Lima bean (internat.gene bank)
Ibadan (c)	Moor plantation, Agric. Res. Council of Nigeria	legumes e.g. cowpea (gene bank)cucurbits Vegetable pathology of perennial indignous vegetables
Ibadan (d)	Nat. Hort. Res. Inst.	leaf veg., tomato
Ife	Univ. Ife, Inst. Agric. Res. & Training	cowpea, tomato
Samaru (a) Zaria	Ahmadu Bello Univ.,Dept. Biol. Sci.	tomato,onion,carrot
Samaru (b) Zaria	Inst. Agric. Res.	onion, tomato
NORWAY		
Vollebekk	Agric. Coll. Norway	cabbage
PAKISTAN		
Lyallpur	Pakistan Agric. Univ.	tomato,okra,mung bean
Mirpur Khas	Govt. Res. Sta.	tomato
Sarial, Quetta	Agric. Res. Inst.	okra
PAPUA NEW GUINEA		
Port Moresby (a)	Univ. Papua New Guinea	winged bean (coll).
(b)	Dept. of Primary Industry	taro

PERU		
Lima	Estac. Exp. Agraria de La Molina	onion,common bean, peppers
PHILIPPINES		
Los Baños-Laguna	Univ. Philippines, Coll. Agric. Inst. Plant Breeding and Gene Bank for Economic Crops, SEARCA	seed prod; agronomy coll.indigenous vegetables cabbage(Coll.200), Lima bean (coll.200), cowpea(coll.200), (regional gene bank) regional coll. mung beans and winged bean proposed,nat.coll. soyabean,yam
POLAND		
Reguly	Inst. Warzywniczy	tomato
Skjerniewice	Res. Inst. Vegetable crops	especially onion and carrot
PORTUGAL		
Lisbon	Inst. Superior Agronom. Lisboa	melon
PUERTO RICO		
Mayaguez	USDA, Agric. Res. Service	common bean, leaf vegetables
ROMANIA		
Bucharest	Inst. Agron. N.Balcescu	eggplant
Olomouc	Res. Inst. of Vegetables	Many species espec. tomato, *capsicum*.
SENEGAL		
Bambey	Centre Nat. Rech. Agron. (CNRA)	cowpea
Camberene	Centre for Horticultural Devel.	vegetable var. testing
SEYCHELLES	Grand'Anse Exper. & Food Prod. Centre	vegetables var. testing
SOUTH AFRICA		
Pretoria	Hort. Pres. Inst.	squash
Stellenbosch	Univ. Stellenbosch, Dep. Pl. Path.	onion

SPAIN		
Madrid	Inst. Nac. de Investigaciones Agraricas	*Brassica* (coll.)
SRI LANKA		
Maha-Illuppallama	Agric. Res. Sta.	mung bean
Peradeniya	Central Agric. Res. Inst.	vegetable var. testing
SUDAN		
Gezira	Gezira Res. Sta.	*Cucurbita*, pea, tomato,peppers, onion,okra,egg-plant,cabbage
Hudeiba	Hudeiba Res. Sta.	common bean
Khartoum	Shambat Hort. Res. Sta.	garlic
SURINAM		
Paramaribo	Agric. Exp. Sta.	peppers,cucurbits, cabbage
SWEDEN		
Hammenhög	Sveriges Utsädesförening	tomato,onion,cucumber,cauliflower, lettuce
TAIWAN		
Tainan	Asian Veg. Res. & Devel. Centre, AVRDC	tomato (coll.4000), Chinese cabbage (coll. 600),mung bean, (coll.2500),(int. gene bank)
Taiper	Nat. Taiwan Univ., Dept. Hort.	asparagus, mushrooms, Chinese chives
THAILAND		
Kasetsart	Kasetsart Univ.	radish,onion,(vegetable seed production)
Bangkok	Horticultural Experiment Station (10 sub-stations)	Nat. gene bank proposed for mung bean, soyabean, wing bean, yam
TRINIDAD & TOBACO		
St. Augustine	Univ. W. Indies, Fac. Agric.	tomato,eggplant, cucumber,cabbage,

TURKEY		
Menemen, Izmir	ARIC.	beet, spinach, beans etc. (Regional gene bank)
UGANDA		
Kampala	Dept. Crop Science, Makerere Univ.	common bean
UNITED KINGDOM		
Camborne	Rosewarne Exp. Hort. Sta.	tomato, cauliflower, cabbage, melon, onion
Cambridge (a)	Dept. Applied Biol. Univ. Cambridge	common bean, cauliflower
Cambridge (b)	Nat. Inst. Agric. Bot.	
Efford	Exp. Hort. Sta.	tomato
Fairfield	Exp. Hort. Sta.	peppers
Jersey	Dept. Agric.	broccoli, *Brassica*, tomato
Leeds	Univ. Leeds, Dept. Agric. Sci.	*Brassica*
Norwich	John Innes Inst.	peppers, pea, tomato
Reading	Univ. Reading, Dept. Agric. Bot.	peppers
Southampton	Dept. Biol., Univ. Southampton	common bean
Wellesbourne	Nat. Veg. Res. Sta.	lettuce (coll. 1200), onions (coll. 300) *Brassica* (coll. 2000), carrots (coll. 250), common bean, tomato
UNITED STATES OF AMERICA (USA)		
Ames (a) Iowa	Iowa State Univ.	peppers
Ames (b)	USDA Pl. Introd. Sta.	tomato (coll.), onion (coll.), cucumber (coll), (gene bank)
Auburn Alabama	Auburn Univ. Agric. Exp. Sta.	tomato, cucumber melon, watermelon okra
Baton Rouge, Louisiana	Louisiana State Univ.	tomato
Belle Glade, Florida	Univ. Florida, Inst. Food & Agric. Sci.	lettuce, peppers
Beltsville (a) Maryland	Agric. Res. Centre	eggplant, tomato, (plant introd. gene bank)
Beltsville (b) Maryland	Pl. Genet. & Germplasm Inst.	onions

UNITED STATES OF AMERICA

Bloomington, Indiana	Indiana Univ., Dept. Pl. Sci.	tomato,peppers
Bradenton, Florida	Univ. Florida, Inst. Food & Agric. Sci. (IFAS)	tomato
Brawley, California	USDA, Agric. Res. Service Calif.	lettuce
Charleston	USDA Veg. Breeding Lab.	tomato,common bean, cowpea
Cinnaminson	Inst. Agric. Res.	tomato
Columbia, Missouri	Univ. Missouri, Agric. Exp. Sta.	mung bean,tomato
Davis, California	Univ. Calif.	tomato,peppers, onion,melon, lettuce
Dover, Florida	Univ. Florida, Agric. Res. Centre	okra
Durham, New Hampshire	Univ. New Hampshire	watermelon
East Lansing (a) Michigan	Mich. State Univ.	cucumber, common bean, tomato, melon watermelon, peppers
East Lansing (b) Michigan	Mich. Agric. Exp. Sta.	
Experiment (a) Georgia	Georgia Agric. Exp. Sta.	melon,watermelon
Experiment (b)	USDA, Pl. Introd. Sta.	watermelon(coll.), melon (coll.) peppers (coll.), (gene bank)
Fort Collins, Colorado	Nat. Seed Storage Lab.	(nat. gene bank)
Fayetteville, Arkansas	Univ. Arkan., Agric. Exp. Sta.	cucumber,spinach
Franklin,	Sweet Potato Res. Centre	peppers
Gainesville Florida	Univ. Florida, Inst. Food & Agric. Sci Veg. Crops Dept.	peppers,melon,water-melon,tomato,okra, lettuce,carrot,soya-bean,cowpea,common bean,(coll.)
Geneva (a)	New York State Agric. Exp. Sta.	cucumber,cucurbits, common bean,cabbage
Geneva (b) New York	U.S.A. Pl. Introd. Sta.	cucumber (coll.), onion (coll.); (gene bank)
Honolulu (a) Hawaii	Coll. Trop. Agric. Univ. Hawaii	*Brassica*, onion, *Phaseolus*
Honolulu (b) Hawaii	Univ. Hawaii, Agric. Exp. Sta.	tomato,eggplant, cucumber,wax gourd, bean,pea, cauliflower, lettuce,sweet corn, mustard
Ithaca, New York	Cornell, Univ., Agric. Exp. Sta.	cucurbits, cabbage, tomato,cucumber

UNITED STATES OF AMERICA

Lafayette, Indiana	Purdue Univ.	Lima bean, tomato, grain legumes
La Jolla, California	USDA, Agric. Res. Services; S. Regional Plant Introduction Station	*Cucumis* (coll. 50 Africa); (gene bank)
Las Cruces, New Mexico	New Mexico State Univ., Agric. Exp. Sta.	onion
Lexington, Kentucky	Univ. Kentucky	watermelon
Lincoln, Nebraska	Univ. Nebraska	common bean
Lubbock, Texas	Texas Agric. Exp. Sta.	onions
Madison, Wisconsin	Univ. Wisconsin, USDA, Agric. Res. Service	onion, cucumber, cabbage, common bean, cowpea
Miami	Miami Univ.	peppers (coll. 700), roselle, *Xanthosoma*
Newark, Delaware	Univ. Delaware	Lima bean
New Haven (a) Connecticut	Yale Univ.	carrot
New Haven (b) Connecticut	Agric. Exp. Sta.	tomato
Pullman (a) Washington	Washington State Univ.	spinach
Pullman (b) Washington	USDA, Fl. Introd. Sta.	onion, cabbage, beans, lettuce (gene bank)
Raleigh, North Carolina	N. Carolina State Univ.	cucumber egg-plant
Riverside, California	Univ. Calif.	peppers, *Cucurbita*
Salinas	USDA, Agric. Res. Service Western Region	lettuce
Stillwater, Oklahoma	Oklahoma State Univ.	mung bean
St. Louis, Missouri	Missouri Bot. Garden	peppers
Storrs, Connecticut	Univ. Connecticut	pumpkin
University Park, Pennsylvania	Penns. State Univ.	peppers
Urbana, Illinois	Univ. Illinois, Dept. Agron.	mung bean, winged bean
Washington	USDA, Pl. Genet. & Germplasm Inst.	legumes (gene bank)
UPPER VOLTA		
Farakoba	Inst. de Rech. Agron. Trop. (IRAT)	tomato

USSR		
Bykovo	Cucurbit breed, Sta.	cucurbits
Gribovka	Hort. Breed. Sta.	peppers,onion
Khar'kov	Inst.Ovoshchevodstva i bakhchevodstva	tomato
Kiev	Inst. Microbiol. & Virol.	selected vegetables
Leningrad	VIR	veg.(coll.),cucurbits(coll.20000), cucumber,*Cucurbita* (coll.400.),Melon (coll.400),tomato (coll.3000) onion, cabbage(nat gene bank)
Lesnoy Gorodok	N.-i selektsii Ovoshchnykh Kul'tur	onion
Maikop	VIR, Exp. Sta. of the All-Union Inst. for Plant.Prod.	peppers,eggplant
Moscow (a)	Univ. USSR	onion
Moscow (b)	Inst. Obshchei Genetic	tomato
Tambov	Training Coll.	cucumber
Tiraspol, Moldavia	N.-i Inst. Oroshaemogo Zemledeliya	tomato
VENEZUELA		
Cagua, Aragua	Fundation Servicio para el Agricultor	cucumber melon, watermelon,cauliflower
Caracas (a)	Univ. Central de Venezuela, Escuela de Biologia	common bean
Caracas (b)	C.A. Venezolana de Alimentos	tomato
Maracay	Centro Nac. de Investig. Agropec.	common bean
VIETNAM		
Cantho	Fac. Agric., Univ. Cantho	peppers
YUGOSLAVIA		
Novi Sad (a)	Poljoprivredni Fakultet	peppers
Novi Sad (b)	Fac. Agric.	common bean
Sarajevo	Poljoprivredni Fakultet	common bean,melon
Skopje	Zemjodelsko-sumarski Fak.	watermelon
Smederevska	Inst. za povrtarstvo	cabbage

B. RESEARCH WORKERS, PLANT BREEDERS

3. SOLANACEOUS FRUITS

Tomato

ALGERIA		
Alger		var. testing
ARGENTINA		
Castelar	Goldenbergh J.B. 1976	breeding
Rio Negro	Calvar, D.J.	breeding
Tucuman	Martin G.O., Salvioli R.A.L. 1971	selection
AUSTRALIA		
Canberra	Singh C.B. et al. 1974	breeding
St. Lucia	McLeod K.A. 1975	pollen growth
BANGLADESH		
Dacca	Kamaluddin A. 1973	var. testing
BELGIUM		
Antwerp	Liekens F. 1973	res. *Fusarium*
BRAZIL		
Campinas	Nagai H., Costa A.S. 1972	res. diseases
Sete Lagoas	Gomez J.G. 1970	var. testing
Vicosa	Puschmann R. et al. 1972	var. testing(vit.C)
BULGARIA		
Plovdiv	Jordanov. M. 1975	corky root res.
	Manuelyan K. et al. 1975	carotene,hybridisation
Sofia (a)	Mikhailov L., Ognyanova A. 1975	hybridisation
Sofia (b)	Sotirova V.,Beleva,L.1976	res. *Xanthosomas*
CANADA		
Deschambault Lake	Rushdy R. 1973	var. testing
Guelph	Campbell C.G. 1974	genetics
Ottawa	Loiselle R. 1976	(gene bank)
CHILE		
Santiago (a)	Sanz de Badilla 1974	res. *Verticillium*
Santiago (b)	Avarado V.P., Cortazar S.R. 1972	breeding

CUBA		
Habana (a)	Mitov N. 1973	res. diseases
CZECHOSLOVAKIA		
Olomouc	Moravec. J.	breeding
EGYPT		
Cairo (a)	Selim A.K.A., Nazeem H.R. 1975	breeding
EL SALVADOR		
Santa Tecla	Anaya M., Waite B.H. 1974	res.bacterial wilt
	Canas Prietro G. 1971	var. testing
FRANCE		
Montfavet	Laterot, H. 1973	res. TMV
	Pilhouze J. 1974	male sterility
GERMAN DEMOCRATIC REPUBLIC		
Greifswald	Eggert D. 1974	res. *Phytophthora*
	Herrmann H., Gunther E.1972	mutation breeding
GHANA		
Kumasi	Norman J.C. Affran D.K. 1974	var. testing
HUNGARY		
Kecskemet	Andrasfalvy A. 1973	breeding
	Baldy B. 1972	breeding
	Farkas J. 1972	genetics,res. TMV
INDIA		
Bangalore	Rao M.V.B. 1975	res. *Pseudomonas*
Chaubattia	Solanki S.S. et al. 1975	breeding
Hebbal	Hanumanthappa H.S. 1973	triploids
Hissar	Bhutani R.D. et al. 1973	heterosis
Hyderabad (b)	Asif M.I. 1975	vivipary
Ludhiana	Kaul D.L. et al. 1972	hybridisation
Ludhiana	Nandpuri K.S. et al. 1973	genetic variability
Ludhiana	Singh G. et al. 1974	combining ability
New Delhi (a)	Singh B., Chaudhury B. 1973	res. root-knot
Udaipur	Naik S.M. 1973	res. root-knot
INDONESIA		
Jakarta	Sahat S. 1974	var. testing
	Sunarjono H., 1974	res. diseases
ISRAEL		
Rehovot	Alon H., Katan J., Kedar N. 1974	res. *Fusarium*

ISRAEL		
Rehovot	Frenkel R., Pilovski 1974	breeding
	Rabinowitch H.D. 1974	breeding
ITALY		
Bologna (a)	Casarini B. et al. 1970	var. testing
Milan	Soressi G.P. 1974	breeding
Minoprio	Svanosio A., Vandoivi G. 1974	combining ability
Rome	Tomarchio L. 1974	res. *Phytophthora*
JAPAN		
Funajuka-cho	Adachi T. 1974	breeding
Tsu	Kuriyama T., Kuniyasu K. 1974	res. *Cladosporium* *Fusarium*
Yamagata City	Imanishi S., Hiura I. 1975	fruit characters
KENYA		
Thika	Warui, J.N. 1973	var. testing
MEXICO		
Chapingo	Belalcazar C.S., Galindo A. 1974	virus
Chapingo (b)	Bravo G.H. 1968	mutations
Chapingo (c)	Pinto Cortes B. 1970	var. testing
NETHERLANDS		
Wageningen	Hogeboom N.G. 1975	breeding
NIGERIA		
Ibadan (b)	Adeniran M.O., Wilson G.F. 1975	breeding lowland tropics, res. virus (used cropping)
Samaru (a)	Choudhuri H.C. 1972	genetics
Samaru (b)	Quinn J.G. 1971	breeding for processing
PAKISTAN		
Lyallpur	Hussain C.A. et al. 1973	var. testing
	Yousaf M. et al. 1971	var. testing
Mirpur Khas	Baluch A.A., Inayat A.R. 1974	var. testing
POLAND		
Reguly	Czyzewaska S., Bialkowska H. 1973	var. testing
TAIWAN		
Tainan	Villareal R.L. 1974	breeding

UNITED KINGDOM		
Efford	Shelby R.A. 1975	heat tolerance
U.S.A.		
Baton Rouge	Hernandez T.P. 1972	breeding
	Phills B.R., Hernandez T.P. 1975	combining ability
Beltsville (a)	Barksdale T.H. 1975	res. diseases *Rhizoctonia*
Bloomington	Heiser C.B.	taxonomy
Bradenton	Jones J.P.,Crill P. 1975	res. *Verticillium*
Charleston	Fery R.L, Cuthberg F.P. 1974	res. *Heliothis*
Cinnaminson	Hikida H.R.,Raymer W.B. 1973	res. virus wild types
Columbia	Lambeth V.N. 1973	combining ability
Davis	Rick Ch.M., Zobel R.W.1972	coll.wild types evolution
East Lansing (b)	Herner R.C., Sink K.C., Vriesenga J.H. 1974	carotenoids,res. *Fusarium*
Gainesville	Matthews R.F. et al. 1973	vit. C
Ithaca	Munger H.M. 1974	blotchy ripening
Lafayette	Tigchelaar E.C. et al. 1974	breeding,
New Haven	Claybergh C.D. 1974	res. pests
U.S.S.R.		
Khar'kov	Krylova M.I. 1975	res. *Cladosporium*
Leningrad	Breznev D.D., Simonov A.A. 1974	male sterile mutants
Leningrad	Luk'yanenko A.N. 1974	breeding
Leningrad	Machulin L.L.	res.heat drought
Moscow	Makhalova M.R. 1975	interspecific hybridisation
Tiraspol	Zhuchenko A.A. et al. 1975	genetics
VENEZUELA		
Caracas (b)	Colmenares C.S. 1971	var. testing
Caracas (b)	Lasso R. 1974	res. *Pseudomonas*

Peppers (3.3)

ARGENTINA		
Castelar	ahlen A.v.d. 1974	breeding
Castelar	ubrzycki H.M. 1974	mutations
BRAZIL		
Campinas	osta A.A., Nagai H., 1973	res. *Fusarium*,
São Paulo	renhani A.A. et al. 1972	*Xanthomonas*

BULGARIA		
Lom	Ignatov B. 1973	var. tests
Plovdiv	Genchev S. 1973	cytochrome oxydase
Sofia (a)	Daskaloff F. 1974	male sterile mutants
Sofia (a)	Markova M. 1973	induced mutants
Sofia (a)	Mikhailov L. 1974 Popova, D. 1975	heterosis
CANADA		
Simcoe	Cantliffe D.J. 1974	growth regulation
CZECHOSLOVAKIA		
Bratislava	Zaujcova L. 1974	var. testing
Olomouc	Betlach, J. 1972 Novak F. 1974	genetics,haploids, male sterility
ETHIOPIA		
Addis Ababa	Bezuneh T. 1973	collection,evaluation
FRANCE		
Avignon	Dumas de Vaulx R. 1974	haploid parthenogenesis
Montfavet	Pochard E. 1974	res. CMV, *Phytophthora*
HUNGARY		
Budapest (b)	Daskalov S.,Milkova L.	breeding
Budapest (b)	Tuza S. 1971	var. testing
Budapest (a)	Zatyko L. 1973	res. TMV virus
Kecskemet	Andrasfalvy A. 1973	res. TMV virus
INDIA		
Bangalore	Singh S.J. 1973	res. virus
Coimbatore (a)	Mohanasundaram M. 1971	res. aphids
Coimbatore (b)	Premsekar S. 1973	var. testing
Hissar	Singh B., 1974	res. root-knot
Jabalpur	Mishra I.P., Singh K. 1974	var. testing
Ludhiana	Singh M. 1974	natural cross pollination
New Delhi (a)	Bansal H.C. 1973	induced mutation
Simla	Nagaich B.B. et al. 1972	heterosis
Vellayani	Navi P.M. 1973	breeding
Warangal	Subash K. 1975	aneuploidy, irradiation
ISRAEL		
Bet Dagan	Shiffriss C. 1973	male sterility

ITALY		
Bologna (c)	Piazzi R. 1974	var. testing
Bologna (b)	Scossiroli R.E.	genetics
Perugia	Lorenzetti F. 1974	breeding
Torino (c)	Bigotti P.G. 1974	res. TMV
Torino (a)	Quagliotti L. 1973	genetic variability
JAPAN		
Mishima (a)	Ohta Y. 1970	male sterility
Takumatsu-shi	Hirose T. 1975	male sterility
KENYA		
Thika	Warui, J.N. 1973	var. testing
KOREA, SOUTH		
Suweon	Jo Y.K.	var testing
NIGERIA		
Ibadan (b)	Adeniran M.O., Wilson G.F. 1975	local cvs. res. virus (mixed cropping)
UNITED KINGDOM		
Reading	Pickersgill B. 1975	evolution,taxonomy
U.S.A.		
Ames (a)	Horner H.T. 1974	breeding
Belle Glade	Zitter T.A. 1975	breeding
Bloomington	Heiser C.B. 1975	taxonomy,evolution
East Lansing (b)	Honma S. 1974	res. TMV virus
Franklin	Etzell W.W., Hernandez T.P. 1973	var. testing
Gainesville	Bartz J.A., Stall W.M. 1974	breeding
	Laborde J.A. 1973	genetics
Miami	Esbaugh W.H. 1974	coll. *C. pubescens*
Riverside	Lippert L.F., Marin V.O., 1975	combining ability
St. Louis	d'Arcy W.G. 1974	taxonomy
University Park	Ferretti P.A. 1974	res. TMV virus
U.S.S.R.		
Gribovka	Alpatev A.V. 1974	heterosis
Maikop	Dikii S.P. et al. 1973	male sterility
	Studentsova L.I. 1973	heterosis
VIETNAM		
Cantho	Yasuo Ohta; Phan Van Chuong 1976	virus,grafting
YUGOSLAVIA		
Novi Sad	Lazic B. et al. 1975	var. testing

Eggplant (3.4)

BANGLADESH		
Dacca	Kamaluddin A. 1973	var. testing
Mymensingh	Siddique M.A., Husain A. 1971	morphology
BRAZIL		
Campinas	Medina D.M. et al. 1972	breeding, selection
Rio de Janeiro(b)	Ribeiro R. de L.D. et al, 1971	res. *anthracnose*
FRANCE		
Avignon	Auber S. 1972	composition, quality
Montfavet	Dumas S.	res. diseases
INDIA		
Annamalainagar	Rajasekaran S. 1970	cytogenetics
Coimbatore (a)	Rangaswamy P. 1973	hybridisation
Coimbatore (a)	Sambandam C.N. et al. 1973	res. *Epilachna*
Hebbal (b)	Siddarame G. et al. 1974	res. *Pseudomona*
Kanpur	Singh H.N. et al. 1974	combining ability
Ludhiana	Waraitsh K.S. 1974	res. *Alternaria*
Madurai (b)	Ramaswamy N. 1973	var. testing
Pantnagar	Singh B. 1974	heterosis, cytogenetics
Udaipur	Srivastava L.S. 1973	yield characters
Vellayani	Swaminathan M., Srinivasan K. 1971	hybridisation
ISRAEL		
Bet Dagan	Nothmann J. 1975	pollen fertility, cold stress
ITALY		
Bologna (b)	Scossiroli R.E. 1972	genetics
Torino (a)	Quagliotti L.	breeding
JAPAN		
Tsu	Kuriyama T. 1975	res. diseases
MARTINIQUE		
Fort de France	Daly P.M.J. 1972	breeding
ROMANIA		
Bucharest	Stancu E. et al. 1970	var. testing
U.S.A.		
Beltsville (a)	Schalk J.M. et al. 1975	res. *Tetranychus*
Honolulu (b)	Tanaka Y.S. 1972	breeding
Raleigh	Jenkins S.F.	res. *Pseudomonas* root-knot

U.S.S.R.		
Maikop	Dikii S.P. et al. 1975	fruit composition
Hebbal (b)	Siddarame Gowda T.K. 1974	res. *Pseudomonas*

4. CUCURBITS

Cucurbits general (4.1)

EGYPT		
Alexandria	Herakly F.A.,Zeid M. 1974	res. *Tetranychus*
INDIA		
New Delhi (a)	Choudhury	breeding
U.S.A.		
La Jolla	Dane F., Tsuchiya T., 1976	wild *Cucumis*
U.S.S.R.		
Bykovo	Shuman N.I. 1974	breeding
Leningrad	Brezhnev D.D. 1972	collections

Watermelon (4.2)

INDIA		
Bangalore	Sohi H.S. 1976	res.anthracnose
Jaipur	Chandola R.P. et al. 1975	pollen studies
Ludhiana	Brar J.S., Nandpuri K.S., Thakur J.C. 1974	var. testing, fruit weight
Madurai (a)	Soundrapandian G. et al.1973	storage irradiated seeds
Vallabhnagar	Sachan C.P., Tikka S.B.B. 1973	variability
ITALY		
Milan	Soressi G.P. et al. 1974	var. testing
LIBYA		
Tripoli (b)	Warid W.A. et al. 1971	polyploidy
U.S.A.		
Durham	Loy J.B., Liu P.B.W. 1975	genetics
Lexington	Mohr H.C.,Sandhu M.S. 1975	genetics mutants
U.S.S.R.		
Leningrad	Fursa T.B., Shcheglov S.W. Tekhanovich G.A. 1974	evaluation, wild types
YUGOSLAVIA		
Skopje	Simonov D. 1974	grafting

Melon (4.3)

BRAZIL		
Campinas	Bernardi J.B. 1974	var. testing
CHILE		
Santiago (a)	Rojas E. et al. 1974	growth regulators, sex expression
EGYPT		
Minia	Imam M.K. et al. 1973	crossings, res. *Erysiphe*
FRANCE		
Montfavet	Dumas de Vaulx R. 1974	polyploidy
Montfavet	Risser G. 1974	floral biology
GUADELOUPE		
Petit Bourg (c)	Kaan F. 1973	res. diseases
HUNGARY		
Budapest (b)	Mandy G. 1974	breeding
INDIA		
Annamalainagar	Kannaiyan S., Puru Shothaman D. 1973	res. *Fusarium*
Coimbatore (c)	Chelliah S., Sambandam C.N. 1973	res. fruit fly
Ludhiana	Nandpuri K.S. et al. 1974	combining ability
Muzaffarnagar	Bisaria A.K. 1974	var. testing
New Delhi (a)	Choudhury B., Sivakami N. 1974	var. testing
New Delhi (b)	Sharma R.R. 1971	sex expression
Rewa	Shrivastwa G.P. 1974	hypogyny
ISRAEL		
Neve Ya'ar	Karchi Z. et al. 1975	res.CMV virus
Rehovot	Elasser G., Kedar N. Rudich J. 1974	growth regulators, parthenocarpic fruit
ITALY		
Bologna (c)	Piazzi R. et [illegible] 1974	var. testing
JAPAN		
Fukuoka	Sugahara Y. 1974	breeding
Kamihama	Yabumoto Y. 1975	pectin content
Tsu	Kuriyama T. 1975	res. diseases
Tsu	Takada K. et al. 1974	res. powdery mildew
Yamagata City	Kitamura T. 1974	storage

PORTUGAL		
Lisbon	Sousa L. a C.E. 1972	sex expression
U.S.A.		
Auburn	Norton J.D. 1975	var. testing
Davis	Mann L.K. 1960	breeding
Experiment (a)	Sowell G. 1974	res. *Sphaerotheca*, *Mycosphaerella*
Gainesville	Halsey, L.H., Elmstrom G.W., 1973	var. testing
La Jolla	Bohn G.W. 1960	breeding
U.S.S.R.		
Leningrad	Fursa T.T. 1974	collection
Leningrad	Meshcherov E.T., Tekhanovich G.A., 1975	hybrid seed production
Leningrad	Shchukina A.S. 1972	coll. res. *Fusarium*
Leningrad	Tuvardzhieva L.V. 1975	res. *Fusarium*

Cucumber (4.4)

BRAZIL		
Jaboticabal	Churata-Masca M.G.C., Awad M. 1974	ethephon, sex expression
Rio de Janeiro (b)	Castro L.A.B. de et al. 1972	F1 hybrids: res. diseases
BULGARIA		
Plovdiv	Genchev S., Mikhov A. 1974	breeding
CANADA		
Simcoe	Cantliffe D.L., Phatak S.C., 1975	breeding
CZECHOSLOVAKIA		
Prague-Ruzyne	Jakubkova Z. 1974	breeding
GERMANY D.R.		
Quedlinburg	Kampe F. 1973	breeding
GUADELOUPE		
Petit Bourg (c)	Anais	var. testing
INDIA		
New Delhi (c)	Gill I	breeding
Patna	Singh	cytological studies
ISRAEL		
Rehovot	Rudich	sex expression

JAPAN		
Tokai-Kinki	Ezuka A., Komada H. 1974	res. downy mildew
Tsu	Kuriyama T. 1975	res. diseases
NETHERLANDS		
Wageningen (a)	Ponti O.M.B. de 1976	parthenocarpy
U.S.A.		
Auburn	Chambliss O.L. 1975	res. *Mycosphaerella* insects
East Lansing (a)	Baker L.R., Rudich J., Scott J.W., Wittwer S.H. 1974	plant regulators, sex expression
Fort Collins	Bowers J.L. 1974	res. *Colletotrichum* *Erysiphe*
Geneva (a)	Robinson R.W. 1976	res. diseases
Honolulu	Takeda K.Y.,Gilbert J.C. 1975	res.watermelon MV
Ithaca	Munger H. 1975	res. TMV virus
La Jolla	Whitaker T.W. 1976	wild relatives
Madison	Peterson C.E. 1975	breeding
Madison	Walker J.C. 1975	res. CMV virus, scab
Raleigh	Lower R.L., Goode M.J. 1975	sex expression, var. testing
Raleigh	Cuthbert F.P., Quisumbing A.R., 1975	res. insects
U.S.S.R.		
Leningrad	Medvedev A.V. 1974	res. *Erisyphe* *Sphaerotheca*
Tambo	Ivanov O.V. 1972	heterosis

Pumpkins & Squashes (4.5)

BRAZIL		
Jaboticabal	Dematté et al. M.E.S.P. 1975	breeding
Piracicaba	Rochelle L.A. 1975	taxonomy
CUBA		
Habana (b)	Alonso R.R.C., Cueto Robayana, I. 1974	selection
EGYPT		
Alexandria	Abdel-Al Z.E. et al. 1973	breeding
Minia	Abo Bakr M.A. 1973	res. *Erysiphe*

INDIA		
Chaubattia	Singh B.B. 1975	plant regulator, sex modification, fruit yield
Coimbatore (a)	Thamburaj S., Kamalanthan S. 1973	sex expression
ISRAEL		
Bet Dagan	Shifriss C., Cohen S. 1974	res. CMV virus
ITALY		
Milan	Borghi B. *et al*. 1973	heterosis
JAPAN		
Hyogo	Nakamura N. 1972	vegetative hybrids
LIBYA		
Tripoli (a)	Goma H. *et al*. 1973	ethrel,sex expression
NIGERIA		
Ibadan (c)	Oridiji M.O.	oil content of seeds
SOUTH AFRICA		
Pretoria	Joubert T.G. La G. 1974	breeding
U.S.A.		
Ithaca	Armbruster G. Woodside C.J.,1974	storage
La Jolla	Whitaker T.W., Bohn G.W. 1974	breeding
Storrs	Scarchuk J. 1974	genetics
U.S.S.R.		
Byokovo	Schuman N.L. 1974	breeding
Leningrad	Fursa T.T. 1974	taxonomy
Leningrad	Shelepina G.A. 197?	genetics

itter gourd (4.6)

INDIA		
Bangalore	Dutta O.P. *et al*. 1974	breeding
Muzaffarnagar	Bisaria A.K. 1974	sex expression
Nagpur	Wanjari K.B. 1973	colchicine
Patna	Trivedi R.N., Roy R.P. 1973	cytogenetics
Trivandrum	Ravindram P.N. 1971	ethrel,sex expression

lottle gourd, wax gourd, loofah, snake gourd (4.7 to 4.10)

INDIA		
Coimbatore (a)	Thamburaj S., Kamalanthan S., 1973	sex expression, wax gourd

INDIA (cont)		
Gwalior	Joshi D.P. et al. 19[illegible]	bottle gourd, temperature
Gwalior	Joshi D.P. 1974	loofah & snake gourd temperature
Varanasi	Katijar R.B. 1974	loofah irradiation
U.S.A.		
Honolulu	Tanaka J.S. 1970	wax gourd, local cvs

5. ALLIUM

Onion (5.2)

BANGLADESH		
Dacca	Kamaluddin A. 1973	var. testing
BRAZIL		
Campinas	Silveira A.P. et al. 1971	res. *Alternaria*
Jaboticabal	Churata-Nasca M.G.C. 1975	var. testing
Piracicaba	Costa C.P. da 1974	breeding, virus
Piracicaba	Vale E.C. do 1972	var. testing
Piracicaba	Zimmermann M.J. de O. et al. 1974	endogamy
Viçosa	Koguishi et al. 1971	res. *Pyrenochaeta*
CANADA		
St. Jean	Crete R., Hogue E.J. 1974	res. smut
FRANCE		
Versailles	Schweisguth B. 1974	dry matter content
INDIA		
Srinagar	Koúl A.K. 1971	breeding
IRAN		
Teheran	Assadi P., Izadyar M. 1973	res. *Peronospora*
NETHERLANDS		
Wageningen	Meer Q.P. v.d. 1976	breeding, self-fertilisation
NIGERIA		
Samaru (b)	Green J.H. 1973	var. testing, seed production
Samaru (b)	Amstel H. van 1976	breeding

PERU		
Lima	Holle M., Valdiva M.G.	var. testing
SOUTH AFRICA		
Stellenbosch	Holtz G., Knox-Davies P.S. 1974	res. *Fusarium*
THAILAND		
Kasetsart	Drabyasara S. et al. 1973	var. testing
UNITED KINGDOM		
Wellesbourne	Stow J.R. 1975	res. rotting
U.S.A.		
Beltsville (b)	McCollum G.D. 1974	breeding
Davis	Ahmed Abu, Harrington J. 1974	var. testing, seed yield
Davis	Carlson E.C. 1974	seed yield
La Cruses	Corgan J.N., Cotter D.J. 1972	var. testing
Lubbock	Lipe,W.N. 1975	growth regulators
Madison	Hosfield G.L. et al. 1975	combining ability
Madison	Gabelman W.H., Peterson C.E., 1975	hybrids
U.S.S.R.		
Gribovka	Efimochkina O.N. 1970	primitive cvs
Leningrad	Anuchina T.V., Ludovnikova G.A. 1975	flower genetics
Lesnoy	Knonkov P.F. et al. 1975	selection

Garlic (5.5)

BRAZIL		
São Paulo	Cruz B.P. et al. 1973	res. *Sclerotium*
CUBA		
Habana	Munoz de Con L. 1973	var. testing; res. *Alternaria*
CZECHOSLOVAKIA		
Olomouc	Moravec J. et al. 1974	var. testing
INDONESIA		
Jakarta	Sunarjono 1973	var. testing, res. *Erwinia*
KOREA, SOUTH		
Iri	Ku Y.S. et al. 1974	local cvs

SUDAN		
Khartoum	Abdel-Al Z.E. 1971	var. testing

Shallot, Japanese bunching onion, leek a.o. (5.1, 5.3, 5.4, 5.6)

GHANA		
Legon	Sinnadurai S. 1973	cultivation shallot
TAIWAN		
Taiper	Tai K.S. 1973	var. testing Chinese chives
U.S.S.R.		
Moscow (a)	Orlova N.N. et al. 1975	seed Jap. bunching onion

6. LEGUMINOUS VEGETABLES

General (6.1)

BRAZIL		
Campinas	Leitao Filho H. de F. 1974	taxonomy *Phaseolus*
CAMEROON		
Yaounde	Westphal E. 1975	var. testing local cvs
MEXICO		
Chapingo (a)	Hernandez X.E. 1973	introduction, genetic erosion

Common bean (6.2)

ARGENTINA		
Campinas	Bernardi J.B.	breeding
AUSTRALIA		
Canberra	Ogle H.J. Johnson J.C. 1974	var. testing
Rydalmere	Ballantyne B. 1974	res. rust
BRAZIL		
Belo Horizonte	Almeida L. d., Bulisani E.A. 1974	var. testing

BRAZIL		
Belo Horizonte	Zimmermann M.J. de C. 1975	var. testing
Campinas	Pompeu A.S., Paradela Filho O. 1975	res. anthracnose
Linhares	Pacova B.E.V., Rocha A.C. de 1975	natural crossing
Pelotas	Costa J.G.C., Antunes I.F. 1975	natural crossing, res. diseases
Recife	Albuquerque M.M. de, Vierra C. 1974	heterosis
Rio de Janeiro (a)	Coelho R.G. et al. 1974	var. testing
Viçosa	Cardoso A. 1972	var. mixtures
Viçosa	Vieira C. 1974	breeding
BULGARIA		
Ruse	Patenova G. 1975	var. testing
Sofia (b)	Dekov D. et al. 1975	breeding
Sofia (b)	Ganeva D. 1975	breeding
CANADA		
Deschambault Lake	Routhier B. 1974	var. testing
CHILE		
Chillan	Guglielmetti M.H. 1974	res. virus, *Fusarium*
Santiago (a)	Cafati K.C.R., Kimati H., Ubilla R.C. 1974	res. *Xanthomonas*
COLOMBIA		
Pasto Narino	Bastidas R.C. et al. 1973	res. bean weevil
Cali	Grahams P.H.	germplasm collections
COSTA RICA		
Turrialba	Pinchinat A. 1974	breeding, collection
EGYPT		
Cairo (c)	Abdel Aziz Abdel Fattah Nassar S.H. et al. 1974	var. testing
Cairo (d)	Assem M.A. 1974	res. *Melanagromyza*
Cairo (b)	Sirry A.R. 1974	res. root-rot
GERMANY, F.R.		
Freiburg	Schnock M.G. et al. 1975	res. *Colletotrichum*
GUADELOUPE		
Petit Bourg (a)	Messiaen C.M. et al.	res. root-knot *Pythium*
INDIA		
Bhuntar	Singh B.M. et al. 1974	res. *Ramularia*

INDIA		
New Delhi (c)	Aggarwal V.D., Singh T.P. 1973	genetics
IRAN		
Karaj	Saraffi A. 1974	breeding
JAPAN		
Tokachi	Narikawa T. 1972	var. testing
MALAWI		
Lilongwe	Allen D.J. 1973	res. rust
Lilongwe	Edje C.T. et al. 1974	var. testing
NETHERLANDS		
Wageningen (a)	Drijfhout E. 1975	breeding, res. virus
PUERTO RICO		
Mayaguez	Vakili N.G. et al. 1975	res.bacterial blight
SUDAN		
Hudeiba	Ayoub A.T. 1974	breeding
UNITED KINGDOM		
Cambridge (a)	Evans A.M. 1974	genetics
Southampton	Smartt J. 1973	*Phaseolus coccineus*
Wellesbourne	Innes N.L. 1974	breeding
U.S.A.		
Charleston	Deakin J.R. 1975	res. *Rhizoctonia*
East Lansing(a)	Lolas G.M. 1975	phytic acid
Geneva (a)	Providenti R. 1974	res. watermelon virus
Honolulu (b)	Gilbert 1974	res. root-knot
Lincoln	Coyne D.P. 1974	res. *Xanthomonas*, rust
Madison	Hagedorn J.C. 1974	breeding
VENEZUELA		
Maracay	Ortega V.S. 1974	natural cross pollination
YUGOSLAVIA		
Sarajevo	Vidovic O. 1975	var. testing

Lima bean (6.3)

GUADELOUPE		
Petit Bourg (a)	Messiaen C.M. 1972	var. testing
U.S.A.		
Lafayette	Warren H.L. 1975	res. *Rhizoctonia*
Newark	Fisher V.J., Weaver C.K. 1974	var. testing

Hyacinth bean (6.4)

INDIA		
Coimbatore (c)	Mohamed Hanifa A. et al.1973	res. black bean aphid
Coimbatore (a)	Veeraswamy R. et al. 1973	breeding,cross pollination
Kanpur	Srivastava J.P. 1973	breeding
New Delhi (a)	Patel P.N., Jindal J.K. 1973	res. *Xanthomonas*

Mung bean (6.5)

INDIA		
Coimbatore (a)	Veeraswamy R. et al. 1973	breeding
Hissar	Chandra S. et al. 1974	var. testing
Jabalpur	Deshkar M.V. et al. 1974	res. *Rhizoctonia*
Jabalpur	Maheswari S.K. et al. 1974	row spacing
Junagadh	Joshi S.N., Kabaria M.M. 1973	res. *Rhizoctonia*
Kanpur	Singh P. et al. 1975	interspec hybridisation
Ludhiana	Malhotra R.S. et al. 1974	selection
Ludhiana	Singh T.P., Malhotra R.S. 1975	crossing technique
Nadia	Dana S., Das N.O. 1974	hybridisation
New Delhi (a)	Ranamujam S. et al. 1974	genetics
New Delhi (a)	Tikoo J.L., Jain H.K. 1974	mutation breeding
IRAN		
Karadj	Kaiser W.J., Mossahebi G.H. 1974	res. bean mosaic virus
PAKISTAN		
Lyallpur	Asghar Ali, Khurshid Alam 1972	soil moisture
SRI LANKA		
Maha-Illuppalama	Fernando G.W.E. 1972	var. testing
TAIWAN		
Tainan	Mackenzie D.R., Hyo-Guen Park 1974	breeding

U.S.A.

Columbia	Poehlman J.M. et al. 1974	var. testing
Stillwater	Kirby J.S., Galeotti C. 1974	var. testing

cowpea, yardlong bean (6.6)

BANGLADESH

Dacca	Ahmad K., Ali M.B. 1974	var. testing

BELGIUM

Gembloux	Otoul E. 1973	amino-acids

GHANA

Legon	Arycetey A.N., Laing E. 1973	breeding

GUADELOUPE

Petit Bourg	Schoch P.-G. et al. 1975	shade,stomatal reactions

INDIA

Coimbatore (a)	Henry Louis I., Kadambavanasumdaram M. 1973	mutation breeding
Coimbatore (a)	Mahudeswaran K. et al. 1973	breeding
Coimbatore (a)	Veeraswamy R. et al. 1973	breeding
Hebbal	Chandrappa H.M. et al. 1974	introductions
Hissar	Jayaprakash R.K. et al. 1974	genetics
Junagadh	Bapna C.S., Joshi S.N. 1973	hybridisation
Ludhiana	Khatri H.L., Lalinder Singh 1974	res. mosaic virus
New Delhi (b)	Paliwal K.V., Maliwal G.L. 1973	salt tolerance
New Delhi (b)	Singh H.B. et al. 1974	breeding

NIGERIA

Ibadan (a)	Adedipe N.O., Ormrod D.P. 1975	breeding
Ibadan (d)	Ojomo O.A. 1974	breeding
Ibadan (b)		crossing technique
Ibadan (b)	Williams R.J. 1975	res. diseases

SENEGAL

Bambey	Sene D., N'Diaye S.M. 1974	breeding

U.S.A.

Charleston	Ferry R.L., Cuthbert F.R. 1975	res. *Curculio*
Gainesville	Dougherty R.H. 1975	pod-opening force
Madison	Bliss F.A. et al. 1973	var. testing
Madison	Franckowiak J.D. 1973	var. testing

Winged bean (6.7)

GHANA		
Legon	Karakari S.K.	agronomy
INDONESIA		
Bogor	Sastrapradja S. et al.	variability
PAPUA NEW GUINEA		
Port Moresby	Khan T.N.	agronomy, variability

7. BRASSICAS

General (7.1)

GERMANY D.R.		
Quedlinburg	Kunmer M. 1973	interspecific crosses
INDIA		
Hissar	Dhinsda K.S. et al. 1975	composition
Hissar	Khanna V.K. 1974	interspecific crosses
JAPAN		
Sendai	Mizushima U. 1966	genetics, evolution
SPAIN		
Madrid	Gomez-Campo C. 1972	germplasm preservation, taxonomy
UNITED KINGDOM		
Wellesbourne	Ockendon D.J. 1975	breeding, collections

White cabbage (7.2)

BRAZIL		
Rio de Janeiro (a)	Leal N.R. et al. 1974	var. testing
COLUMBIA		
Manizales	Torres Torres E. 1972	res. *Plasmodiophora*
GERMANY D.R.		
Quedlinburg	Fabig. F. 1973	hybrid breeding
JAPAN		
Sendai	Nakanishi	self-incompatibility

NETHERLANDS		
Wageningen (a)	Eenink A.H. 1974	matromorphy
Wageningen (a)	Marrewijk N.P.A. 1972	incompatibility
Wageningen (a)	Nieuwhof M. 1975	hybrids
U.S.A.		
Geneva (a)	Dickson M.H., Stamer J.R. 1975	hybrids
U.S.S.R.		
Leningrad	Lukovnikova C.A. 1974	photosynthesis

Chinese cabbage (7.3)

GERMANY D.R.		
Quedlinburg	Clauss E. 1973	amino-acid
TAIWAN		
Tainan	Opena R.T. 1974	breeding

Cauliflower, broccoli (7.4)

BANGLADESH		
Mymensingh	Bhattacharjee A.K. et al. 1971	var. testing
CANADA		
Charlottetown	Cutcliffe J.A. 1975	var. testing (broccoli)
Deschambault Lake	Rushdy R. 1974	var. testing
GUADELOUPE		
Petit Bourg (a)	Daly P. 1972	var. testing
INDIA		
Aurangabad	Tekale N.S. 1976	protein extraction
New Delhi (a)	Sharma B.R. et al. 1972	res. blackrot
ITALY		
Pisa	Baroncelli S. 1974	selection
JAPAN		
Kanagawa-ku	Hiaoka T. 1974	var. testing broccoli
NETHERLANDS		
Wageningen (b)	Nieuwhof M. 1974	self-incompatibility

UNITED KINGDOM		
Cambridge	Beckett J.L. 1973	breeding
Wellesbourne	Crisp P. 1975	purple colour defect
VENEZUELA		
Cagua	Colmenares C.S. 1969	var. testing

8. LEAF VEGETABLES

General (8.1)

PHILIPPINES		
Los Baños	Lugod G.E. 1970	wild vegetables
PUERTO RICO		
Mayagüez	Martin F.W., Rubertê R.M. 1975	tropical leaf vegetables (coll.)

Common annual leaf vegetables (8.2)

AUSTRALIA		
Merbein	Sauer M.R. 1975	amaranth cult.
BENIN		
Porto-Novo	Grubben G.J.H. 1975	var. testing trop. leaf vegetables (amaranth, *Celosia*, *Corchorus*, *Solanum*)
CAMEROON		
Yaounde	Westphal E. 1976	coll. local leaf vegetables
INDIA		
Coimbatore	Kamalanathan S. et al. 1973	breeding
Lucknow	Khoshoo T.N., Pal M. 1971	amaranth, genetics
Lucknow	Madhusoodanan K.J. 1976	amaranth genetics
NETHERLANDS		
Amsterdam	Grubben G.J.H. 1976	amaranth agronomy
Wageningen	Samson J.A. 1972	coll. amaranth, kangkong, *Xanthosoma*
NIGERIA		
Ibadan (b)	Wilson G.F. 1974	amaranth, *Celosia*, *Corchorus* var. testing
Ibadan (c)	Omideji, M.O.	indigenous species

TAIWAN		
Tainan	Deutsch J.A. 1975	amaranth var. testing
U.S.A.		
Miami	Morton J.F. 1976	coll. *Xanthosoma roselle*

Lettuce (8.2)

BRAZIL		
Campinas	Costa A.S. Nagai H. 1971	res.mosaic virus
Rio de Janeiro (a)	Leal N.R. 1974	var. testing
CHILE		
Santiago (a)	Rojas E.E. 1975	var. testing
CZECHOSLOVAKIA		
Olomouc	Moravec J., Krasnicka S. 1973	var. testing
INDIA		
Jaipur	Kaul V.,Singh D. 1974	cytology wild *Lactuca*
NETHERLANDS		
Wageningen (a)	Eenink A.H. 1976	res. disease, *Bremia*
UNITED KINGDOM		
Wellesbourne	Gray D. 1975	temperature, germination
U.S.A.		
Belle Glade	Litter T.A. 1974	res. mosaic virus, mottle virus
Brawley	Whitaker T.W. 1974	breeding
Davis	Zink F.W., Duffus J.E. 1975	res.mosaic virus, downy mildew
Gainesville	Basset M.J. 1975	inheritance heading
Salinas	Ryder E.J. 1975	res. big vein

Spinach (8.2)

EGYPT		
Alexandria	Nassar N.M. et al. 1973	polyploidy
Cairo (c)	Stino K.H. et al. 1973	var. testing
ITALY		
Bologna (c)	Piazzi R. et al. 1975	var. testing

NETHERLANDS		
Wageningen	Eenink A.H. 1974	res. *Peronospora*, cuc. virus
U.S.A.		
Fayetteville	Bradley G.A. 1975	var. testing
Pullman	Sams D.W.,Bienz D.R. 1974	var.testing (coll.185)
YUGOSLAVIA		
Zagreb	Pavlek P. 1974	climatic factors

9. OTHER WARM WEATHER VEGETABLES

Okra (9.2)

BRAZIL		
Campinas	Inforzato R., Bernardi J.B. 1974	var. testing, root system
Joboticabel	Churata-Masca M.G.C. 1975	photoperiod
Piracicaba	Mitidieri J. 1974	cross pollination
Rio de Janeiro (b)	Ribeiro R. de L.D., Robbs C.F. 1971	res. *Fusarium*
Viçosa	Pereira A.A. et al. 1971	photoperiod, flowering
CANADA		
Guelph	Arulrajah T., Ormrod D.P. 1973	photoperiod, temperature
EGYPT		
Assiut	Shalaby G.I. 1972	cross pollination
Cairo (c)	Abdel Aziz Abdel Fattah M. 1972	seed germination
Cairo (e)	Abdel-Salam A.S. 1972	chemical constituents
GHANA		
Legon	Suppiah Sinnadurai	local varieties
INDIA		
Bangalore	Randhawa G.S. 1972	breeding
Bangalore	Sohi H.S., Sokhi S.S. 1974	res. *Erysiphe*, *Cercospora*
Coimbatore (a)	Thamburaj S. 1973	var. testing
Coimbatore (a)	Uthamasamy S. et al. 1973	res. leaf hopper
Delhi	Chandra S. 1974	seed set
Dharwar	Giriraj K., Swamy Rao T. 1973	irradiation, pod characters
Dharwar	Sulikeri G.S. 1972	var. testing,floral ecology, fruit formation

INDIA (Contd)

Hissar	Singh K. *et al*. 1974	genetic variability
Ludhiana	Jhooty J.S. *et al*.	res. *Cercospora* and *Erysiphe*
Meerut	Yashvir 1975	induced mutation
New Delhi (a)	Arora R.K., Singh H.B.	taxonomy
New Delhi (a)	Joshi A.B. 1974	genetics

IVORY COAST

Abidjan	Siemonsma J.S. 1975	germination, growth

PAKISTAN

Lyallpur	Akram M. 1971	heterosis
Sarial	Abdul Majid Zafar C. 1972	var. testing

U.S.A.

Dover	Albregts E.E. 1974	var. testing

C. SEED GROWERS

In addition to the limited number of companies or institutions producing vegetable seeds in tropical areas, some commercial firms based in temperate countries can often obtain selected cultivars which are suitable for the tropics.

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A N N E X III

TROPICAL VEGETABLES - COMMON NAMES

TROPICAL VEGETABLES - COMMON NAMES

(Fr)	=	French
(Mal)	=	Malaysia
(Nig)	=	Nigeria
(Phil)	=	Philippines
(Sp)	=	Spain
(WA)	=	West Africa
(WI)	=	West Indies

Botanical Name	Synonyms	Common Names
SOLANACEOUS FRUITS		
Lycopersicon lycopersicum (L.) Karst.	*Lycopersicon esculentum* Mill., *Solanum lycopersicum* L.	Tomato;Gitomate(WI); Tomate(Fr);Tomate (Sp).
	C. annuum var. *cerasiforme* (Miller) Irish. *C. annuum* var. *grossum* (L.) Sendt.	Sweet pepper, Bell pepper, Capsicum, Cayenne pepper, Pimente (Fr); Pimiento (Sp).
Capsicum frutescens L.	*C. minimum* Roxb., *C. baccatum* L.	Tabasco,Bird Chilli Hot pepper,Birdseye pepper,Red pepper.
Solanum melongena L.	*S. esculentum* Dunal.	Eggplant, Garden egg, Brinjal,Aubergine,Melongene; Bringelle (Fr); Berenjera (Sp).
CUCURBITS		
Citrullus lanatus (Thunb.) Mansf.	*C. vulgaris* Schrad., *Colocynthis C.* (L.) D. Ktze.	Watermelon;Sandia, Patilla (WI); Pakwan (Phil); Pasteque (Fr); Scandia,Melon de agua (Sp).
Cucumis melo L.		Melon, Sweet melon, Cantaloupe, Musk melon;Melon (Fr); Melon (Sp.)

Previous Page Blank

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Cucumis sativus L.		Cucumber, Gherkin; Concombre, Cornichon (Fr); Cohombro, Pepino (Sp).
Cucurbita maxima Duch. ex Lam.		Pumpkin, Winter squash, Crookneck squash, Chinese pumpkin, Squash Gourd; Potiron (Fr); Calabasa (Sp).
Cucurbita moschata (Duch. ex Lam.) Duch. ex Poir		Pumpkin, Winter squash, Cushaw
Cucurbita mixta Pang.		Pumpkin, Winter squash
Benincasa hispida (Thunb.) Cogn.	*B. cerifera* Savi.	White or wax gourd, Hairy wax gourd, Tallow gourd, Ash pumpkin; Kandol (Phil); Kundur (Mal); Calebassier, Courge cireuse (Fr); Calabaza China (Sp).
Lagenaria siceraria (Molina) Standl.	*L. vulgaris* Ser., *L. leucantha* (Duch.) Rusby.	Bottle gourd, White-flowered gourd, Calabash gourd; Spaghetti squash, Cucuzzi, Zucca melon (Phil); Calebassier, Courge bouteille (Fr); Cojombro, Guiro amargo (Sp).
Luffa acutangula (L.) Roxb.		Angled loofah, Silky gourd, Angled gourd, Ridged gourd, Vegetable gourd; Chinese okra, Patolang Tagalog (Phil); Sponge gourd, Courge torchan (Fr).
Luffa aegyptiaca Mill.	*L. cylindrica* (L.) Roem.	Smooth loofah, Sponge gourd, Dishcloth gourd, Vegetable sponge; Patola (Phil).
Momordica charantia L.	*M. muricata* Willd.	Bitter gourd, Bitter cucumber, Bitter melon Balsam pear, Margose (Fr); Cundiamor (Sp).

Botanical Name	Synonyms	Common Names
Sechium edule (Jacq.) Swartz		Choyote,Chayote (Sp); Christophine, Cho-Cho,Sou-Sou,Chucko, Choyote(Fr);Apupu, Guisquil,Tayote, Murliton (WI).
ALLIUMS		
Allium chinense G. Don	*A. bakeri* Regel	Rakkyo, Ch'iao T'ou
Allium schoenoprasum L.		Chives;Ciboulette, Civette (Fr);Cebollino (Sp).
Allium tuberosum Rott.	*A. odoratum* L.	Chinese chive,Chinese leek; Nira(Phil).
Allium ledebourianum Schult.		Atasuki
Allium macrostemon Bunge.		Chinese garlic
Allium cepa var. *cepa* L.		Dry or bulb onion, Common onion;Oignon (Fr); Cebolla (Sp); Sibuyas (Phil).
Allium ascalonicum L.		Shallot; Yabbas (WA); Echalotte (Fr); Chalote (sp).
Allium fistulosum L		Welsh Onion,Japanese bunching onion,Green bunching onion,Two-bladed onion;Cibol, Ciboule (Fr);Ceboletta (Sp).
Allium sativum L.		Garlic;Bawang(Phil); Ail (Fr); Ajo (Sp).
Allium porrum L.		Leek; Poireau (Fr); Kutsai (Phil);Puerro (Sp).
LEGUMINOUS VEGETABLES		
Phaseolus vulgaris L.		Common bean,French bean,Kidney bean, Bush bean,Haricot bean, Navy bean, Pole bean; Haricot commun (Fr); Judia, Frijol comun (Sp); Habichuela (WI).

Botanical Name	Synonyms	Common Name
Phaseolus lunatus L.	*P. limensis* MacF.,	Lima bean, Sieva bean, Butter bean, Madagascar bean, Haricot de Lima, Pois du Cap(Fr); Judia de Lima, Judia de Sieva(Sp); Haba Lima (WI); Patani (Phil).
Dolichos lablab L.	*Lablab niger* Medik. *L. vulgaris* Savi. *Dolichos purpureus* L.	Hyacinth bean, Bonavist bean, Lablab bean, Seim bean, Waby bean, Lubia bean, Egyptian bean; Batao (Phil); Dolique d'Egypte (Fr); Lablab (Sp); Chicaro (WI).
Vigna radiata L. Wilczek.		Mung bean.
Vigna unguiculata (L.) Walp.	*V. sinensis* L. Savi *V. cylindrica* (L.) Skeels *Dolichos unguiculata* L.	Yardlong bean, Long bean, Snake bean, China pea; Pois de Brésil (Fr); Frijol de Ojo Negro (Sp).
Psophocarpus tetragonolobus DC.	*Tetragonolobus purpureus* Moench.	Winged bean, Goa bean, Winged pea, Asparagus pea, Manila bean; Pois Carré (Fr); Sesquidillas (Sp).
Parkia biglobosa Benth.	*P. africana* R.Br.	African locust, Locust bean.
Canavalia gladiata (Jacq.) DC	*C. ensiformis* (L.) DC.	Sword bean.
Pachyrrhizus erosus (L.) Urban.	*P. angulatus* Rich. ex DC. *P. bulbosus* (L.) Kurz. *Dolichos erosus* L.	Yam bean; Sinkamas (Phil); Jicama de Agua (Sp); Dolbulbeux (Fr).
Glycine max(L.)Merr.	*G. soja* (L.) Sieb. & Zucc. *G. hispida* (Moench.) Maxim. *Soja max* (L.) Piper	Soya bean, Soybean; Habichuela soya (Sp).

Botanical Name	Synonyms	Common Name
Cajanus cajan (L.) Mill.	*C. indicus* Spreng.	Pigeon pea, Congo bean, Congo pea, Angola pea, Red gram; Ambrevade, Pois d'Angole, Pois pigeon (Fr); Guandu, Gandul, Guisante de Paloma (Sp).
Arachis hypogaea L.		Groundnut, Peanut, Monkey nut; Arachide (Fr); Alaahuete, Mani (Sp).
Voandzeia subterranea (L.) Thou.		Bambara groundnut, Earth nut, Madagascar groundnut; Vouandzou (Fr).
BRASSICAS		
Brassica campestris (L.) subsp. *chinesis* (L.) Makino	*B. napus* L. var. *chinensis* O.K. Schult, *B. pekinensis* (Lour.) Rupr., *B. petsai* Bailey, *B. campestris* L.	Chinese cabbage, White cabbage, Shantung cabbage, Paak ts'oi; Pe-tsai (Mal); Pechay (Phil); Chou de Chine (Fr); Col China (Sp).
Brassica juncea (L.) Czern. & Coss.	*B. juncea* var. *rugosa* (Roxb.) Tsen & Lee *Synapis juncea* L.	Indian mustard, leaf mustard, Leaf mustard cabbage, Chinese mustard; Kai Choy (Mal); Moutarde de Chine (Fr); Mostazza de la tierra (Sp).
Brassica oleracea var *acephala* (DC.) Alef.	*B. oleracea f. sabellica* L. *B. alboglabrata*, *B. oleracea f. viridis* DC., *B. oleracea* var. *viridis* L.	Borecole, Collard, Kale, Green Cabbage, Curly greens; Chou frisé (Fr); Col rizada (WI); Berza (Sp).
Brassica oleracea L. var. *botrytis* L.		Cauliflower; Choufleur (Fr); Coliflor (Sp).
Brassica oleracea L. var. *capitata* L.		Cabbage; Chou pommé, Cabus (Fr); Repollo de Col. (Sp).
Brassica oleracea L. var. *italica* Plenck.	*B. oleracea* L. var. *botrytis* L. subvar. *cymosa*	Sprouting broccoli

Botanical Name	Synonyms	Common Names
LEAF VEGETABLES		
Amaranthus cruentus (L.) Sauer *A. dubius* Mart. ex Thell.	*A. hybridus* subsp. *cruentus*	African spinach, Spinach, Amaranth, Bush greens, Chinese Spinach, Green leaf, Spinach Greens, Amarante (Fr); Bledo (Sp).
Basella alba L.	*B. rubra* L., *B. rubra* var. *alba*, *B. cordifolia* Lam.	Ceylon spinach, Malabar nightshade, Indian spinach, Gambian spinach(WA); Alugbati, Grana (Phil); Remayong (Mal); Bretãna, Libato, Acelca trepadora (WI); Brede de Malabar (Fr); Espinaca de Malabar (Sp).
Beta vulgaris L.		Swiss Chard, Leaf Beet.
Celosia argentea L.	*C. cristata* L.	Cock's comb, Sokoyokoto, green or white soko (Nig); Crete de coq (Fr); Mirabel (Sp).
Colocasia esculenta (L.) Schott.	*C. antiquorum* var. *esculenta* Schott. *C. antiquorum* Schott.	Cocoyam, Taro, Eddoes, Dasheen; Dalc, Keladi (Mal); Gabi (Phil).
Corchorus olitorius L.		Jew's mallow, Jute mallow, Long-fruited jute; Bush Okra, West African sorrel, Krin-krin (WA); Corette potagère (Fr); Yute (Sp).
Hibiscus sabdariffa L. var. *sabdariffa*		Roselle, Red Sorrel, Sour-sour (WA); Indian sorrel; Jamaican sorrel; Oseille de Guinée (Fr); Sereni (Sp).

Botanical Name	Synonyms	Common Names
Ipomoea acquatica Forsk. var. *acquatica* *Ipomoea aquatica* var. *repens*	*I. reptans* Poir. *I. repens* Roth.	Kangkong, Water cabbage, Swamp cabbage, Water convolvulus, Water spinach; Patate acquatique, Liseron d'eau (Fr).
Ipomoea batatas(L.)Lam.		Sweet potato; Camote (Phil); Kumara (Pac.Is.); Batatas (Sp); Patate douce (Fr).
Lactuca sativa L.		Lettuce, Let sugas (Phil); Lechuga (Sp); Laitue (Fr).
Manihot esculenta Crantz.	*M. utilissima* Pohl. *M. dulcis* Pax. *M. palmata* Muell. Arg.	Cassava, Tapioca, Mandioc, Manioc; Yuca, Guacomote (Sp).
Solanum macrocarpon L. *Talinum triangulare* (Jacq.) Willd.	*T. racemosum* Rohrb.	Water leaf, Surinam purselane.
Xanthosoma brasiliense (Desf). Engler		Calalou, Yautia, Belembe.
Xanthosoma sagittifolium (L.) Schott.	*X. vidaceum* Schott.	Tanier, Elephant's ear; Chou caraibe (Fr); Malanga (WI).
Cnidoscolus chayamansa McVaugh.	*Jatropha aconififolium* Mill.	Chaya, Tree spinach
Gnetum gnemon L.		Bulso
Moringa oleifera Lam.	*M. pterygosperma* Gaertn.	Drumstick tree, Horseradish tree
Sauropus androgynus Merr.	*S. albicans* Blume	
Vernonia amygdalina Delile		Bitter leaf.
Telfairia occidentalis Hook.f.		Oyster nut. Fluted pumpkin

Botanical Name	Synonyms	Common Names
OTHER WARM WEATHER AND TEMPERATE VEGETABLES		
Hibiscus esculentus L.	*Abelmoschus esculentus* (L.) Moench.	Okra, Okro, Lady's finger; Gombo, Bele; Bhindi(India); Gombo (Fr); Quingombo (Sp).
Zea mays L.		Sweet corn, Maize, Melies, Corn; Mais (Fr); Maiz (Sp).
Daucus carota L.	*D. carota* L. subsp. *sativus* (Hoffm.) Thell.	Carrot; Carotte (Fr); Zanahoria (Sp).
Raphanus sativus L.	*R. sativus* L. var. *hortensis* Backer.	Radish, Rabano (Sp).

ANNEX IV

CENTRES OF DIVERSITY OF THE MAJOR VEGETABLE SPECIES

Centres of diversity of the major vegetable species

a. Primary centres of origin and domestication
b. Secondary centres

1. Chinese-Japanese	a.	eggplant, wax gourd, Welsh onion, soya, Chinese cabbage, kangkong
	b.	watermelon, amaranth
2. Indochinese-Indonesian	a.	wax gourd, loofah, bitter gourd, sword bean, wing bean, mung bean, *Corchorus*, taro, cucumber, bottle gourd, chayote, yam
	b	cucumber, bottle gourd, chayote, shallot, yam bean, yardlong bean, Chinese cabbage, amaranth, kangkong
3. Hindustani	a.	eggplant, wax gourd, cucumber, loofah, bitter gourd, pigeon pea, hyacinth bean, mung bean, kangkong, okra, drumstick tree
	b.	watermelon, melon, bottle gourd, amaranth, roselle
4. Central Asian	a.	onion, garlic, mustard, spinach, carrot
	b.	eggplant, watermelon, melon, cauliflower
5. Near Eastern	a.	onion, garlic, leek, mustard, beet
	b.	okra
6. Mediterranean	a.	white cabbage, cauliflower, broccoli, beet, radish
	b.	sweet pepper, garlic, okra
7. African	a.	eggplant, watermelon, melon, bottle gourd, locust bean, cowpea Bambara groundnut, okra, roselle
	b.	onion, shallot, Lima bean, mustard, amaranth, Corchorus
8. European-Siberian	a.	lettuce,
	b.	onion, common bean, white cabbage, cauliflower, spinach, carrot
9. South American	a.	tomato, hot pepper, pumpkins & squashes, chayote, Lima bean, groundnut, cassava, *Xanthosoma*
	b.	common bean
10. Meso American/Mexican	a.	tomato, hot pepper, pumpkins & squashes, yam bean, common bean, amaranth, sweet potato, sweet corn
	b.	----------
11. North American	a.	----------
	b.	tomato, eggplant, peppers, melon, watermelon, pumpkins & squashes, onion, lettuce, common bean, Lima bean, okra, sweet corn

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