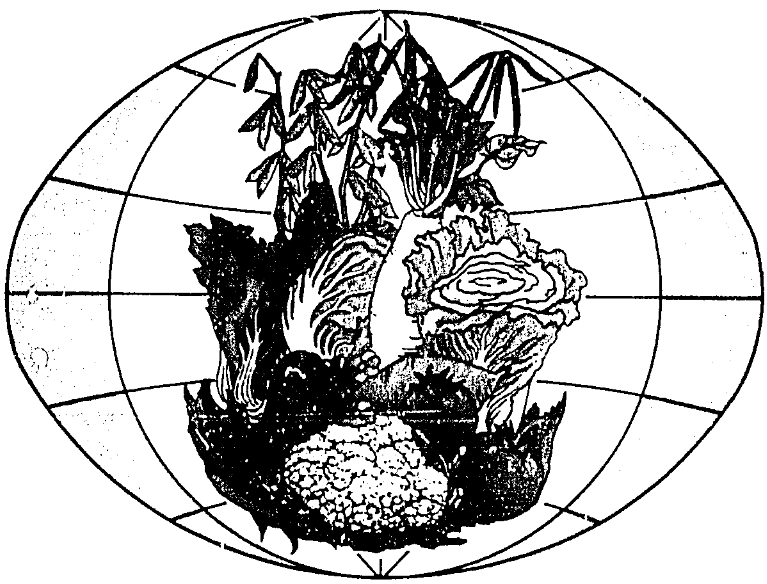
Vegetable Research and Development in South Asia

Proceedings of a Workshop held at
Islamabad, Pakistan, 24-29 September 1990

Editor: S. Shanmugasundaram



Asian Development Bank
Asian Vegetable Research and Development Center
Pakistan Agricultural Research Council

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Cosponsored by

Asian Development Bank
Asian Vegetable Research and Development Center
Pakistan Agricultural Research Council

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Foreword

This consultation workshop brought together senior policymakers and research managers from six South Asian countries (Bhutan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka) to review the status of vegetable production and research and to discuss the most effective means of sharing human, technical and financial resources to enhance the role of vegetables in the region.

As an outcome the participants agreed to organize the South Asian Vegetable Research Network (SAVERNET), with a mandate to serve as a regional framework for collaborative vegetable research and related activities to solve the pressing problems of vegetable production and utilization. The detailed proposal for SAVERNET is available as a separate document from AVRDC.

This publication contains important information on vegetable production, problems, research accomplishments, research needs and future directions for South Asian countries. Together with the special topic papers, this publication will serve as a valuable reference document for those who are interested in vegetable research in South Asia.

We acknowledge with profuse thanks the efforts of Dr. C.M. Anwar Khan, Chairman of the Pakistan Agricultural Research Council and his staff at PARC for the warm welcome and excellent arrangements for the workshop.

We recognize as well the encouragement and prodding of the Asian Development Bank without whose moral and financial support the consultation would not have been possible.

Emil Q. Javier
Director General
AVRDC

Acknowledgments

Many people are responsible for making this international initiative a success. AVRDC, PARC and the participants are especially grateful to the Asian Development Bank for providing financial assistance, and to Drs. Alhaj M.Z. Azam, S.C. Jha, Nihal Amerasinghe, Mr. K.L. Lim and Mrs. Carmen Dimayuga for their assistance.

We express our sincere thanks to the Federal Minister for Food, Agriculture and Cooperatives, Hon. Pir Syed Aftab Hussain Shah Jilani, for presenting the keynote address and officially opening the workshop.

The Secretary of ARD and Chairman of PARC readily agreed to host the conference in Islamabad, for which we express our sincere thanks. We express our thanks to Drs. M.H. Qasi, Member Crops, PARC, and Zahur Alam, Director of Horticulture, PARC, and Mr. T.H. Sial, PARC for their continued support.

Special thanks go to Messrs. N.A. Bhutta and B.A. Khan for meticulously taking care of all aspects of the local arrangements. Thanks are also expressed to the local staff: Messrs. A.M. Wadhwani, M. Shuaib, M. Rafig, M. Javed, M. Riza, and Alim Bangesh.

We convey our thanks to IRRI and IBPGR for their participation and contribution to the workshop.

We express our sincere appreciation to all the participants who served as chairpersons, facilitators or as rapporteurs.

Thanks are extended to Ms. Macy S. Lo, Ms. Teresa S.C. Liang, Ms. Tammy Kang for typing the manuscripts; Ms. Betty S. H. Wu for typesetting and Mr. M.H. Yang for artwork.

Welcome Address

C.M. Anwar Khan
Secretary, Agricultural Research Division and
Chairman, Pakistan Agricultural Research Council
Islamabad, Pakistan

I am indeed honoured and privileged to welcome you to the South Asia Vegetable Research Planning and Consultation Workshop. We are grateful to the Asian Development Bank (ADB) and the Asian Vegetable Research and Development Center (AVRDC) for choosing Pakistan as the venue for this important workshop. The decision to hold this workshop in this country is timely as the Government of Pakistan attaches great importance to the development of horticulture, including vegetable production, in the National Agriculture Development Plan. The holding of this workshop is a positive and welcome step to enhance vegetable production in the region, not forgetting their economic role in the farming systems for the small-scale farmers. The presence of so many international experts, vegetable scientists, administrators and policymakers is indicative of the keen interest being taken in the subject by the participating countries of the region.

I am personally grateful to all the delegates and experts who have traveled long distances to participate in this workshop, and hope you will have a very pleasant stay in Islamabad as well as a fruitful exchange of ideas. In the next five days we shall be looking forward to your deliberations in this important area of agriculture. I hope that the deliberations and interaction among the scientists and policymakers will stimulate new ideas in resolving various problems and issues, particularly in achieving greater scientific and technological advancement in the vegetable sector.

As you know, vegetables form a group of specialized crops and are important economically and from a health point of view. They fit well in most farming systems as their maturity period from planting to harvest is short. With the ever-increasing human population, vegetables have played an important role in our national economy, and in the economies of other countries in the region. Vegetables provide maximum output and hence more income per unit area of land to small-scale farmers, particularly when compared to cereals. In Pakistan, in fact, the development efforts in the agriculture sector in the past have primarily focused on production and development of cereal crops such as wheat and rice and cash crops such as cotton. The efforts have paid off in terms of self-sufficiency and production of exportable surpluses. In this process vegetable crops have not had a matching success in the comparable period because of the less concerted efforts devoted to research and development of these crops. Besides a country's own escalating demand for vegetables, tremendous export opportunities exist for these commodities both in fresh and processed form.

The Pakistan Agricultural Research Council is conducting research on several commodities through the National Coordinated Projects. Research on vegetable crops is being carried out in all the provincial research institutes. The Pakistan Agricultural Research Council coordinates provincial research through its National Coordinated Programme. In addition, several individual projects dealing with different aspects have also been awarded to individual researchers in different institutions. Considerable new information has been generated through these research programs.

Vegetable yields per unit area in Pakistan have remained static for many years. This situation demands concerted effort which has to be supported by: (1) appropriate policy measures; (2) development of improved varieties suited to agroenvironments of the country; (3) improved production technology within a farming systems perspective; (4) ensured availability of quality seed; (5) attractive farm-level prices; (6) effective postharvest handling system including storage and transport facilities; and (7) training of adequate R and D personnel as well as farmers.

AVRDC, with its tremendous dedication, has made significant strides in developing suitable cultivars for tropical environments, notably heat-tolerant cultivars of tomato and Chinese cabbage. The present mandate of the Center is to focus on tomato, Chinese cabbage, mungbean, peppers (hot and sweet), soybean and sweet potato. It is hoped that the Center will expand its mandate and include other economically important vegetable crops of the region like onion, garlic, cucurbits, cauliflower and okra.

AVRDC has also made significant contributions in training scientists from various countries in vegetable research and production, and in providing germplasm. It is also heartening to know that ADB and AVRDC have recently jointly taken another step forward to promote regional research on common problems of the member countries on individual crops through their Asian Vegetable Network (AVNET) program. I must admit that Pakistan so far has not been able to benefit from advances made at this Center. I sincerely hope that during this workshop a workable mechanism can be developed for close collaboration between AVRDC and PARC.

In conclusion, I would like to express my deep personal gratitude to the Federal Minister for Food, Agriculture and Cooperatives, Syed Aftab Hussain Shah Jilani for being with us this morning to grace the occasion.

I would also like to compliment my colleagues from PARC and Dr. Shanmugasundaram from AVRDC who have put much effort and hard work into making all the arrangements for this workshop.

Thank you.

Remarks

Emil Q. Javier
Director General
Asian Vegetable Research and Development Center
Shanhua, Tainan 74199, Taiwan

Allow me first to respond to Dr. Anwar Khan's words of welcome, and on behalf of all of us here, express to him personally, to the staff of PARC, and to the Government of Pakistan how pleased we are to have the privilege of visiting their beautiful country. We are most grateful to Dr. Khan and to PARC for generously agreeing to host this workshop, and we wish to convey to him and the staff our most sincere appreciation for all the courtesies, arrangements and warm welcome they have so far graciously bestowed upon us.

Support of the Asian Development Bank

I want also to pay a special tribute to our colleagues in the Asian Development Bank, represented here today by Dr. Satish Jha and Mr. K.L. Lim, for the encouragement and material support for the organization of this workshop.

The ADB is a founding member of AVRDC and has through the years generously supported our vegetable outreach program in Southeast Asia and Mainland China. The Bank, even more than in the recent past, is stimulating the development of horticultural production in the region and its financial support for this workshop is a manifestation of that policy. But, of course, a Bank like any other institution is managed by individuals who articulate and implement policy. And I am pleased to acknowledge the very strong support from Director Azam of the Agriculture Department; from Dr. Satish Jha here; from Nihal Amerasinghe, the Division Manager responsible for AVRDC activities; and to K.L. Lim. Dr. Jha initiated this idea of a consultation and his presence underscores the value that the Bank attaches to this event.

Rationale for Vegetables

The virtue and need for vegetables from the human nutrition point of view is well known and I will not elaborate on the obvious. However, I will stress the potential of vegetables to generate farm family incomes, expand employment through intensive cultivation, and produce greater value-added products through processing, and the prospects of vegetable exports for some developing countries that are close to certain foreign markets.

It is no wonder therefore that development planners in the whole of Asia are increasingly looking into the development of horticultural production, including vegetables, fruits and flowers, to improve incomes of rural producers, generate employment and earn valuable foreign exchange. The strategy that is being adopted and espoused is one of diversification of agriculture into higher value-added commodities like vegetables.

In each of the developing countries there are excellent examples of individual farmers and farming communities who are successfully engaged in vegetable production, distribution and processing. Because of the higher incomes obtained from vegetables, vegetable farmers tend to be more prosperous than those who grow cereals and other staples.

The idea is to spread the success of this small group of farmers to a larger body so that producers and consumers alike can benefit from higher incomes, an abundance and wide variety of vegetable supplies, better quality produce and affordable food prices. But to do this, a lot of things need to be in place: The farmers need good quality seeds of improved varieties. They need more efficient and more ecologically sustainable production technology. Institutions for efficient handling, marketing and distribution of this highly perishable produce need to be strengthened. They need credit, fair prices, good transport and communications and effective extension. Part of our task this week is to understand the conditions that make vegetable production efficient and sustainable; to anticipate the policies that need to be enacted to encourage producers; and to anticipate, plan and organize for the scientific and technology generation and dissemination effort required to support development of the vegetable industries of the countries of the region.

National Efforts and International Collaboration

The countries of South Asia are taking steps to improve productivity of their respective vegetable industries. Given time and resources, these efforts will certainly bear fruit.

However, we are here precisely with the realization that each of us can in the end achieve more if we cooperate, share information and technology and training opportunities among ourselves and with like-minded international/regional institutions as well as with other countries in the world with similar problems and needs, than if each country goes completely on its own. Even the larger, more economically powerful industrialized countries find it in their own interest to reach agreements with other countries on activities of mutual benefit. The call is for interdependence rather than isolation and autarky.

By reasons of geography, similarities in cultural, social and ethnic backgrounds and similarities in ecology, many problems in agricultural development cut across the countries in a region. This commonality of problems, interests and opportunities provides the basis for collaboration and mutually reinforcing approaches which call for the pooling of efforts, specialization, the sharing of responsibilities and resources for mutual and equitable gain.

The need is great but the capacity to respond is invariably limited. In the next few days we hope to hear from each other how we -- the NARS, the IARCs, the donor community -- can get together to advance vegetable production in the countries of South Asia to help improve nutrition, generate more income and employment and help stabilize our environments.

During the time allotted, we hope the countries in the region can achieve a broad consensus on the priority commodities and problems; on who, where, when and how these researchable problems can be addressed and our preferred modalities of cooperation and mutual help. Many of these issues will require more time and greater analysis than would be possible during this workshop. We hope, too, that at the end of the workshop we can establish the appropriate forum or mechanism for continuing dialogue among the member countries in the region and interested parties elsewhere.

Willingness of AVRDC

We at AVRDC are very pleased and feel greatly honored and privileged to be associated with this regional initiative. We are ready and willing to serve as an instrument by the member countries in pursuing whatever objectives you may agree upon as far as they relate to our mandate on vegetable improvement.

Our experience in Southeast Asia makes us believe very strongly that there is a tremendous scope for cooperation on vegetable industry development among the countries of South Asia. Each of the countries have their own strengths and weaknesses, their respective needs and priorities which with imagination, goodwill, political determination and enlightened self interest can be welded together into an effective regional endeavor. The fact that we are all here today with the heads of delegations represented by senior government officials, and the presence of the Honorable Federal Minister of Agriculture of Pakistan, affirm that the above conditions exist and these indeed augur well for the future.

Finally, I wish you a rewarding and stimulating experience, a pleasant stay in Islamabad, and a most fruitful workshop.

Opening Address

S. C. Jha
Deputy Director, Agriculture Department
Asian Development Bank
Manila, Philippines

I am very honored today to have this opportunity of addressing such a distinguished audience of top policymakers and scientists in the field of vegetable research. On behalf of the Asian Development Bank (ADB), I would like to thank each and every one of you here today for taking time off your busy schedules to contribute, in the next four days, to the deliberations on a coordinated approach to vegetable research in South Asia. ADB is happy to be able to sponsor this important workshop which has been made possible through the initiative and hard work of the staff of the Asian Vegetable Research and Development Center (AVRDC).

ADB has, from the early days of its establishment, been a strong supporter of agriculture research activities in the Asian and Pacific regions, and AVRDC was the first international agricultural research center (IARC) to benefit from this policy through the Bank's technical assistance program. Since then, AVRDC and the Bank have established a long and mutually beneficial relationship, with the Bank providing technical assistance to its vegetable research and training programs. In turn, AVRDC has been generating research technologies in the form of improved varieties of heat-tolerant Chinese cabbage and lowland potato, photoperiod- and temperature-insensitive soybean and mungbean varieties, improved agronomic practices and disease control measures. These improved technologies have made significant contributions to vegetable production in some developing member countries (DMCs) of the Bank. Other than research, the Bank also provides support to AVRDC's training program which has trained since 1974 over 1,000 vegetable research and extension workers in the region. I am particularly pleased to note that ADB has contributed significantly to the success achieved by AVRDC.

As policymakers and researchers in vegetable research, we are aware of the importance of vegetables as a supplementary food that is in demand by all, irrespective of level of income. More important, however, is the fact that vegetables are valuable sources of carbohydrates, proteins, fats, vitamins, and minerals, the lack of which in daily diets has been a primary cause of malnutrition and undernutrition. An adequate supply of vegetables can greatly alleviate such nutritional problems especially among the poorer sections of the population.

In South Asia, where over one billion of the world's people live, and where a high proportion of its peoples are still poor, adequate availability of vegetables will play a significant role in reducing the levels of malnutrition and undernutrition. The promotion of vegetable growing among smallholder farmers can be a source of significant supplementary income and thus contributes to poverty alleviation. These objectives, simple as they may sound, are really difficult to achieve. The promotion of vegetable growing among smallholders will require an efficient extension service and the backing of a strong research effort to provide the technological inputs which have been proven to be the important requirements for any significant production breakthrough. The work of AVRDC gives us confidence that further progress is possible. Recent examples of impressive achievement may be drawn from the work of AVRDC in cooperation with the respective national agricultural research systems (NARS) in Thailand and the People's Republic of China (PRC). In Thailand, improved varieties of mungbean areas, and the crop-generated income estimated at US$80 million in 1988, makes Thailand the top mungbean exporter in the world. AVRDC-released mungbean varieties are also well accepted in the PRC. In 1989, the total area planted to these varieties in the PRC was estimated at 370,000 ha with a production value of US$118 million. Heat-tolerant varieties of Chinese cabbage are also spreading rapidly in the PRC and countries in Southeast Asia.

AVRDC, with its limited resources, has in the past been concentrating its operations mainly in East and Southeast Asia. A recent independent assessment of the impact of Bank support in vegetable research and development concluded that Bank assistance to AVRDC has been instrumental in forging strong relationships between AVRDC and the NARS, and has catalyzed impressive developments in the vegetable industry in Southeast Asia. The study also concluded that the outreach model is an effective means for the transfer of improved technology from an IARC to NARS, and provided the foundation for technology generation and adoption. Having achieved considerable success in vegetable research and development, and gained experience in outreach program planning and implementation in the East and Southeast Asian regions, AVRDC is planning to give further emphasis to its operations in the South Asian region, which is also a very important operational area of the Bank.

Agricultural research in countries within the South Asian region, as in most other Asian countries, has concentrated mainly on cereals and plantation crops. As a result, support for vegetable research has been weak and capacities to undertake research vary widely from country to country within the region. Even in countries where research capacities are relatively strong, the critical mass of scientists and financial commitments needed to develop new technologies may not be present. The development of regional research networks is, therefore, given special focus. Pooling of resources of countries with sufficient homogeneity in objectives and production environment and constraints, often with external financial support, overcomes country-specific weaknesses. One such model which I can think of readily is the ongoing Collaborative Vegetable Research Program, which includes four DMCs, namely, Indonesia, Malaysia, Philippines and Thailand. This ongoing program is being coordinated by AVRDC and supported by a Bank technical assistance grant.

I understand that this Workshop has been organized for exchanging information on the policy and status of vegetable research and production in your individual countries; for identifying common problems, the strengths and weaknesses of national research programs; and for designing a program of collaboration which would maximize the use of existing resources possibly with the assistance of AVRDC and the Bank.

As I stated earlier, the Bank regards the South Asian region as a very significant and important area in its operations, and will be eagerly looking forward to the recommendations of this workshop on the most appropriate form of regional cooperation in the area of vegetable research and the required follow-up actions to operationalize those recommendations. The Bank, on its part, will be ready to consider your final recommendations and provide whatever assistance which may be appropriate.

Lastly, I would like to congratulate the Director General of AVRDC and his staff for their excellent organization and arrangements for this meeting. I would also like to express my appreciation and thanks to departments and officials in Pakistan for their cooperation and assistance in the conduct of this workshop. I wish all of you a successful workshop.

Keynote Address

Pir Syed Aftab Hussain Shah Jilani
Federal Minister for Food, Agriculture and Cooperatives
Islamabad, Pakistan

It is a great honour for me to be here with you this morning on the occasion of this South Asia Vegetable Research Planning and Consultation Workshop, the first of its kind organized in Pakistan. On behalf of the Government of Pakistan, I extend to you all a most hearty welcome. I offer my special greetings to those of you who have come from far and wide to share with us the benefits of your rich and valuable experience in this subject which is of vital significance. The initiative of the Asian Development Bank, the Asian Vegetable Research and Development Center and the Pakistan Agricultural Research Council in bringing together eminent scientists and policymakers from countries of the region is indeed highly commendable.

As you know, vegetables are universally recognized as having the special advantage of being a cheap and easily available source of carbohydrates, proteins, minerals and vitamins. Pakistan is blessed with a varied agroclimate ranging from tropical, subtropical to temperate conditions, thus making it possible to grow almost all types of vegetables year-round. Therefore, most vegetables are available in the market throughout the year. The present area cultivated for vegetable crops in Pakistan is 192,000 ha with a total annual production of 2.5 million t. The average yield of about 13 t/ha is considered to be low compared with world standards.

Punjab is the leading province in area and production of vegetables, contributing 55% and 65%, respectively. Though other provinces have comparatively low shares both in area and production, their contribution is significant in making the vegetables available in the market during lean periods due to different production seasons.

Distinguished delegates, onion, garlic, hot pepper, coriander and turmeric are the major condiments grown and consumed in this country. The total area under condiments is 134,000 ha. Sind, with a mainly tropical climate, is the leading province in area and production of condiments, except turmeric, which is primarily grown in Punjab. Overall average yields of condiments are quite low in Pakistan.

White potato is cultivated on an area of about 60,000 ha with a production of 5.6 million t. Due to varied climatic conditions it is possible to grow three potato crops in a year. Two crops in the plains, autumn and spring, one after the other and the third summer crop in the mountainous areas. Thus, ample quantities of white potato are available throughout the year at reasonable prices. Punjab produces most of this crop followed by the NWFP and Baluchistan provinces. Very few potatoes are produced in Sind due to the tropical climate.

As I have said earlier, vegetable yield per unit area is significantly low. The reasons are:

(1) Vegetables have remained low priority crops in the governments' agricultural research and development program in the past;
(2) Most of the varieties of vegetables grown commercially were bred outside Pakistan for different environments, generally for temperate climatic conditions. The province of Sind suffered the most as it has a tropical climate;
(3) Though good quality imported seeds of recommended exotic varieties are available in ample quantities, quality seed of indigenous condiments is not available. Seed of variable quality is being planted resulting in low yields;
(4) There are great yield losses due to insect pests and diseases. No integrated pest management program is available for vegetables and plant protection coverage is poor;
(5) Existing postharvest handling and marketing systems do not provide the farmers the incentives to increase productivity; and
(6) Acute shortage of highly qualified and trained people is another handicap. There are about 12 PhDs in horticulture in the country.

Despite all these constraints, considerable advances have been made in vegetable research, and packages of production technology have been generated for most crops.

Pakistan is in a position to produce seed of almost all types of vegetables. Its mountain areas with an arid climate offer unlimited scope for the production of seed. So far no concerted efforts have been made towards alleviating the present problem of vegetable seed production resulting in government's liberal import of vegetable seed. Mountainous areas of the country provide unique opportunities to produce out-of-season vegetables and quality seed.

Yet another vital area I would like to mention is vegetable export. Pakistan, due to its geographical location, is in a happy position to export fresh vegetables to the nearby Gulf States. Over the years we have been exporting fresh vegetables in variable quantities. However, the Government, after realizing the great potential both for domestic and export markets, has now given due importance to vegetable crops in the National Agricultural Developmental Plan. I believe that the efforts of our agricultural scientists, farmers and policymakers will bear fruit and vegetable production will be given a further boost in Pakistan through joint and concerted efforts. The Government will play its role in this regard and will provide help, assistance and incentives to the vegetable growers in the country.

I shall not take more time as I see a very interesting and busy program ahead of you. I hope that you have successful deliberations. Before I conclude, I would like once again to extend my heartiest welcome to all of you and hope that your stay in Pakistan will be most enjoyable and rewarding.

In conclusion, it is my pleasure to declare this workshop open.

The South Asia Vegetable Research and Planning Workshop: Its Organization and Objectives

S. Shanmugasundaram
Director, International Cooperation Program, AVRDC
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In 1988 there were 1066 million people in the six South Asian countries of Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. The population continues to grow at a rapid rate, leading to increased urbanization. All the countries in the region have made significant progress in increasing staple food production, and per capita income, though they are not keeping pace with the level of increases in developed countries. All the above factors lead to increases in demand for vegetables, pulses and vegetable oils, the production of which has stagnated.

Vegetables and pulses have enormous potential to contribute to the amelioration of poverty and malnutrition in South Asian countries. Improving vegetable productivity will put the prices of vegetables within reach of the urban and rural poor. It will also provide generous employment opportunity, and higher income to small farmers and landless workers. Increased productivity will lead to the establishment of a vegetable processing industry, and it will also help to promote export of vegetables to earn valuable foreign exchange.

As an international agricultural research center dedicated to the improvement of vegetable production in the tropics, the Asian Vegetable Research and Development Center (AVRDC) has considerable experience in research, human resource development and exchange, information exchange and institution-building in vegetable improvement particularly with Southeast Asian national partners. The center has resolved to extend the focus of its research and training activities to Africa and South Asia through joint partnerships with the national agricultural research systems (NARS).

The Center is supported by contributions from the Governments of Australia, Federal Republic of Germany, Japan, Republic of China, Republic of Korea, Philippines, Thailand, United States of America and the World Bank. Special project support is provided by the Asian Development Bank, IBPGR, IDRC, GTZ, JICA, Japan Shipbuilding Industry Foundation, Rockefeller Foundation and the Swiss Government.

The Asian Development Bank supported the establishment of bilateral programs in the Republic of Korea, Philippines, Thailand, Malaysia, and Indonesia and a regional training program in Thailand with additional support from the Swiss Government. Currently, ADB is continuing to support the regional training program. The Bank was also instrumental in the organization of a collaborative vegetable research network, called the Asian Vegetable Network for Southeast Asia since 1989.

Since the contiguous countries in a region have similar ecologies, closely allied economic, social and cultural preferences and backgrounds, they have agreed to exchange information, technology and genetic materials, and to training opportunities for mutual benefit.

Vegetable Research: AVRDC/NARS Partnership Achievements

Through joint partnership with cooperating scientists and policymakers in various NARS, AVRDC embarked on the following areas of major concern in vegetables: germplasm buildup, documentation and exchange; germplasm enhancement; human resource development; information exchange and institution strengthening.

AVRDC has accumulated close to 31,000 germplasm accessions in tomato, Chinese cabbage, mungbean, peppers, and soybean, making it one of the largest vegetable genebanks in the world (Table 1). In addition there are about 700 accessions of adzuki bean, amaranth, blackgram, ricebean and others. The Center has distributed about 260,000 seed packets of germplasm and improved breeding lines of the above crops to cooperating scientists in 171 countries and territories. In cooperation with AVRDC the NARS from 67 countries have released 152 improved cultivars of the above crops (Table 2).

Table 1. AVRDC germplasm collection as of August 1990.

Commodity	No. of accessions
Chinese cabbage	856
Mungbean	5,274
Pepper	5,471
Soybean	12,505
Sweet potato	1,438
Tomato	5,831

Table 2. Number of cultivars released by the NARS using AVRDC's improved germplasm.

Commodity	Number of	
	Countries	Lines
Chinese cabbage	7	15
Mungbean	19	42
Soybean	10	17
Sweet potato	3	11
Tomato	28	67

AVRDC's improved mungbeans were grown in about 370,000 ha in China in 1989. China has also produced 2.5 t of AVRDC F_1 Chinese cabbage hybrid seeds for 1990 planting. Nearly 41% of Thailand's mungbeans are planted to AVRDC-derived materials. In Indonesia and Thailand, nearly 360,000 and 75,000 ha, respectively, are planted to improved soybeans which had at least one parent from AVRDC improved lines. Similarly AVRDC's improved grain and vegetable soybeans occupy about 50 and 84% respectively of the production areas of the above crops in Taiwan in 1990.

During the hot, wet summer seasons in 26 countries, where it was extremely difficult to grow tomatoes, 66 new AVRDC tomatoes are now successfully and profitably grown.

AVRDC has trained at its headquarters almost 1000 people from over 50 countries in Asia, the Pacific, Africa, the Middle East, South America, Europe and America. In addition, the regional training program in Thailand has trained people from Bangladesh, Burma, Cambodia, China, Laos, Nepal, Pakistan, Sri Lanka and Vietnam.

As part of its information program, in addition to a regular newsletter (Centerpoint), annual progress report summaries and progress reports, the Center has a variety of technical bulletins, guidesheets, newsletters, monographs, manuals, directories, bibliographies, catalogs of germplasm, training reports, training manuals, proceedings of various symposia and workshops, slide sets, and videotapes. The Center has sponsored and cosponsored with other agencies more than 25 international symposia and workshops. AVRDC's publications are distributed to 421 libraries and numerous individuals in 160 countries and territories.

AVRDC's past contact with South Asia has been primarily through provision of improved germplasm, information sharing and some training. All the South Asian countries have expressed considerable interest in collaborating with AVRDC. This regional consultation, supported by ADB, was planned to determine the national policies on vegetables, national and regional requirements, priorities and preferred modes of collaboration among the countries in the region and between them and AVRDC, and other international institutions as well as donors like ADB.

National Vegetable Programs

Each country was asked to prepare and present two country reports, one on vegetable production and policy and another on vegetable research. In addition, there are four papers on special topics. All the above will provide an overview of the status of the vegetable industry in the countries of the region, the policies, strategies of the governments concerned, and their current and planned support activities particularly in research, training and information exchange.

These papers will set the stage for ensuring working group discussions. After the presentation of all the country reports the following also should be apparent: constraints to vegetable research, production and use; commodities of interest and priorities for each country; strengths and weaknesses in research, personnel and fiscal resources; institutional status; and future directions.

The policy issues are like front wheels and the research issues are like rear wheels of a vehicle. We are like a team of drivers who put the vehicles into gear and steer them in the right direction.

Working Group Mode 1: Policy Level

The participants were divided into two groups to facilitate full discussion. In each working group there were representatives from each of the six countries, donor member, invited resource person and sponsor/organizer.

Each group elected a discussion leader, a rapporteur and a facilitator. The discussion was guided using a special DSE visualization participatory technique. The technique was developed by the German Foundation for International Development. The technique provides opportunities for all individuals to express themselves in a group.

The broad subject matter for discussion was policy support for vegetable industry development. Discussion utilized the basic information from the country reports (on policy) and studied the constraints, opportunities and recommended courses of action at a policy level.

Some of the key questions suggested for discussion were:

(1) What are the principal constraints to vegetable productivity among the countries in South Asia?

(2) What policies/institutions are required of the governments, private sector, and international community to overcome the constraints?

(3) What relevant policy recommendations/actions addressed to different sectors would be needed to attain
(a) Higher vegetable productivity
(b) Increased rural income
(c) Better nutrition and
(d) Higher standard of living

The discussion leader and the rapporteur were responsible for consolidating and summarizing the discussions and preparing the final recommendations/actions. The discussion leader or the person designated by each group presented their working group reports which were discussed before drawing up final conclusions to be adopted for implementation.

Working Group Mode II: Experts Consultation

Similar to Working Group Mode I, in this working group discussion, the participants were divided into two groups. Each group elected a discussion leader, a rapporteur and a facilitator and conducted the discussion using the DSE visualization technique.

The following issues were suggested for discussion:

(1) Regional priorities among commodities;
(2) Research priorities within commodities;
(3) Guidelines in the management of research networks;
(4) Guidelines for the movement of germplasm and of testing nurseries;
(5) Priorities for human resources development;
(6) Training opportunities within countries in the region;
(7) Promotion of information exchange;
(8) Prospective assignment of country roles;
(9) Preferred country contributions;
(10) Preferred modes of collaboration
  (a) among countries, and
  (b) with regional and international institutions;
(11) Expected role and contributions of AVRDC and other international institutions; and
(12) Expectations from ADB.

Regional Collaboration to Realize Mutual Benefit

For regional collaboration to be successful there has to be technology sharing, personnel sharing and information sharing. Through such an arrangement, the region will be able to draw upon the best raw materials and finished products; will have access to draw on the creative talent and share fiscal resources for mutual benefit.

Six countries, the IARCs and donor, have been motivated and have come together to achieve the common goal of regional prosperity through vegetable production research to attain national prosperity, better nutrition and a higher standard of living. Through discussions the national agricultural research systems will interlock and complement each other. Each country will take responsibility to do what it is best at, utilizing the resources effectively. The group in the region can draw on the resources from the broader area to address a common problem and resolve it to the satisfaction of all concerned.

The recommendations from the two working group modes are expected to blend into a joint proposal for a collaborative vegetable research program for South Asia. This is therefore a joint planning exercise. The future of our program and collaboration depends largely on how diligently we formulate our strategies.

Expected Outputs

The workshop is expected to provide:

(1) A clear understanding of the vegetable research policies and current vegetable research capabilities of the NARS in the region;
(2) Identification of constraints to vegetable production, distribution and consumption, to research and human resource development and recommendations to overcome them;
(3) Clarification of priorities for vegetable research in each country in the region and definition of regional priorities;
(4) A set of recommendations agreeing on division of responsibilities, mutual exchange of germplasm, information and expertise among countries for mutual benefit;
(5) Joint development and signing of memoranda of agreement;
(6) Joint drafting of bilateral programs;
(7) Joint planning and development of South Asia Vegetable Research Network (SAVERNET); and
(8) A published record of the workshop.

Summary and Recommendations

Constraints to Vegetable Production

The group discussed and identified the various constraints to vegetable productivity among countries in South Asia and suggested future approaches to resolve them.

It was noted that governments of South Asian countries have accorded a low priority to vegetable crops, and the participating policymakers and vegetable research scientists of member countries feel that this has been the main cause for the existing constraints to vegetable research and production.

The following constraints and possible solutions were identified in the order of priority, for use in future planning and development programs in South Asia.

(1) Availability of inputs

(a) **Seed.** It was observed that nonavailability of quality seed, due to inadequate production, is the most important constraint in vegetable production. Due to limited production/availability, the cost of seed is too high. Effective delivery systems are not operating, which also restricts the availability of seed when it is needed. Because of quality control measures which have not been operated or implemented properly, the quality of available seed is generally substandard. The lack of an organizational setup for vegetable seed in particular is responsible for these problems.

(b) **Fertilizer.** The balanced use of manures and fertilizers, with an integrated approach for the use of farmyard manure, green manure and chemical fertilizers, is lacking, and soil testing facilities for the farmers, for making optimum use of nutrients, are not available to the extent required.

(c) **Credit.** Loans to vegetable growers are inadequate and credit is generally not available to the small-scale farmers. Procedures are complicated and interest rates are high. Repayment systems need to be streamlined to replenish the revolving fund.

(d) **Labor.** Labor availability is becoming increasingly difficult. Alternatives to human labor for these crops are limited.

(e) **Irrigation.** There is a shortage of good quality water for irrigation. Water management devices in these countries are inadequate and the power supply is unreliable. The operation and maintenance systems need to be strengthened.

(2) Extension/Transfer of Technology

Properly trained people particularly in vegetable crops, are not available to run extension services, and linkages between extension and research are weak. In-service training opportunities for the development/extension personnel is limited. Proper demonstrations to transfer technology from the laboratory to the farmers are not being done.

(3) Postharvest Handling

On farm storage facilities and technologies are not available or insufficient, and long term storage including commercial cold storage facilities are inadequate.

There are no vegetable-based processing industries located in the production areas. Low cost technologies for postharvest handling and packaging for domestic and export market have not been adequately developed. Transport facilities specifically suited to vegetables are lacking.

(4) Marketing

Marketing facilities for vegetables are limited and in the hands of intermediaries. There is no price support and market intelligence is lacking, including forecast information on demand. Intermittent situations of gluts and scarcities put both producer and consumer at a disadvantage. There are no consistent policies of the various governments on export of vegetables.

(5) Plant Protection

Injudicious use of pesticides causes a serious health hazard. Information on plant protection measures in vegetable crops is inadequate. Integrated pest management systems have not been developed. Unsafe chemicals banned in developed countries are being used in South Asia. Cheap and effective plant protection equipment is not readily available.

(6) Resource Allocation

There is insufficient funding being allocated for vegetable production and research.

Recommendations

(1) Governments of various countries must promote and encourage vegetable seed production in a larger way by creating adequate infrastructure and facilities. The private sector must be encouraged to take up seed production of improved varieties of vegetables.
(2) There should be greater regional cooperation among the countries of South Asia.
(3) Different countries must promote integrated plant nutrient application.
(4) Delivery systems for fertilizer must be improved and strengthened.
(5) Disbursement procedures need to be simplified and collection systems improved.
(6) Low-cost and more efficient farm implements must be designed as labor-saving devices.

(7) Small-scale irrigation systems and technology for optimum use of irrigation water must be developed, and proper operation and maintenance systems developed.
(8) Extension capabilities on vegetable crops, deploying extension specialists trained particularly in vegetables, must be strengthened.
(9) Strengthening postharvest technology and the infrastructure for handling and storage through low cost alternatives at the farm level and through the encouragement of private sector investment for domestic and export market, must be given higher priority.
(10) Integrated pest management must be promoted for controlling diseases and insect pests.
(11) There should be regulations on the use of plant protection chemicals to ensure the use of only safe pesticides.
(12) Resource allocations for vegetable R and D must be appropriately increased.

Policy Support for Vegetables

The following recommendations emerged after detailed discussion on policy support for vegetables.

(1) Policy Pertaining to Human Resource Development

There is a need to improve the capabilities of personnel by promoting:

(a) Short term training programs;
(b) Long term training programs; and
(c) Specific training program at the national and regional level.

(2) Collaboration

Collaboration is required in the exchange of germplasm, scientists and research information:

(a) At the national level emphasis should be placed on an interdisciplinary approach within the organization as well as collaboration among the government research organizations and private industry; and
(b) At the regional level all the participating countries showed interest in collaborating with AVRDC.

(3) Institution Building Policy

There is a need for:

(a) Establishment of separate research institute(s) on vegetable crops;
(b) Establishment of a separate agency for vegetable seed production and distribution;
(c) Strengthening of extension services with more emphasis on horticultural crops;

(d) Promoting linkages between extension and research services; and
(e) Strengthening of statistical departments to cover major vegetable crops.

(4) Farmer Organizations

Governments should promote development of farmers organizations which in turn help the vegetable growers by providing inputs like quality seed, fertilizers, pesticides, implements, marketing facilities, etc.

(5) Socioeconomic Structure

Emphasis should be given to:

(a) Generating awareness of better nutrition through vegetable consumption; and
(b) Improving the purchasing power of rural and urban poor.

(6) Postharvest Losses

Priority should be given to minimizing postharvest losses by generating inexpensive transport, storage, packaging and grading facilities.

(7) Production Technology

Emphasis should be placed on production technologies to promote the year-round supply of vegetables, and on the use of an integrated pest management approach in production.

(8) Government Policy

High priority should be given to vegetable crops in national planning, to streamlining export-import policy, and relaxing some of the existing regulations, and to strengthening of market intelligence and credit facilities.

Regional Priorities among Commodities

In terms of area of production and economic importance, the crops are listed in order of decreasing importance:

(1) Onion
(2) Tomato
(3) Chilies
(4) Cauliflower
(5) Cabbage
(6) Pea
(7) Okra
(8) Eggplant
(9) Phaseolus beans
(10) Cucurbits (melons and cucumbers)

It was also noted that soybean and mungbean are considered very important but the group decided that they should be discussed in a different forum.

Certain crops with high nutritional value (leafy vegetables and carrots) are also considered important, but on a crop area basis did not receive further discussion.

Crops were also outlined in order of importance of major problems, in decreasing order:

(1) Tomato	(5) Peas and beans
(2) Onion	(6) Okra
(3) Chilies	(7) Cucurbits
(4) Cauliflower/cabbage	

Research Priorities within Commodities

Tomato: Breeding for abiotic stress tolerances (e.g. heat, cold and drought and high moisture), breeding for disease and pest tolerances (e.g. leaf curl virus, mosaic virus, early and late blight, bacterial wilt, root knot nematode, fruit borer).

Improved fruit quality for extended shelf life, and acceptance by processing industry. Technologies to improve postharvest handling and transport.

Onions: Breeding for processing quality, good storage capability, and resistance to purple blotch, *Stemphylium* blight, bulb rot (*Fusarium* and *Erwinia*) and thrips.

Development of appropriate seed technologies including hybrid seed production.

Chilies: Breeding for virus resistance, disease resistance (e.g. bacterial wilt, *Phytophthora* and *Colletotrichum* rots), pest resistance (thrips and mites), improved quality (color and acceptable levels of pungency) and tolerance to drought. Studies on seed production (emphasizing storage and longevity) and methods to economize hybrid seed production.

Cauliflower and Cabbage: Breeding of F_1 hybrids and heat tolerant cultivars, and tolerances to clubroot, black rot, and *Alternaria*.

Integrated Pest Management (IPM) of diamondback moth and studies on micronutrient requirements.

Improved seed production technologies, including control of *Sclerotinia* and *Alternaria*.

Peas and Beans: Breeding for tolerance to powdery mildew, rust, fusarium wilt, viruses and development of varieties suitable for processing.

Okra: Develop varieties tolerant to yellow vein mosaic, fusarium wilt, nematodes and fruit-borer.

Cucurbits: Varietal improvement through breeding for tolerance to powdery mildew, downy mildew, fusarium wilt, anthracnose, *Alternaria* and virus complex and fruitfly, and through development of F_1 hybrids.

(1) Develop IPM practices for fruitfly.
(2) Develop technologies to facilitate off-season cucurbit production.

Cross-commodity Research

Certain research areas do not fall within the commodity classification, and are therefore indicated separately, as follows:

(1) Applications of biotechnology as and where applicable (virus elimination, varietal improvement, micropropagation).
(2) Optimization of nursery techniques for vegetables.
(3) Protected cultures (e.g. plastics, mulches).
(4) Labor-saving implements.
(5) Pesticide hazards and role of IPM in reducing pesticide usage.
(6) Efficient use of available water.
(7) F_1 hybrid seed production techniques.
(8) Weed control practices.
(9) Plant nutrition.

Priorities for Training

(1) Frontier areas in biotechnology.
(2) Breeding for resistance to multiple stresses.
(3) Seed technology including hybrid seeds.
(4) Postharvest technologies.
(5) Integrated pest management.
(6) Off-season including protected vegetable production.
(7) Extension training.
(8) Genetic resources conservation, evaluation and characterization.
(9) Vegetable production through hydroponics.

Training will be oriented towards research, production and specialized topics (short- and long-term) as required, and trained persons will be expected to act as trainers to multiply the training effect. Emphasis will also be placed on degree training to meet current personnel shortages.

South Asia Vegetable Research Network (SAVERNET)

All participating countries of South Asia, in principle, agreed to the establishment of SAVERNET. The details of agreed SAVERNET mandate, objectives, functions, governance, coordination, working groups, activities and responsibilities are described below.

Mandate

To serve as a regional framework for collaborative vegetable research and related activities to solve the pressing problems of vegetable production and utilization in the countries of South Asia: Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka.

Objectives

(1) To foster collaborative research partnership among the NARS, to attain better and more efficient use of expertise, technologies, germplasm and scarce resources available in the region.

(2) To facilitate the generation and adoption of improved technologies for selected vegetable crops, through collaborative research, information exchange and scientific consultation.

(3) To help develop/strengthen the technical proficiency of vegetable researchers with the ultimate goal of building a critical mass of scientists capable of responding to the national and regional needs for efficient and sustained vegetable production.

(4) To strengthen linkages for acquisition and exchange of relevant technologies among the countries in the region and external sources of technology.

(5) To develop an information network which will facilitate the assembly and dissemination of information among vegetable researchers, extension workers, growers, processors and policymakers in the region and elsewhere.

Functions

(1) Coordinate and foster collaboration and complementary research and technical exchanges taking into account the institutional strengths, weaknesses and needs of the member NARS.

(2) Through consultation, identify research needs, assist in setting priorities, and encourage NARS in the region to focus on those problems.

(3) Provide the forum and mechanisms for improving communication and rapid exchange of technology derived from research.

(4) Hold periodic network meetings as one mechanism for developing collaborative plans, evaluating results, and fostering exchange of information.

(5) Identify training needs among the member countries and promote training activities within the member NARS.
(6) Provide financial and technical support to enable the NARS, with lead roles on specific research problems, to effectively discharge their responsibilities on behalf of the network.

Governance

Steering Committee

(1) Composed of senior research administrators/managers responsible for horticultural crops from the member countries and head of the executing agency.
(2) Set policy, priorities and approve strategic plan of network.
(3) Review and approve annual work plans and budgets of network.
(4) Monitor and assess progress of network and report to responsible national authorities.
(5) Meet at least once a year.
(6) Members will elect the Chairman for One-Year Term and Chairmanship will be rotated among the members.
(7) The steering committee may invite the donors to send their representatives to attend the meeting.

Network Coordination

Network coordination will be accomplished through a secretariat provided by the executing agency and will be headed by the Regional Network Coordinator. The members of the Network Countries agreed that AVRDC be the executing agency.

The executing agency should have the following responsibilities:

(1) Provide scientific and administrative support to the network.
(2) Provide network coordinator and other research specialists as needed by the network.
(3) Provide operational support.
(4) Mobilize funding support from the donor community.

The Regional Network Coordinator who is employed by and administratively responsible to the executing agency should have the following functions:

(1) Responsible to Steering Committee for overall coordination, execution, monitoring and assessment of network activities; act as Secretary to the Committee.
(2) Formulate, in consultation with the Working Groups, the network strategic plan, and annual programs and budgets.
(3) Liaise with AVRDC and other agencies on behalf of the network.
(4) Responsible for information programs of the network.

Working Groups

There should be five working groups as follows:

(1) Germplasm and Breeding.
(2) Crop and Resource Management.
(3) Crop Protection.
(4) Postharvest Management.
(5) Socioeconomics (including Marketing).

Each working group should be composed of a key scientist from each member country. The members should meet at least once a year or as needed to develop plans and budgets and implement working group activities.

Potential Activities of the Network

(1) Germplasm collection, conservation, characterization and exchange in close collaboration with IBPGR.
(2) Conduct of regional testing of improved varieties, segregating lines and other relevant materials.
(3) Collaborative research on agreed upon topics with individual countries taking lead roles in areas where they have interest and comparative advantage.
(4) Conduct seminars, conferences, workshops and training courses on topics of common interest.
(5) Organize an information network, including publication of newsletters, bibliographies, bulletins and manuals.

NARS Responsibilities

Subject to relevant national policies and availability of resources, the NARS will:

(1) Facilitate exchange of germplasm.
(2) Facilitate participation of scientists in the network activities.
(3) Help exchange information, technologies and expertise within the member countries of the network.
(4) Execute agreed program and provide venue and support for all agreed activities.

Session I

Status of National Vegetable Programs

Vegetable Production in Sri Lanka

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Introduction

Sri Lanka is an island situated between 6^{0} and 10^{0} north of the equator. Its land area of 6.46 million ha is divided into three major climatic zones: wet zone (1.54 million ha), intermediate zone (0.85 million ha) and dry zone (4.07 million ha), based on rainfall which is bimodal and received during two monsoons - northeast from October to March (maha season) and southwest from April to September (yala season). These climatic zones are further subdivided into 24 agroecological regions based on temperature differentiation due to elevation (sea level to 2500 m) and rainfall (Table 1).

Table 1. Environmental parameters of major agroecological regions.

Agroecological region	Elevation (m)	Mean temperature (^{0}C)	Rainfall (mm)
		Wet zone	
Up country	1000-2000	10-15	2500-5000
Mid country	500-1000	20-15	2000-3000
Low country	0-300	20-25	2000-3000
		Intermediate zone	
Up country	1000-1500	15-22	1500-2250
Mid country	350-500	24-26	1500-2250
Low country	0-300	25-29	2000-2200
		Dry zone	
Low country	0-300	28-30	900-1000

From historical times vegetables have been grown in such climatic diversity. Consequently, plant species adapted to specific climatic and soil conditions have evolved and a wide array of annual and perennial crops are used as vegetables. In Table 2 only some of the more important vegetables are listed and divided into four groups based on the part of the plant that is consumed. In a few plant species, e.g. drumsticks (*Moringa oleifera*), the leaves and fruits are used as vegetables. Most of these vegetables are identified as indigenous vegetables, whereas those that are grown in the hill country and require cool temperatures are classified as exotic. These vegetables are all produced in mixed cropping systems, chena (shifting cultivation) systems, rice-based cropping systems or backyard gardening. Vegetable production is therefore an intrinsically important agricultural activity in the country.

Table 2. Common vegetable crops grown in Sri Lanka.

Botanical name	Local name	Botanical name	Local name
		Leafy Vegetables	
Centella asiatica	gotukola	*Basella alba*	spinach
Amaranthus tricolor	amaranthus	*Alternanthera sessilis*	mukunuwenna
Moringa oleifera	drumstick	*Ipomoea aquatica*	kankung
Sesbania grandiflora	Kathurumurunga	*Brassica oleracea*	cabbage
Cuycas circinalis	madukoku	*Lactuca sativa*	lettuce
		Fruit Vegetables	
Lycopersicon esculentum	tomato	*Solanum melongena*	brinjal (eggplant)
Capsicum annuum	sweet/hot pepper	*Phaseolus vulgaris*	beans
Momordica charantia	bitter gourd	*Trichosanthes anguina*	snake gourd
Luffa acutangula	luffa	*Cucurbita maxima*	pumpkin
Abelmoschus esculentus	okra	*Moringa oleifera*	drumstick
Artocarpus altilis	breadfruit	*Artocarpus heterophyllus*	lamk jak (jackfruit)
Lagenaria siceraria	bottle gourd	*Psophocarpus tetragonolobus*	winged bean
Musa sapientum	ash plantain	*Cucumis sativus*	cucumber
		Roots and Tubers	
Beta vulgaris	beetroot	*Daucus carota*	carrot
Raphanus sativus	radish	*Solanum tuberosum*	potato
Ipomoea batatas	sweet potato	*Manihot utilissima*	manioc
Coleus rotundifolius	innala	*Dioscorea alata*	wellala
Xanthosoma sagittifolium	tannia	*Lasia spinosa*	kohilaala
		Seeds	
Cajanus cajan	toor dhal	*Artocarpus altilis*	jak (breadfruit)
Vigna unguiculata	cowpea	*Phaseolus vulgaris*	beans
Vigna radiata	mungbean	*Glycine max*	soybean

Importance of Vegetables

Dietary Needs

Vegetables are usually consumed with rice, the staple food, twice a day. They are a rich and comparatively cheap source of protein, minerals, vitamins and calories for a large sector of the population who abstain from animal protein. The culinary variations that are produced from these vegetables by the different social, cultural and ethnic groups is ample testimony to their importance in providing a palatable and nutritionally valuable meal to the family.

Nutrition

According to nutritionists, the optimum per capita requirement of vegetables is 157 g comprised of 47 g obtained from leaves and 110 g from fruits, pulses, roots and tubers. However, there is a wide gap between the required (157 g) quantities of vegetables and their availability (87.9 g in 1982, according to the Sri Lanka Department of Census and Statistics). In actual fact, however, these figures may not reflect the true situation of many households, since most maintain a back garden which has an array of leafy vegetables, gourds, root, and tubers which are essential to meet their dietary habits. From the statistics that are available, an estimated 600,000 t of vegetables are produced annually. These include the more common vegetables: brinjal, okra, pumpkin, gourd, luffa, capsicum, radish, cabbage, potato, beet, carrot, leek, tomato, green bean, sweet potato, leafy vegetables and many others. These are produced on about 60,000 ha during the maha season and about 32,000 ha during the yala season.

Leafy vegetables are nutritionally important. They contain protein, minerals and vitamin A, and provide roughage. The composition of the more popular leafy vegetables is given in Table 3.

Table 3. Composition of some popular leafy vegetables.

Crop	Protein (%)	Minerals (%)	IU/100g Vit A	Vit B	Vit C
Sesbania grandiflora	7.0	2.4	1,916	-	181
Centella asiatica	2.9	2.1	355	-	-
Ipomoea aquatica	4.4	1.4	2,476	-	-
Moringa oleifera	8.1	2.2	2,750	-	-
Alternanthera sessilis	4.1	2.4	536	-	-
Lactuca sativa	2.1	1.2	828	-	-
Brassica oleracea	1.8	0.6	2,000	12	35

Source: Central Board of Agriculture 1955.

Fruit vegetables provide variety, and some like breadfruit provide calories and vitamins. Among the gourds, bitter gourd is rich in vitamin C and minerals. Similarly tomatoes are rich in vitamin A (Table 4).

Table 4. Protein, minerals and vitamin contents of some selected fruit vegetables.

Crop	Protein (%)	Minerals (%)	IU/100g Vit A	Vit B	Vit C
Artocarpus altilis	1.9	0.8	35	21	17
Musa sapientum	0.7	1.0	-	-	-
Lagenaria siceraria	0.5	-	-	10	4
Momordica charantia	2.9	1.4	210	24	450
Moringa oleifera	2.2	1.0	184	-	119
Lycopersicon esculentum	1.9	0.7	320	23	31
Cucumis sativus	0.4	0.3	-	6	6
Capsicum annuum	2.0	-	333	18	200

Source: Central Board of Agriculture 1955.

Root and tuber vegetables are nutritionally inferior to others. They contain more starch, less protein than rice and are deficient in vitamin C. However, sweet potato (yellow varieties) and carrots are superior to other root crops as they contain vitamin A (Table 5).

Table 5. Composition of selected root and tuber crops.

Crop	Starch (%)	Protein (%)	Minerals (%)	IU/100g Vit A	Vit B	Vit C
Manihot utilissima	29.6	0.8	0.4	-	17	-
Ipomoea batatas	16.0	1.4	1.2	-	-	-
Solanum tuberosum	22.8	1.7	0.6	-	40	-
Coleus rotundifolius	24.6	1.9	0.8	-	-	-
Daucus carota	10.8	0.9	1.1	2,020	18	-

Source: Central Board of Agriculture 1955.

The pulses are an important source of vegetables and include groundnut, green gram, toor dhal and others. Lentils are also an important source of vegetables and the country's requirements are imported. Toor dhal is now being popularized among farmers and is expected to replace lentils. Other pulses are therefore being used as substitutes because of the escalating prices of lentils.

Exports

During the past decade fresh and processed vegetable exports have been rising rapidly with a near 100% increase recorded in one year (1778 t in 1987, 3286 t in 1988 for a value of US$2.65 million).

The fresh vegetables, comprised of tomato, capsicum, cucumber, cabbage, brinjal, sweet potato, cassava, green chili, leafy vegetables and potatoes, were exported principally (58%) to meet the needs of the large Asian expatriate workers resident in Middle East countries. The second largest export market (30%) is to the Maldive Islands, and small quantities of fresh vegetables are also exported to Singapore and a few European countries.

Vegetable processing is a relatively new industry and is primarily limited to gherkins in brine which are exported to Australia, Netherlands and UK. In 1989 the export earnings from gherkins (US$ 3 million) was equivalent to the value of all other vegetables.

Increase Farmer Incomes

Despite massive investments on rice, it is increasingly evident that rice production is becoming unprofitable, or will entail only marginal increases in incomes. However, the complex farming systems that have been practiced by farmers from ancient times have invariably cushioned these rice farmers from economic disaster. For instance, during the rainy season rice is grown in the lowlands and vegetables in the highlands and backyard gardens, and in the dry season a vegetable crop is established soon after the rice harvest. Farmers are therefore self-sufficient in vegetables and any excesses or exotic contribute towards increasing their income. With exotic crops (potato, capsicum, cabbage, carrot, etc.) farmers have made tremendous gains in income and have improved the quality of life of their families. In recent times, even select indigenous vegetables such as brinjal, tomato and also leafy vegetables which have an export potential and are produced during times of scarcity, have substantially increased farmers' incomes. Farmers are therefore aware of the economic benefits accruing from vegetable production, by judiciously timing the establishment of select crops and the application of new technology to increase yields and produce high-quality vegetables for demanding markets.

Production Constraints

There are several production constraints that impede the full benefits of vegetables as an important supplementary source of food and nutrition, including the development and availability of appropriate production technologies to profitably increase yields, modern and inexpensive methods of packaging, processing, storage and marketing to meet domestic needs, and increased exports in a highly competitive market.

Appropriate Production Technologies

The supply of vegetables in the domestic market has been the criterion that determined priorities for technology development to improve the quality and enhance the yields of select crops. Priority was given to vegetables that were in short supply and obtained premium prices. Consequently, the focus was on exotic vegetables that require cool temperatures and are invariably produced in the upland area where land is a limiting factor and which are dependent on imported seed. The yield increases obtained for select exotic vegetables are given in Table 6.

Table 6. Mean yields of select vegetable crops from 1984 to 1987.

Crop	Mean yield (t/ha)			
	1984	1985	1986	1987
Beet root	3.4	8.0	14.2	14.2
Cabbage	13.2	20.5	16.4	20.0
Carrot	3.2	9.4	8.6	11.6
Knolkhol	3.4	8.4	8.2	10.4
Capsicum	2.9	3.6	3.6	4.1
Beans	3.2	3.6	6.3	5.3

Source: Economics and Projects Division, Department of Agriculture.

Several indigenous vegetables are produced in abundance and are generally available throughout the year. It was therefore not considered expedient to channel the limited trained people and financial resources into developing new technology, except for some select vegetables like brinjal, okra, tomato, sweet potato, etc. However, it is now recognized that due to high population pressures and a rapidly expanding export market for select vegetables a greater commitment has to be made to increase productivity.

High Production Costs

Available statistics reveal that the production costs of vegetables (exotic and indigenous) have been rising and profit margins have been decreasing, because of increasing labor costs (although family labor is also utilized), costs of implements, seeds, fertilizers, agrochemicals and packing materials. Farmers also have to absorb heavy losses due to the high perishability of vegetables and volatile market forces.

These are important production constraints that have to be speedily alleviated if the economic well being of the farmers is to be improved.

Handling, Packing and Storage

Postharvest production losses in handling, packing and storage are estimated to range from 10 to 40%. The methods of handling, packing and storage that are being adopted have been developed by producers, transport agents and dealers using their innovative abilities and skills. Producers of most vegetable crops are located in remote areas where transport and communications are poor. In many instances farmers are unable to dispose of their produce.

Postharvest technology generation has been marginalized due to a lack of financial and technical resources, rather than a lack of appreciation of its significance in production systems. We are now attempting to strengthen the development of low-cost appropriate technology to reduce the postharvest losses of vegetables.

Marketing

Efficient marketing is necessary to sustain increased vegetable production and ensure fair prices to producers and consumers. This is necessary because vegetables are highly perishable, produced in remote areas, and have to be transported over long distances. The existing marketing systems have been sensitized to these factors and is therefore a well organized activity. The producers, transporters and the dealers have established a partnership that includes the granting of credit to farmers. However, both producers and consumers are often exploited by dealers whose only motive is to maximize profits.

The government is sensitive to the problems within the existing marketing systems, and every effort is being made to effect changes that will benefit the producers and consumers.

Research Allocation

Most of the funds (81%) allocated for agricultural research in the Department of Agriculture is committed to meet salary costs, leaving a meager 19% for operational expenses. In 1989, the total allocation for all vegetable research was US$386,457. This is a small sum considering the importance of vegetables in contributing to the nutrition of the people. With the increasing emphasis on agricultural productivity, there is every prospect of directing more national funds into vegetable research.

National Vegetable Policy

Successive governments in recent years have pursued policies to increase agricultural productivity. In 1989, policy shifts in agriculture were made to respond to the challenges of rapid population growth and to ensure economic advancement by the year 2000 and beyond.

Three major thrusts have been identified for the agriculture sector:

(1) Increase agricultural productivity per unit area of land;
(2) Increase farmers' incomes; and
(3) Generate employment.

The major thrust is therefore directed towards increasing not only rice production but also the country's requirements of vegetables and fruits. In doing so, it is also expected to produce surpluses that have an export market and will therefore generate employment and increase incomes.

Implementation

The Department of Agriculture is now on the threshold of implementing the policy initiatives of government. There are nine regional agricultural research centers (Fig. 1) with satellite agricultural stations and adaptive research units situated in distinct agroecological regions of the country. In each of these regional centers a multidisciplinary team of scientists is working on technology generation for priority vegetable crops (Table 7). For each crop, however, thrust areas are identified depending on the biotic and abiotic stresses and other socioeconomic factors that influence productivity. Furthermore, on-station research is supplemented by adaptive and/or on-farm research.

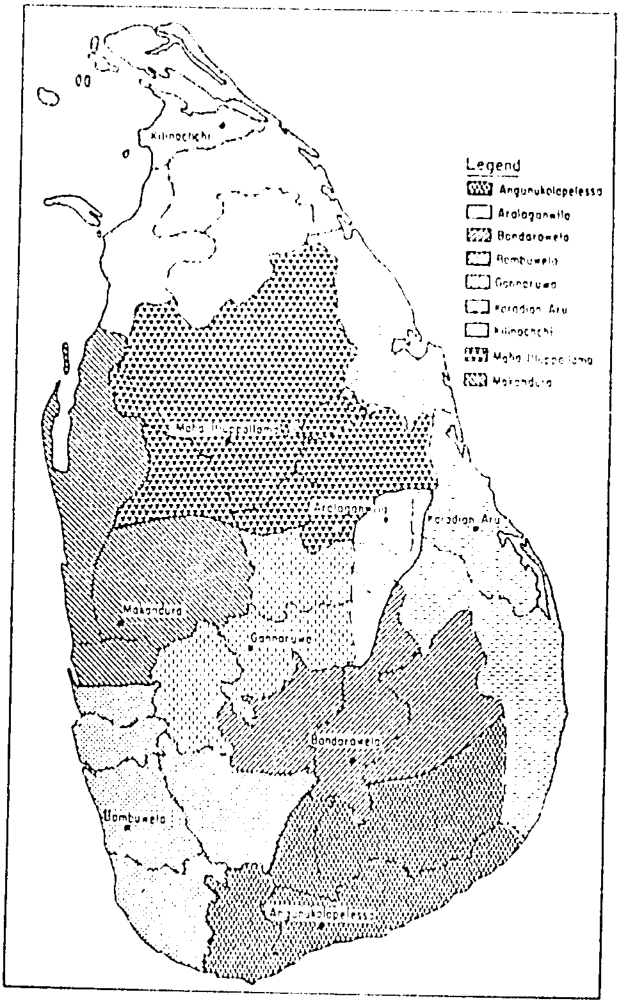

Fig. 1.
Map showing the nine regional research centers and their area of operation.

Table 7. Regional agricultural research centers and vegetable crops research responsibilities.

Institution and location	Vegetable crops/responsibilities
Plant Genetic Resources Center, Peradeniya	germplasm exploration, collection, introduction and conservation
Regional Agricultural Research Centers:	
Angunukolapelessa	Cucumber, pumpkin, luffa, bitter gourd, snake gourd, okra, brinjal, radish, cowpea, mungbean, soybean, groundnut.
Aralaganwila	Winged bean, tomato, capsicum, cucumber, okra, brinjal, cowpea, mungbean, groundnut, soybean, pigeon pea.
Bandarawela	Beans, garlic, tomato, potato, cabbage, carrot, beetroot, leeks, capsicum, cauliflower, lettuce, radish, knolkhol, brinjal
Bombuwela	Sweet potato, luffa, vegetable cowpea, okra, brinjal, leafy vegetables, cocoyams, dioscorea, innala, snake gourd, bitter gourd
Peradeniya	Tomato, vegetable cowpea, winged bean, cabbage, beans, capsicum, cucumber, pumpkin, luffa, bitter gourd, snake gourd, okra, brinjal, leafy vegetables, postharvest technology of selected vegetables
Kilinochchi	Brinjal, chili, cowpea, black gram, cucumber, vegetable cowpea, okra, potato, sweet potato, dioscorea, mungbean
Mahaillupallama	Pigeonpea, cowpea, mungbean, soybean, chili, onion, tomato pumpkin, okra, brinjal, winged bean.
Makandura	Cassava, pigeonpea, capsicum, pumpkin, luffa, bitter gourd, snake gourd, leafy vegetables, potato, sweet potato, cocoyams, dioscorea, innala

Due to resource limitations postharvest technology generation is presently confined to the centralized facilities at CARI, Peradeniya.

The mature technologies that emerge are then transferred to farmers through the coordinated efforts of extension and training divisions, and the impact of such technologies and their socioeconomic implications are regularly monitored by the Economics Division.

Crop Diversification

To increase productivity and effectively utilize the land and water resources, crop diversification in rice lands is being intensified. It is now increasingly evident that farmers are growing vegetables in their well-drained rice fields soon after harvest.

Farmer Organizations

The land holdings of an estimated 1.8 million farm families are small, ranging from 0.1 to 1.5 ha. With the objective of increasing productivity, institutional arrangements have been made to consolidate these fragmented units by encouraging the formation of farmer organizations. Hopefully such organizations will synchronize production which will eventually lead to crop specialization in well defined areas, and, more importantly, increase production efficiency and enhance profits.

Pension Schemes

Hitherto, farmers had no security in their agricultural pursuits. They were associated in a vital enterprise which was subject to the vagaries of the weather and market forces. The government has recently initiated a pension scheme for farmers to provide a livelihood for them and their families in their old age.

Crop Insurance

Many farmers who had invested their meager savings in agriculture, particularly on annual vegetable crops, have lost their entire savings through crop losses due to natural disasters. To provide relief for such farmers, the government has now drawn up a scheme to insure the crops and provide relief when there are crop losses.

Future Directions

Vegetables will become increasingly important in supplementing the food and nutritional needs of the people. At an annual growth rate of 1.7%, the population of Sri Lanka will increase from the present 17 to 20 million by the year 2000, while the arable land area for annual crops will remain at 1.2 million ha (the total arable land area is 2.2 million ha). Unless the productivity of the land is substantially increased there will be a shortfall in vegetables to meet domestic requirements. Furthermore, with the projected annual economic growth of 5% of the GDP, the demand for quality vegetables, which are nutritionally beneficial, will increase and consumers will become more discriminating. As employment opportunities for the family unit increase, there may well be an increased demand for processed vegetables in the coming years. Future strategies in vegetable production must also consider increasing demand for export.

To meet these challenges, it is imperative to identify and prioritize vegetable crops that are nutritionally beneficial to consumers and can be profitably produced, by judiciously exploiting the climatic diversity that exists in Sri Lanka. What is envisaged is crop specialization, to fit into the rhythmic climatic variation in the different agroecological regions, to ensure the availability of these vegetables throughout the year. This has to be supplemented through crop improvement and better management practices that can increase the productive capacity of the limited land and water resources, to meet domestic requirements and the potential increases in exports.

An increasing awareness and sensitivity to environmental pollution and health hazards due to the excessive use of pesticides has stimulated integrated pest management methods in vegetable production which will be vigorously pursued.

Most significantly, increasing productivity will not be rewarding unless technologies are speedily developed for processing of vegetables, and the establishment of industries at the village level to generate employment and increase incomes of the rural people. Every endeavor is therefore being made to initiate research to develop simple agro-based industries that can be established in farming communities.

The role of vegetables in health and nutrition requires further investigation to establish their efficacy, and to encourage increased consumption.

Vegetable Research in Sri Lanka

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The food value of vegetables has long been recognized by the Sri Lankan population and vegetables constitute a large portion of their daily diet. Vegetables are grown year-round in most parts of the country.

Important Vegetables

The major vegetables grown in the country and the annual production are given in Table 1. The other important vegetables on which statistics are not available include: *Luffa aegyptiaca*, melons (*Cucumis melo*), ash plantain (banana variety), big onion (*Allium cepa*), drumstick (*Moringa oleifera*), and the leafy vegetables *Amaranthus*, Ceylon spinach (*Basella alba*), gotukola (*Centella asiatica*), kangkong (*Ipomoea aquatica*), mukunuwenna (*Alternanthera sessilis*) and kathurumurunga (*Sesbania grandiflora*). The area under leafy vegetables is about 400 ha (Perera 1989). Vegetables that are grown mainly for export include gherkins (*Cucumis* spp.) and *Brassica* sp. such as cauliflower, broccoli, brussels sprouts and Chinese cabbage.

Potato (*Solanum tuberosum*) and sweet potato (*Ipomoea batatas*), though widely grown, are grouped under Root and Tuber Crops, mungbean (*Vigna radiata*) and soybean (*Glycine max*) under Grain Legumes and chili (*Capsicum annuum*) under Condiments.

Land Use

The farm size under vegetables is generally small and shows a wide variation in different agroecological zones. In the low country dry zone, the average farm size under vegetables varies from 0.09 to 0.37 ha (Gunawardena and Chandrasiri 1980). The cropping system is mainly a shifting one, with very low crop intensity. The use of inputs such as quality seed, agrochemicals and fertilizer is low, and the crops are rainfed. However, the farming in Jaffna (the northern low country, dry zone region) is intensive and is associated with high inputs and management systems.

In the low-lying areas of the dry zone and certain areas in the low and mid-country intermediate zones, vegetables are grown in rotation with rice. In the dry zone areas with major and minor irrigation systems, a certain degree of vegetable monoculture is practiced and some agrochemicals and fertilizer are used. The average farm size in the irrigated areas varies from 0.5 to 1 ha. Most of the seed requirement is met by farmers themselves and the remainder is supplied by the government seed farms. The annual requirement for local vegetable seed is given in Table 2.

Table 1. Average annual area and the production of some important vegetables in Sri Lanka 1983-87.

Crop	Area (ha)	Production (t)	Yield (t/ha)	Yields under research (t/ha)
Tomato (*Lycopersicon esculentum*)	2802	28074	10.0	20-50
Capsicum (*Capsicum annuum*)	1764	6007	3.4	10-15
Brinjal (*Solanum melongena*)	5464	60718	11.1	20-30
Cucumber (*Cucumis sativus*)	2252	23810	10.6	30-40
Pumpkin (*Cucurbita* spp.)	9038	115672	12.8	30-40
Bitter gourd (*Momordica charantia*)	3371	20776	6.2	12-15
Snake gourd (*Trichosanthes cucumerina*)	3141	26591	8.5	30-40
Beans (*Phaseolus* spp.)	7286	36818	5.0	7-18
Vegetable cowpea (*Vigna* spp.)	2354	11353	4.8	10-20
Okra (*Hibiscus esculentus*)	5576	2246	4.0	10-15
Cabbage (*Brassica oleracea* var. *capitata*)	2891	52673	18.2	40-60
Carrot (*Daucus carota*)	1181	8978	7.6	20-30
Beet (*Beta vulgaris*)	1655	14612	8.8	25-40
Radish (*Raphanus sativus*)	2609	23209	8.9	30-40
Kohlrabi (*Brassica oleracea* var. *gongylodes*)	1681	11526	6.9	20-35
Shallots (*Allium ascalonicum*)	8213	92649	11.0	15-25
Leek (*Allium porrum*)	893	8930	10.0	20-40

Source:Department of Agriculture, Sri Lanka.

tivate very steep hillsides make soil erosion a serious problem. The fertilizer and agrochemicals used in these areas are often over and above the recommended amounts, often resulting in high P and K build-up in the soil. Seeds of the exotic vegetables (temperate types) are imported by the private sector (Table 3) and are expensive.

Table 2. Approximate annual requirements (*kilograms*) of local vegetable seed.

Crops	1985	1986	1987	1988
Beans	100,000	120,000	140,000	150,000
Capsicum CA-8	1,000	1,250	1,500	1,500
Capsicum H.Y.W.	3,500	4,000	4,500	4,500
Tomato	750	850	900	1,000
Cowpea - Pole	3,000	3,500	4,000	4,500
Cowpea - Bush	15,000	17,500	20,000	20,000
Okra	5,000	5,250	5,600	6,000
Snake gourd	1,500	1,700	1,900	2,000
Bitter gourd	1,500	1,700	1,900	2,900
Luffa	1,500	1,700	1,900	2,000
Cucumber	750	850	950	1,000
Eggplant	1,500	1,650	1,850	2,000

Table 3. Vegetable seed imports (*kilograms*) into Sri Lanka.

Crops	1981	1982	1983	1984	1985	1986	1987
Beet	14707	6071	8244	-	22770	18120	8850
Cabbage	1446	2120	3445	-	4065	2217	1057
Carrot	7715	6148	8574	-	13009	14687	9960
Cauliflower	54	22	58	-	175	150	210
Leek	4340	1365	1031	-	8350	7217	4425
Tomato	266	236	1049	Locally	produced		
Kohl rabi	2217	4827	3523	-	5425	2550	5900
Radish	1144	9674	4992	Locally	produced		
Beans	120700	105200	37000	25000	Locally	produced	
Capsicum	2543	1992	2853	-	6680	8627	2400
Lettuce	400	366	98	-	137	201	50

Source: Seed Division, Department of Agriculture, Sri Lanka.

Organizational Structure

The Department of Agriculture is the principal organization executing agricultural research and development on crops other than the plantation crops such as tea, rubber and coconut and the minor export crops. The Department consists of nine Divisions headed by the Director of Agriculture. The Division of Research is responsible for the planning and development of new research technologies for the field crops. Research is headed by the Deputy Director of Agriculture (Research) and has nine regional research centers and three specialized research units: (1) Central Rice

Breeding Station (CRBS), (2) Land and Water Management Research Center, and (3) Plant Genetic Resources Center (PGRC).

The regional research centers are located in the major agroecological zones with 18 smaller satellite agricultural research stations. All the stations undertake research on vegetables and other field crops suited to each region. The national average yields for most vegetables are low when compared with yields obtained under research conditions (Table 1). Many factors that influence and limit the productivity in farmers' fields have been identified. However, vegetable research itself is beset with a series of constraints that need to be resolved, so that meaningful solutions can be worked out to increase the quantity and quality of vegetables produced in Sri Lanka.

Research projects are formulated according to their perceived economic benefits to farmers, and hence crops that are most widely grown often receive more attention (e.g. chili, beans, brinjal, tomato). Research is also undertaken to develop crops with an export market (gherkins, brassicas and green chili). Research at the regional level also functions to solve problems faced by farmers of that particular region. These problems are presented by the Extension Division of the Department of Agriculture biannually to the Regional Technical Working Group (RTWG), comprised of Research, Extension, Education and Training personnel, where priorities are established. Research determined in accordance with new national agricultural policy decisions and revisions of such decisions made from time to time are also executed at the national and regional levels.

Current Research Program

In each regional research center, the main disciplines in vegetable research include plant breeding (varietal development and evaluation), crop management (agronomy, crop physiology and farming systems), soil science, crop protection (entomology, pathology and weed science) and food technology.

The vegetable breeding program is essentially an evaluation and selection program, and is closely integrated with other disciplines to identify high-yielding varieties with desirable characteristics such as resistance to important pests and diseases. Emphasis is also placed on selecting varieties suited to each agroecological zone. Such varieties are then recommended for multiplication or introduction. Regular hybridization programs are restricted to tropical vegetables, since exotic vegetables from temperate climates rarely flower and set seeds under local conditions.

Research is also carried out on finding suitable agronomic practices, fertilizer levels, seed rates, nursery management practices and crop protection measures for different vegetable crops.

Constraints to Vegetable Research

Difficulties in executing the vegetable research program include:

Biotic Constraints

Germplasm. The present varieties have been selected mostly on the basis of high yield and not on their nutritional and consumer qualities. This is primarily due to the lack of a broad-based germplasm collection available for evaluation and selection.

Persistent Diseases and Pests. Most areas in the intermediate and dry zones are infested with bacterial wilt pathogen (*Pseudomonas solanacearum*) making the experiments on solanaceous crops difficult. The soils in the upcountry are infested with club root (*Plasmodiophora brassicae*), which renders the brassica experiments useless. Research on most vegetable crops is complicated due to infestation with root knot nematode (*Meloidogyne* sp.). Virus diseases on the solanaceous crops okra, cucurbits and legumes also create problems. Their vector control uses up a large portion of the operating funds. Damping off is probably the most severe disease of vegetable seedlings caused by *Rhizoctonia, Pythium, Sclerotium* and *Fusarium*.

Abiotic Constraints

(1) **Funds.** The funds allocated for vegetable research are not sufficient to purchase seed material of promising varieties, chemicals and equipment associated with processing and curing, or for construction of greenhouses, curing barns and seed stores.

(2) **Qualified Personnel.** The vegetable improvement program is presently hampered by the shortage of research officers. Each breeder is responsible for several crops with a huge workload resulting in limited output.

(3) **Technical Support.** Shortage of research assistants for research work, variety maintenance and breeder seed production, lessens the effectiveness of vegetable research projects.

(4) **Testing of Commercial Varieties.** Vegetable seed samples supplied by the private sector are not adequate for consistent testing over several seasons. The varieties supplied vary from season to season making proper evaluations difficult.

(5) **Irrigation Facilities.** Due to the erratic rainfall pattern that prevails in virtually all the agroecological zones, most of the experiments suffer due to lack of supplementary irrigation in the research plots. This aspect is also tied up with insufficient funds.

(6) **Difficulty in Obtaining Quality Organic Manure.** This is due to the underdeveloped animal husbandry sector in the country.

(7) **Procurement Procedures.** Difficulties in procurement procedures for obtaining chemicals, building materials and equipment hamper timely research operations.

(8) **Shortcomings in the Variety Evaluation System.** Due to the abovementioned constraints faced by the breeders, they are unable to meet the stringent requirements set by the National Variety Release Committee of the Department of Agriculture. Release of new varieties is also delayed by the lack of a well-organized seed production program.

Funding and Personnel Needs

The research time expended on each project, the number of projects undertaken on each vegetable crop, the cost of research on each crop and the percentage cost of all crops are given in Table 4. The number of scientist person-years per project varies from 0.03 in the snake gourd, pumpkin and bottie gourd to 0.1 in beans, tomato, chilies and most other important vegetables. This shows that the vegetable research component is understaffed. At the rate of 0.1 person-year per project, one scientist is handling 10 projects at any given time. In order to increase the efficiency of the projects, there should be at least one scientist to undertake a maximum of five projects. This calls for doubling the number of researchers in vegetable research or reducing the number of projects by half.

Table 4. Vegetable research: research time, project cost and number of projects by crop, Sri Lanka 1989.

Vegetable	Research time*	Project cost (US$)	No. of projects	Cost of total (%)
Beans (all types)	366	44,168	30	0.9
Beet	22	2,917	2	0.06
Bitter gourd	5	357	1	0.007
Bottle gourd	3	261	1	0.005
Brassicas	184	24,100	23	0.5
Brinjal	94	12,878	11	0.3
Capsicum	62	9,101	4	0.2
Carrot	45	5,534	5	0.1
Cucumber	42	3,892	5	0.1
Gherkin	185	25,790	9	0.5
Gotukola	30	3,252	2	0.07
Khol Rabi	6	711	1	0.01
Leek	12	1,421	1	0.03
Lettuce	6	711	1	0.01
Luffa	36	3,460	3	0.07
Melon	20	3,437	3	0.07
Okra	161	22,360	10	0.5
Onion	171	26,318	19	0.5
Pumpkin	3	261	1	0.005
Radish	16	1,895	3	0.04
Snake gourd	3	261	1	0.005
Tomato	303	42799	21	0.9
Chili	385	73,667	37	1.5
Combined studies	265	68,197	27	1.4
Total vegetables:	2,425	377,748	221	7.78
*Total all crops	24,748	4,891,068	1,552	-
% vegetables of all crops	9.8	7.7	14.2	-

*No. of person-years x 100.

Source: Council of Agricultural Research Policy (CARP), Sri Lanka.

Out of the total cost of doing research on all crops, only 7.7% is spent on vegetable research. The average cost of each project is US$ 1709. In view of the fact that each project often consists of a single field experiment conducted during two seasons per year, that figure is about sufficient to meet the recurrent expenditure of the project. However, since one scientist is responsible for carrying out 10 such projects on the average, the problem is the possibility of not utilizing the total sum of money allocated for the projects. This problem also could be resolved by allocating more scientist time per project.

Priorities for Vegetable Research in the Future

(1) **Vegetable Breeding**

(a) Introduction of germplasm from different sources for screening and selection for the following traits:

* High yield
* Heat tolerance: For growing temperate-type vegetables in the lowland tropics, e.g. tomato, cabbage, Chinese cabbage, capsicum, and carrot
* Good consumer quality (flavor, palatability, color and shape)
* High nutritive value
* Earliness - for growing during off-season
* Disease resistance: e.g. bacterial wilt in Solanaceae, club root in *Brassica* and virus diseases in tomato, okra, legumes and cucurbits
* Insect resistance: wherever possible.

(b) Introduction of segregating populations and screening to select single plants for the above-mentioned characteristics.

(c) Improvement of the local vegetable varieties resorting to hybridization and selection.

(d) Production of breeders' seed of local varieties such as tomato, brinjal, beans, cucurbits, radish and capsicum, to ensure a regular supply of true-to-type good quality seed.

(e) With the emergence of export markets for some locally produced vegetables, e.g. gherkins, Chinese cabbage, carrots, red cabbage, cauliflower, head lettuce and broccoli, it is necessary to study suitable varieties with adequate consumer quality for such markets.

(2) **Postharvest Technology.** Technology for proper handling, packing, transporting and storing vegetables to preserve quality has to be developed locally or introduced.

(3) **Integrated Pest Management.** Since there is an overuse of hazardous insecticides in some areas of Sri Lanka, raising environmental concerns and risks of direct poisoning, research on integrated pest management with minimum use of environmentally friendly insecticides has to be undertaken as a priority. The major pests of vegetables in Sri Lanka include cutworms (*Spodoptera* sp.), leaf-eating caterpillars (*Plutella* sp. and *Pieris* sp.), pod and fruit borers (*Leucinodes* sp. and *Heliothis* sp.), bean fly (*Ophiomyia phaseoli*), cucurbit fruit fly (*Dacus cucurbita*), root-knot nematodes (*Meloidogyne* sp.) and virus vectors such as

white fly (*Bemisia* sp.) and aphids (*Aphis* sp.).
High priority also should be given to detecting insecticide residues in the produce and in the environment (groundwater monitoring if nematicides are used).

(4) **Integrated Methods of Disease Control.** It is also important to carry out research on integrated methods of disease control such as cultural methods, time of planting studies, resistant varieties, mixed cropping with resistant species and seed treatments. Inoculation with nonvirulent (mild) strains of viruses to build up virus resistance in crops is a new development that warrants careful study.

Research Training Needs

(1) Postgraduate training is needed for technical officers (research officers and experimental officers) on plant breeding, agronomy, integrated pest and disease management, soil science, soil-plant-water relationships and biotechnology. The number of trainees will depend on the available funds and the intensity of the local vegetable research program. Government policy decisions also will determine the training program.

(2) Short-term training for technical officers, research assistants and agricultural instructors on postharvest technology, food technology and field experimentation methods is also necessary.

Interaction with AVRDC and Its Impact

AVRDC has been playing a major role in supplying vegetable germplasm. AVRDC has provided breeding lines of tomato, Chinese cabbage, sweet potato, vegetable soybean and mungbean for screening and evaluation under Sri Lanka conditions. This has greatly facilitated the local vegetable improvement and production programs.

The major impact has been in finding bacterial wilt resistance and heat tolerance in tomato lines supplied by AVRDC. The line C-32-d-0-1-2-0 is highly tolerant to bacterial wilt and yields about 28 t/ha compared with about 23 t/ha for the standard variety KWR (Katugastota Wilt Resistant) (Padmasiri 1987). This above line was released for general cultivation as T146 and is popular among farmers. The AVRDC lines have also been used in the local hybridization programs and promising selections made. Three promising lines, B13, B15, B17 were selected from crosses made between the AVRDC line C-32-d-0-1-2-0 and the local Katugastota Wilt Resistant variety (KWR). Another promising hybrid line T245 has been selected from a cross between KWR and C-32-d-0-1-7-0. In variety evaluation trials these have outyielded the parents and show better tolerance to bacterial wilt.

Twelve AVRDC hybrid lines of Chinese cabbage were tested in the mid-elevation Regional Research Station at Bandarawela in 1989. The high yielding AS-VEG 1 gave the highest yield of 18.5 t/ha.

AVRDC selections of vegetable soybeans are gaining importance in research because of their high nutritional value and good consumer quality (palatability) of the grain. A few selections based on yield and grain size have been made. The promising lines are AGS-184, AGS-185, AGS-186 and AVRDC-165. These were introduced recently to the high elevation research station at Sita Eliya for evaluation and have performed encouragingly.

Subregional Collaboration

Subregional research collaboration is desirable in the following areas:

(1) Exchange of germplasm among countries in the subregion.
(2) Exchange of promising technologies among countries in the subregion on (a) Seed production, (b) Virus disease detection techniques, and (c) Establishment of consultancy services for disease and pest identification in the region.
(3) Conduct of Multilocation Coordinated Vegetable Evaluation Trials in the region. AVRDC should coordinate the distribution of seeds and collection of results.
(4) Training of scientists and technicians in the subregion by countries with facilities for such training so as to strengthen the research capabilities in the region.
(5) Providing expertise (experts and consultants) and working scientists on a collaborative basis.
(6) Exchange of scientific literature (published articles, booklets, research reports, summaries, etc.) among subregional countries.

Perception of AVRDC's Role in Vegetable Research

(1) Banking important vegetable germplasm from various areas of the world so that these can be disseminated among Asian plant breeders. Alternatively, through the offices of AVRDC, plant breeders could be provided access to germplasm available in germplasm banks in other countries.
(2) Continuation of supplying F_2 seeds to Asian plant breeders for selection of premising lines. Alternatively, suitable parents can be sent to a particular country, enabling the plant breeders to use such parents as required for specific purposes in their local vegetable breeding programs.
(3) Provision of training to scientists and technicians in vegetable research and development.
(4) Decentralization of AVRDC's activities among participating countries so that each country could undertake the research and development of one or two important vegetables in that country or region.
(5) Support of research, extension, and development projects in Asian countries with AVRDC's expertise and facilities.
(6) Organization of program and project evaluations, publication of results and transfer of mature technologies after verification.

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Summary of Discussions - Sri Lanka

Moderator: **C.M. Anwar Khan**
Rapporteurs: **Imtizaj Hussain**
V. Pal Singh

Vegetables in Sri Lanka are grown in nine soil groups and 24 agroecological regions of the three climatic zones: dry, intermediate and wet.

Vegetable availability is about one-half (88 g/capita) of the requirement (156 g/capita). Pulses are also included as vegetables, and are mostly imported. Even with the insufficient supply for local consumption, vegetables from Sri Lanka are exported to obtain high value foreign exchange.

The production constraints in vegetables are:

(1) Inappropriate production technologies;
(2) High production costs of implements, seeds, fertilizers, agrochemicals, and handling;
(3) Unavailability of modern, inexpensive methods of packaging, processing, storage, and marketing;
(4) Inadequate allocation of funds for research; and
(5) Inadequate trained staff.

Challenges and future directions:

(1) There will be a serious shortfall in meeting the domestic requirements;
(2) With the economic growth of 5%, the demand for quality vegetables will increase;
(3) With high energy prices and more employment opportunities, the demand for processed vegetables will increase;
(4) For earning foreign exchange the prospects for export will increase in future.

The government policies will focus on:

(1) Increasing the productivity per unit area per unit time;
(2) Increasing farmers' income; and
(3) Generating more employment.

They are to be achieved by:

(1) Crop diversification;
(2) Farmers' organizations;
(3) Pension schemes; and
(4) Crop insurance.

The current national vegetable research program focuses on:

(1) Germplasm evaluation and selection of promising material;
(2) Crop management;
(3) Crop protection; and
(4) Food technology.

Future research would also focus on the above areas. Assistance/cooperation is needed in the following specific areas:

(1) Exchange of germplasm, promising technologies on seed production and identification and management of diseases and pests, and scientific literature;
(2) Training of scientists; and
(3) Technical assistance on special issues.

Vegetable Production in Pakistan

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This paper focuses on the current vegetable production situation in Pakistan, and the government policies aimed at boosting and accelerating the pace of development of this subsector which has enormous potential of not only ensuring maximization of resource efficiency in the agriculture sector, but also enhancing incomes of farmers.

It is the policy of the government to achieve self-sufficiency in agricultural production and to increase exports. The proposed strategy envisages an average annual growth of 5% in total agriculture production, and vegetables have been earmarked to grow at the rate of 7%. However, while developing such strategies we cannot ignore serious issues like limitations of land and water, the need for increasing productivity and improving the quality of our crops, the different levels of requirements of national and international markets, the need to develop basic infrastructure, and especially important, the role of the private sector in development. The growth targets can only be achieved if we give proper attention to these issues.

We are passing through a period of transition in agriculture from subsistence to commercial farming. The 7% projected growth can only be achieved through improved productivity, as changes of expansion of area have become limited. This demand focuses our attention on the improvement of technology as well as its dispersal and adoption by farmers. The profitability margins in producing vegetables as high-value crops also gets defeated at the farm level through seasonal gluts. Thus, harvest and postharvest management are being studied since they play a key role in improving the cost benefit ratios for the producers, thereby helping the growth of this subsector.

Vegetable seed is being imported freely which has helped to make the best hybrids and varieties available to the farmers for planting. Simultaneously, our research institutions are also endeavoring to breed adaptable varieties suitable to our specific requirements as well as for the international markets. Although we have achieved certain successes, a much larger effort is needed from foreign research institutions to help in developing the local institutions.

Ongoing efforts at the farm level to improve productivity are essential to retain the economic advantage for vegetable growers. An additional important consideration in seeking to secure such improvement is market efficiencies which in turn foster improvement in quality and quantity of production. The inefficiencies of our markets and lack of market infrastructure demand significant improvement. To address these areas, a project on the improvement of fruit and vegetable marketing and storage was launched in 1989 at a cost of around 0.6 billion rupees (US$30 million) with the assistance of the Asian Development Bank. This project envisages development of markets, improvement of postharvest technology and a market information system. Twelve new modern markets are being set up. The project involves building increased storage capacity of 368,000 t with a primary storage of 5200 t, and increased package and grading capacity of 1.44 million t. We expect that the project will result in increased annual production of 7% and reduction in production wastage by 15%.

Another important step initiated by the government is a regular monitoring program of prices and the availability of minor sensitive crops, such as vegetables and pulses. This was initiated through establishment of a Committee on Minor Crops in the Ministry of Food and Agriculture. In the past, the vegetable programs have mainly been confined to production strategies and monitoring of prices. Monitoring of availability has generally not been carried out, with adverse implications to both growers and sellers.

With substantial investment in surface irrigation and tubewells in the past 25 years, Pakistan's agriculture has acquired a certain stability in production despite inevitable fluctuations in rainfall and weather conditions. It is now moving towards greater technological security by increasing yields and by improving the postharvest management systems. We have a comparative advantage over other competitive producers in the production of vegetables by virtue of natural endowment. This feature is being used for stabilizing the agriculture sector thus contributing to the economic prosperity of the country.

Transportation is another important component in the development of this sector. The present transport infrastructure requires improvement, as there is lack of refrigerated containers, and inadequate cargo facilities. The limited number of vessels of the Pakistan Shipping Corporation causes serious repercussions in exporting of vegetables Most of the export trade is carried out by the unorganized sector using launches, and the consignments suffer in quality. Likewise the cargo service for vegetables on the national airlines is infrequent and inadequate. There are no specific arrangements at the port of dispatch for dealing with the consignments of perishables like vegetables which is recognized as a constraint in the system. Government is taking steps to strengthen refrigerated facilities, logistics and provision of quick, efficient and cost-effective transport services. This would benefit the trade, but still requires assistance from foreign agencies in building up a strong and reliable system.

The Government of Pakistan has declared a policy of free economy. The implementation of this policy places considerable pressure on raising productivity and establishing competitiveness in the national and international markets. This calls for huge investments, with cost-efficient production. We believe that the way to achieve this is to develop the confidence of the private sector and to encourage them to participate in agribusiness and agroindustry.

A first step was the holding of a workshop under the auspices of the Agriculture Development Bank of Pakistan (ADBP). This provided a forum where investors and relevant government institutions could interact and encourage the development of confidence among various interests and help forge a promotional policy for capital investment. Subsequently the Lahore Chamber of Commerce and Industry organized a two-day Horticulture Investment Forum in February 1990. The major focus of this seminar was to investigate the possibilities of US-Pakistani private sector joint ventures. The forum was an excellent venue to evaluate with Pakistani industrialists the prospects of developing an export oriented agroindustry based on a variety of fresh and processed horticulture products. This forum made a positive impact on foreign multinationals which expressed interest in pursuing certain projects.

Seminars on Livestock were also held, and recently a series of seminars on Analysis of Corporate Sector Constraints in Agriculture were held by RONCO Consulting Corporation, a US consulting firm presently working on a USAID-funded project.

In addition to the holding of seminars, MinFAC has formulated an "Agri-Business Cell (ABC)". The main objective of ABC is to ensure growth in the agribusiness and agroindustry through promotion of private sector expansion.

The government is committed to the development of the agriculture sector. Various steps are already being taken. A solid campaign through ABC has been launched to encourage the private sector. However, the government still feels that much more needs to be done. Special emphasis must be put on strengthening of local institutions, training of people, transfer of technology, promotion of the private sector and identification of foreign markets.

Pakistan can be a source of certain agricultural inputs for other developing and developed countries. We as an international community must join hands to exploit this valuable resource in a sustainable way.

Vegetable Production

Pakistan has been blessed with an ideal climate that results in the year-round growth of a variety of key crops. At present the total cropped area of the country is a little more than 20 million ha. Out of this 56% is under food grains, 17% under cash crops and 7% under pulses. Vegetables constitute an integral component of the cropping pattern but the increasing pressure on food and cash crops has limited the area under vegetables to about 0.27 million ha, which is a little more than 1% of the total cropped area.

Some of the main vegetables grown are potato, onion, chilies, tomato and garlic. Other vegetables range from cole crops to tuberous kinds as well as a wide spectrum of all possible choices.

In this paper we concentrate on five major vegetables: potato, onion, chilies, tomato and garlic. These occupy a major portion of the area under vegetables, and they are potentially viable for export either in fresh form or through value-added processing.

Potato

Potato occupies about 70,000 ha and the area has grown at an annual rate of 5.1% over the last 15 years. Potato is grown under diverse seasons in various provinces. The autumn-sown potato is the major crop and contributes 60% to the total production in the country. It is sown in September - October and harvested in December - January. The spring and summer crops each contribute 20% to the total production. The spring crop is sown in January - February and harvested in April - May. In the hill, summer crop is sown in March - May and harvested in September - October. The autumn and spring crops are grown in Punjab and NWFP only, whereas the hill crop is sown in Punjab, NWFP and Baluchistan. The diversity in growing seasons of potato in different agroecological regions makes it possible to ensure supplies to the domestic consumers throughout the year. Yield is about 10 t/ha, with the official statistics placing the size of the potato crop at 734,000 t. However, according to independent field studies carried out by the Pakistan Agricultural Research Council (PARC) and Planning Unit of Food and Agriculture, the per hectare yields are substantially higher (about 20 t/ha) and place the annual production estimates in the range of 1.2-1.5 million t. These figures seem more realistic in view of the market arrivals and consumption requirements of the local population.

Yield per hectare can be improved substantially if we overcome production problems and implement a strong marketing strategy for the promotion of these valuable crops.

In the past, heavy reliance was placed on imports of quality seed of potato, which places a burden on the country's balance of payments. However, the government is in the process of taking steps to improve the situation. Some of these steps are:

- o The development of indigenous technology for quality seed production at a reasonable cost;
- o The introduction of tissue culture techniques for generating a system of quality seed production; and
- o The setting up of laboratories for research and development in the country.

Although public sector agencies like Punjab Seed Corporation are engaged in the commercial seed industry, concrete steps are also being taken to promote and to encourage the private sector in the development of this industry.

Lack of a strong marketing strategy is also one of the major constraints in the development of the potato industry in Pakistan. Although a support price program is available for potato, it only ensures distress-relief action by the government when the prices fall below the support price level. Since potato is a perishable commodity, support of this nature is difficult to implement. Furthermore, the quality of the product is a major factor in determining price, but difficult to enforce in a government-sponsored procurement system. A salvage operation can be of colossal dimensions, as in the 1989 crop year when 106,000 t of potato was procured. It helped to save the farmers and also consumers at a time when the subsequent spring crop failed. Such a situation may not happen again, with resultant huge losses to the procurement agency.

We are at an evaluation stage for implementing a self-sustaining system that could survive market pressures and provide reasonable margins of profit to the producer through linking potato production with industry.

On the export front, substantial quantities of potato have been exported to Middle Eastern countries in the past. However, there are problems in retaining this position as it is difficult to establish reliability in the export market through a dependence on local surpluses only. Buyer markets have become more choosy and unless the product meets the requirements of buyers, and at competitive prices in international markets, chances of survival are remote. Unfortunately, our production, which had been biased towards red skin varieties because of domestic preferences, is not the product acceptable to Middle East markets where varieties with white skin and yellow flesh are preferred.

The consumer's choice for specific size and shape is forcing production of quality through adoption of strict grading. In recent years, the organized sector of one of the cooperatives (Okara Cooperative) has adopted cultivation of white skin cultivars, and the area under white varieties has gone up to 25% of the potato area. The institutional arrangements being made available by the government are helping the private sector to enter the export market.

Onion

Onion is a highly sensitive commodity for growers and consumers. Surpluses make it difficult for the farmers to recover even the cost of digging the produce, whereas shortages take a heavy toll on consumers since onion is an essential ingredient in curry.

The government policy of providing a free market economy, and letting the market forces serve producers and consumers alike, is causing some difficulties, but the industry and researchers are learning from experience. The good onion crop and reasonable market prices helped the private sector export almost 80,000 t in early 1990. This situation, however, has an impact on the local market which started feeling the pressure of demand thus raising prices for the consumer, at least for the period until the later crops became available. The situation could have an adverse effect if the supplies from succeeding crops are lower. A greater stability in production through greater effort and an improved infrastructure for storage and transportation should be a major goal for agroindustrial development at this time.

Like potato, onion is also grown over a number of seasons in the country. This ensures the availability throughout the year. About 200,000 - 230,000 t are harvested from Baluchistan in September - October, whereas a crop of about 180,000 t is harvested from Sind in December - February. This is followed by arrival of a crop in April - May from Punjab and Sind. The size of this crop is around 300,000 t with Punjab contributing 180,000 t and Sind 120,000 t. The crop from NWFP is available about one month later and the size is around 80,000 t. Unlike for potato, storage for onion is difficult even for a limited time. Efforts are under way to devise appropriate storage at a reasonable cost.

Chilies

The agroecological suitability of the southern zone of the country to the production of chilies has resulted in the raising of 75% of total production from Sind. Punjab produces 20% and Baluchistan 5%. There is a lack of taste for chilies in NWFP, so there is little interest in its production in the northwestern region.

The chilies are mainly harvested in September - November, but in Sind a second crop is picked in spring between February and April. About 80% of the production comes in autumn and 20% in spring. Normally we have a surplus production of chilies and export about 10,000 t. However, during 1988-89, the production was lower due to infection by collar rot disease. As a result, the prices were abnormally high. The critical months of shortage were July - September. The situation improved with a widespread and aggressive dissemination of technology on the control of the disease.

Tomato

Like chilies, tomato is also used widely in various dishes and as salad. The production is around 176,000 t. Out of this 35% is contributed by each of NWFP and Baluchistan provinces, and 15% each by Punjab and Sind. Tomato is grown most of the year in some parts of the country. However, the supplies are substantially reduced during intense heat and rains of summer and monsoon months from June to August. Another period of stress is the onset of frost during December and January when production is depressed. More reliable production is possible through the provision of a cover for the crop against scorching heat and frost, a technique which is developing in small areas where profitability margins allow such innovations. However, labor shortages on occasions of religious days, particularly Eid-ul-Azha, present difficulties.

Garlic

The production of garlic is about 61,000 t in the country. We are almost self-sufficient in this commodity. However, during the last two years, the consumer prices of this commodity during postharvest seasons were abysmally low because of the bumper crop. This discouraged the farmers, so the area under garlic reduced from 72,000 ha in 1988-89 to 57,000 ha in 1989-90. The current prices of garlic are Rs. 25-30/kg (US$ 1.25-1.50/kg), which are high for most consumers.

Vegetable Research in Pakistan

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Introduction

Pakistan is blessed with a diverse climate, so it is possible to cultivate many kinds of vegetables. The northern mountainous region, some of which is wet with lush green forests, and some dry without much vegetation, has a temperate climate. The southern parts are desert-like, and the western areas near the Arabian sea have a tropical climate.

The estimated area under different vegetables and condiments in Pakistan is 383,600 ha, with a production of 3.8 million t (Anon. 1989). Chilies occupy the largest area (15.8%), followed by potatoes (15.1%) and onions (14.4%). Melons, tomatoes and turnips are grown in 10, 4.4 and 3.3% of the total area, respectively. Yields of vegetables have remained static at the low level of 10.1 t/ha. Due to progressive developments in the country, the level of nutrition and demand for a larger variety of foods are increasing, but the productivity level is not increasing correspondingly.

The reasons for the low production of vegetables include nonavailability of quality seed of promising cultivars, considerable damage by insects and diseases, enormous weed infestation and poor weed control measures adopted by the growers, low use of fertilizers, etc. Vegetables have remained low-priority crops in the national development programs, so a solid technical base is lacking. There is an acute shortage of scientific personnel which resulted in slow development, dissemination and adoption of production technology. Poor postharvest handling, storage and marketing systems are the major factors that have indirectly affected the production of vegetables. Considerable research is necessary to resolve these production constraints.

National Program

Research on vegetables is being carried out by federal and provincial government institutions, including Pakistan Agricultural Research Council (PARC), Islamabad, Nuclear Institute for Agriculture and Biology, Faisalabad, and Nuclear Institute for Food and Agriculture, Peshawar, working under the federal government. In addition, there are four provincial agricultural research institutes. The departments of horticulture at four agricultural universities are also doing research on vegetable crops. PARC formulated a cooperative research program on vegetable crops which became operative in December 1981. At the federal level, the National Agricultural Research Centre of PARC is the major center of research for agricultural crops, including vegetables. The research studies concentrate mainly on varietal improvement, pest and disease control, production management and tissue culture on economically important vegetable crops, including chilies, potato, onion, tomato, pea, carrot, radish, cucumber, brinjal and melons, with the long-term primary objective of substantial increases in vegetable production in the country.

Research Areas

The following research areas are currently covered:

- Evaluation and screening of germplasm to promote intensive breeding programs for evolving high-yielding cultivars;
- Development of effective control methods for major pests and diseases;
- Development of a package of production technologies for various agroclimatic zones; and
- Development of systems for year-round production of vegetables of economic importance.

Problems in Important Vegetable Crops

The economically important vegetable crops and their problems are given in Table 1.

Table 1. Specific problems in economically important vegetable crops.

Crop	Problems
Chilies	Fusarium wilt, phytophthora root rot, viruses and blossom end rot
Potato	Early blight and viruses
Onion	Cultivar adaptability, purple blotch, weed infestation and storage
Tomato	Early blight, viruses and fruit borer
Pea	Powdery mildew, root rot and leaf miners
Okra	Yellow vein mosaic and fusarium wilt
Cauliflower	Sequential maturity and heat tolerance
Carrot	Early maturity and low carotene contents
Cucumber	Powdery and downy mildews and cucumber mosaic virus
Melons	Powdery and downy mildews, fruit fly and low sucrose contents
Brinjal	Angular leaf spot and fruit borer

Constraints to Vegetable Research

The major constraints to vegetable research in the country are:

- Inadequate trained personnel and financial support;
- Limited germplasm to develop locally adapted varieties;
- Nonavailability of reliable and quality seed;
- High weed infestation and enormous insect pest and disease damage;

- Insufficient information on marketing of specific vegetables;
- Mountainous areas not receiving due attention;
- Low priority crops in the national development programs and low technological base; and
- Insufficient cooperative research among the institutes in the country.

More funds are needed to strengthen vegetable research and development programs, as well as trained people particularly in the fields of breeding, seed technology, postharvest physiology, plant protection and crop management.

Priorities for the Future

The priorities for vegetable research in the future are:

- Germplasm screening and breeding for higher yield, better quality, resistance to biotic and abiotic stresses and adaptation to different ecological conditions;
- Establishment of appropriate vegetable seed production technology;
- Development of postharvest technology;
- Improvement in production technology;
- Research on marketing within and outside the country;
- Introduction of new vegetables with better nutrition; and
- Socioeconomic studies to provide better information for research and development.

Research Collaboration

Research collaboration is desirable in various areas (Table 2).

Table 2. Crops and areas for research collaboration.

Crop	Research areas
Chilies	Germplasm evaluation, seed technology, plant protection and breeding for disease resistance and multifruitedness
Onion	Cultivar adaptability, better keeping quality, seed production technology, breeding and screening for bolting and disease resistance and weed management
Tomato	Breeding for resistance against biotic and abiotic stresses, postharvest physiology and seed production technology
Pea	Germplasm evaluation and screening for higher quality, better yield and insect and disease resistance
Melon	Breeding for disease resistance, high sucrose content and plant protection

Future Collaboration with AVRDC

The national program could receive vegetable germplasm and improved cultivars from AVRDC. Research information generated by AVRDC and South Asian countries could be disseminated by AVRDC. The center should provide training for research personnel in fields such as vegetable breeding, seed production, postharvest technology, plant protection and crop management. In addition, AVRDC should arrange short visits of key national scientists to its outreach programs.

Reference

Anon. 1989. Fruit, vegetable and condiment statistics of Pakistan. Government of Pakistan. Planning Unit, Islamabad. 6 p.

Vegetable Production and Policy in Pakistan

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Introduction

The importance of vegetables in Pakistan can be seen from the per capita consumption relative to wheat (Table 1). Other countries of the region prefer to consume vegetables to maintain a balanced diet. Therefore, considerable emphasis is given to the production of different vegetable crops.

Table 1. Per capita monthly consumption (kg).

Crops	Units
Wheat	11.0
Rice	1.3
Potatoes	0.8
Tomatoes	0.3
Onions	0.7
Other vegetables	1.6
Pepper	0.1
Fruits	5.6

The provinces of Punjab and Sind are the major producers of vegetables and NWFP and Baluchistan are minor producers. Punjab and Sind, as major producers, have areas that are irrigated by canals, whereas the other provinces are devoid of such facilities, although NWFP will soon be enjoying an enhanced supply of canal water. Climatic conditions are equally good in all provinces for the production of vegetables. The area and production of selected crops are given in Table 2.

Each province has particular problems for vegetable growing, with finances being the main one, particularly in Punjab where the land holdings are very small, and individual growers cannot afford to grow vegetables, because of the high cost of seeds, maximum cultural practices, application of fertilizers and plant protection measures. Growing potato, for example, costs about 19,000 rupees/ha (Rs21 = US$1). Therefore, cultivation of vegetable crops can only be done by people with the financial resources, but such people are often not interested because cultivation of vegetables requires constant vigilance, patience, and sufficient experience and knowledge. The only alternative then is to encourage the poor people to become vegetable growers, with the following incentives:

(1) They should be subsidized;
(2) The loan should be interest free;
(3) They should be supplied necessary equipment;
(4) Extra canal water supply must be ensured;
(5) Improved seed should be made available at minimum cost;
(6) Facilities for the disposal of the crops must be provided; and
(7) Transport facilities should be improved.

Table 2. Actual area and production in Pakistan.

Crops	Area ('000 ha)	Production ('000 t)	Production (kg/ha)
Wheat	7729.6	14419.2	1865.0
Maize	865.0	1204.1	1391.0
Onion	57.8	707.0	12.2
Garlic	7.2	60.8	8.5
Chilies	57.6	74.4	1.3
Coriander	7.4	3.4	0.5
Turmeric	3.2	24.4	7.6
Potatoes	63.9	644.8	10.1
Other vegetables	198.4	2627.3	

Marketing

The marketing system is very poor in Pakistan. Vegetables, which are highly perishable, must be processed in a timely fashion. The present system of marketing is not working, and most of the vegetables are damaged. The loss is at least 25%.

It is suggested that intermediaries in the present system should be completely eliminated. Warehouses should be established in every city. In large cities, the number of warehouses should be increased, and the warehouse people must have contact with the vegetable growers. The warehouse operators could also train the growers in the production and marketing of vegetables. This marketing should be established on a cooperative basis, with more than 50% of the members of the marketing body being growers.

Proper grading and production of healthy crops is essential. For grading of the crops, improved vegetable seed is of a high priority. This applies to both Sind and Punjab provinces.

NWFP and Baluchistan should be encouraged in vegetable production. Baluchistan has a favorable climate for the production of summer crops, when there is a scarcity of vegetables. Training of growers and a supply of irrigation water are the main needs. NWPF is improving in these areas, and the growers should be encouraged to increase the area under vegetable crops through the supply of trained labor, improved seed supply and assurance of market for their commodities.

Export

Pakistan is in good position to export (Table 3) as many vegetables as it can afford to produce to European countries. However, transport of vegetables needs special attention.

Table 3. Export of major agricultural commodities, 1988-89.

Crops	Quantity ('000 t)	Value (million rupees)*
Wheat	-	-
Fruits	96.0	681.9
Potatoes	1.0	2.1
Onion	27.1	59.8
Chilies	7.8	202.8
Other vegetables	1.2	102.9
Coriander	0.1	2.0
Castor oil seeds	8.5	63.2

*Rs 21 = 1 US$.

In the USA, for example, vegetables produced in California are transported to the East Coast, a distance of over 3000 miles. They have developed vegetable warehouses for processing and packing of vegetables.

These are transported using air conditioned refrigerated trucks/trailers. With a similar arrangement, Pakistan could earn valuable foreign exchange, thus enhancing the financial status of the producers, and help the economy of the country. Statistical reports have revealed that during 1988-89 foreign exchange on vegetables worth 400 millions rupees was earned. If measures are taken to increase the areas and manage marketing facilities, we could earn over 1000 million rupees of foreign exchange. It would require the formulation of new policies covering the production and marketing of vegetable crops.

Summary

(1) Sind and Punjab provinces are the major vegetable-producing areas, and NWFP and Baluchistan are the minor producers.

(2) In Punjab, the vegetable growers are small farmers while in Sind they are large-scale farmers. These two categories need different approaches.

(3) Vegetable growers in the Punjab need financial help. This can be done by subsidizing on the basis of interest-free loans for seed, fertilizers and plant protection measures.

(4) In Sind, there is a need for training the growers rather than laying exclusive stress on financial aid.

(5) These two major growing provinces should double the area planted.

(6) Since these two areas are receiving canal water, an increase in area could be substantiated by providing them an enhanced water supply specifically for vegetable production.

(7) The minor producing provinces (Baluchistan and NWFP) need a different approach. Climatic and edaphic conditions are quite suitable, but the area under vegetable crops is limited because of water supply. Fortunately, NWFP province is getting canal water facilities very soon.

(8) Special attention has to be focused on Baluchistan. The major problem is the market for their produce. The present system of marketing is discouraging and disappointing. The producers do not get even half of the cost. This goes to the intermediaries.

(9) The present marketing system results in losses of vegetables up to 25%. The technology to improve the system has already been established and it should simply be a matter of adaptation of existing systems. An example is in the USA, where the vegetable produce on the west coast is handed over to the harvesters and transporting agency, etc. who harvest the vegetables and take them to the warehouse for processing and packing. The packed vegetables are then transported in air-conditioned and refrigerated trailers to the east coast, over 3000 miles. Pakistan would not have significant problems transporting vegetables to western countries if such infrastructures are developed.

(10) The US growers handle marketing through cooperative endeavors. The marketing bodies consist of shares from different sources. Growers are also the participants who hold majority shares, which safeguards their interests.

(11) According to statistical data, vegetables worth 400 million rupees were exported during 1988-89. This could easily be increased to 1000 million rupees by adopting and implementing policies that encourage growers through the provision of adequate marketing facilities.

(12) Both research and extension can contribute to enhanced production of vegetables. Researchers should produce improved seed at lower cost, while extension workers should be taught production technologies so they can instruct the growers.

(13) Vegetable growers must be made more aware of the dangers to themselves and to consumers of inappropriate and excessive use of sprays and insecticides.

Vegetable Research in Pakistan

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Vegetables are an important and inexpensive source of vitamins A and C, minerals and protein in the diet. Therefore, there is real need for a substantial increase in the average daily consumption to improve the lives of people, especially in rural areas where per capita consumption of vegetables is low.

In Pakistan, the varied soil and climate throughout the country make it possible to grow large numbers of vegetables throughout the year. There is substantial interprovincial trade assuring the availability of a large range of fresh vegetables throughout the country.

Status of Research

The following vegetable research organizations in different provinces are engaged in intensive research work to improve vegetable production:

Punjab

(1) Vegetable Research Institute, Faisalabad, with substations at Sheikhupura, Sahiwal, Multan, Jhang, Mianwali and Bahawalpur;
(2) Potato Research Station, Sialkot, with substation at Murree;
(3) Post Harvest Research in Food Technology Section, Ayub Agricultural Research Institute (AARI), Faisalabad; and
(4) Plant Virology Section, AARI, Faisalabad.

Northwest Frontier Province (NWPF)

(1) Vegetable Research Section, Mingora-Swat, with substation at Tarnab; and
(2) Potato Research Project, Abbottabad, with substation at Bata Kundi.

Sind

(1) Vegetable Research Section at Horticultural Institute, Mirpur Khas, with Research Station on tomato and onion in the province.

Baluchistan

(1) Vegetable Research Section, Sariab, Quetta.

NARC, Islamabad

(1) Vegetable Research Unit at NARC, Islamabad;
(2) Cooperative research programs on vegetables in different provinces;
(3) Italian Project for Research on Fruits and Vegetables; and
(4) Pak Swiss Potato Development Project.

Universities

(1) Department of Horticulture, University of Agriculture, Faisalabad, Punjab;
(2) Department of Horticulture, University of Agriculture, Tandojam, Sind;
(3) Department of Horticulture, University of Agriculture, Peshawar, NWFP; and
(4) Department of Horticulture, Gomal University, Dera Ismail Khan, NWFP

Objectives

(1) Collection and evaluation of local germplasm to select high-yielding, good-quality, disease-resistant varieties of vegetable crops.
(2) Introduction and selection of high-yielding, good-quality, disease-resistant varieties from the exotic material.
(3) Varietal improvement through hybridization and selection in selected vegetables like potato, tomato, peas and brinjal.
(4) Heterosis and combining ability studies in vegetable crops such as tomato and brinjal.
(5) Standardization of improved production technology through management of agronomic practices.
(6) Research on intercropping and multiple cropping to determine suitable cropping patterns.
(7) Research on vegetable forcing to raise out-of-season vegetables under low and high polythene tunnels.
(8) Production of pre-basic and basic seed of improved varieties of vegetable crops.
(9) Weed control studies in potato, onion, garlic and carrots.

Salient Achievements

Varietal Improvement

Following is a list of crop varieties released and the most promising varieties under trial:

Vegetable	Variety	Year of release	Distinguishing characters
Potato	Ultimus	1963	High yield, red skin and early maturity.
	USA-5	1963	High yield, white skin, wider adaptability.
	Multa	1969	High yield, white skin, wider adaptability.
	Desiree	1969	High yield, good quality, smooth and red skin, slow degeneration, good keeping and cooking quality.
	Patrones	1969	High yield, white skin, early maturity, slightly susceptible to leaf roll virus, good quality.
	Wilja	1975	Early maturity, good quality, high yield, tolerant to frost.
	Cardinal	1975	Red skin, large tuber, good quality.
	Spunta	1975	Tuber size very large.
	Ajax	1975	High yield, round tuber, white skin, medium maturity.
	Laal-e-Faisal	1986	High yield, round tuber, red skin, deep eyes, good quality, resistant to frost.
	Diamant	1986	White skin, high yield, good quality, oval tubers.
	Sialkot Sufaid	1986	High yield, white skin, wider adaptability, good keeping quality.
Watermelon	T-14	1963	High yield and good quality.
	Sugar Baby	1969	High yield, small seeds and fewer in number, excellent quality, tough rind for better transport.
Tomato	T-10	1964	High yield, good quality.
	T-43	1964	High yield, good quality.
	Roma	1969	Early maturity, dwarf plant, high yield, good keeping and transport quality, fruits oblong.
	Red top	1969	Early maturity, dwarf plant, fruits oblong.
Muskmelon	T-96	1963	Good quality and early maturity.
Peas	H-57	1964	Early maturity, high yield, good adaptability.

(Continued)

Vegetable	Variety	Year of release	Distinguishing characters
	Meteor	1964	Early, round and green seed.
	Samrina Zard	1990	Short duration, high yield, well filled pods.
	Climax Improved	1990	Main season, high yielding, wider adaptability, well filled pods.
Chilies	Gola Peshawari	1969	High yield, disease tolerant.
	Tatapuri	1969	High yield, long fruits of attractive color.
	California Wonder	1969	High yield, good quality.
Garlic	G.S. 1	1971	High yield, wider adaptability, disease resistant.
	Lassan Gulabi	1976	High yield, good keeping quality.
Carrot	T-29	1964	High yield, good quality.
Turnips	Golden Ball seed (Lyallpur)	1972	High yield, early maturity, normal setting.
		Improved Varieties	
Potato	Kondor		Red skin, high yielding.
	FB 9555-28		High yielding, white skin.
Peas	FC-3954		Short duration, high yielding, yellow seeded.
	Green Feast		High yielding, medium maturity.
Muskmelon	Ravi		Fruit color yellow, seed and flesh white, cavity small, high yielding.
Tomato	Long Tipped		High yielding, oval fruit with long tip, indeterminate plants, good transportation quality.
Chilies	Narwala		Early, medium-sized fruit, good yield.
	Pusa Iwala		Long, pendant fruit, tolerant to virus diseases, good yield.
Onion	Faisalabad Early		High yielding, most suited to autumn season, bulbs red.

(Continued)

Vegetable	Variety	Year of release	Distinguishing characters
Radish	40 Days		Short duration, heat tolerant and good quality.
	Mino		Mid season, high yielding, good quality, long roots, white color.
	Lalpari		Best variety for salad.
Cauliflower	Andes		Plant dwarf, white and compact curds, suitabie for mid to late season.
	Alpha Veralto		High yielding, snow white curds, good quality, medium maturity and good head covering quality.
	Vernon		High yielding, white heads, late maturity, good quality.
Cucumber	Sialkot Local		High yielding, good quality, disease tolerant.
Brinjal	Multan Selection		High yield, good quality, and round shaped, dark purple in color.
	Qaiser		High yielding, good quality, medium length and dark purple in color.
Okra	Pusa Green		Medium in maturity, high yielding, dark green fruits, less hairy.
Turnip	Purple Top		High yielding, early maturity, upper half purple colored, good quality.
Spinach	S.0.1		Heat tolerant, disease resistant and good quality.
Fennu Greek	Qasuri		High yielding, disease resistant and good quality.
Coriander	CS-1		High yielding, good quality and disease tolerant.
Longmelon	Local Long		High yielding, long and green fruit, good quality
Bitter Gourd	Faisalabad Long		High yielding, long fruit and good quality.

Improved Crop Production Technology

Potato

Technique for Potato Seed Production During Autumn. It has been proved experimentally that the autumn season in the Punjab plains is the most suitable for seed potato production due to the absence of the virus vector *Myzus persicae* during September to December. Consequently the degeneration in the seed produced in autumn is considerably lower. Thus if virus-tested, rapidly propagated seed through tissue culture is directly introduced in autumn, the growers can carry this seed in autumn-to-autumn cycles for many years without any significant decline in yield.

It is also possible to introduce the disease-free seed raised in high hills of Hunza in autumn by harvesting it early, by end of July.

It has been found that the seeds of certain varieties produced in autumn like Cardinal and Diamant have given good results when planted in next spring crop after 10-month storage in cold store provided crop is sprayed weekly against late blight.

Chitted potato seed gave significantly higher yield compared with unchitted seed in varieties Patrones, Cardinal and Desiree.

Weedicides like Gramaxone, Stomp E-330, Tribunal and Topoguard have been found effective for weed control in potatoes.

Onion

Development of Autumn Crop in Punjab. Besides the varietal improvement in Punjab Province, a new technology to raise a second onion crop in the autumn season has also been developed. The varieties Faisalabad Early and Phulkara are successful for this season. The seed is sown in nursery during the end of July and transplanted during September. The crop may be harvested for green onions during December-January or as a mature crop during March.

Garlic

Standardization of Production Technology. The different cultural practices studied and standardized for garlic are:

(1) September 25 to October 15 is the best planting time for garlic in Punjab.
(2) Larger cloves when used as seed yielded significantly higher than medium and small-sized cloves.
(3) Spacing studies revealed that 15 cm between rows and 10 cm within row are best for obtaining highest yield.
(4) Seed produced and stored at about 1000 m elevation in Soan Valley, District Khushab, gave better performance compared with seed produced and stored at Faisalabad.

Chilies

Disease Problem. Phytophthora or collar rot disease has developed on chilies during the last 4-5 years, causing considerable damage. Local and exotic germplasm especially obtained from Italy is being screened at Faisalabad. Fortunately some Italian varieties have shown resistance to this disease. The resistant material is being utilized for hybridization work to develop resistant and high yielding varieties.

It has also been determined that the collar rot disease problem can be considerably reduced if the seed and nursery seedlings are given treatment with Ridomil or Sando Fan, the nursery is transplanted on higher ridges on well drained land, and irrigation water is not allowed to directly touch the plants.

Cucurbits

Muskmelon, watermelon, bitter gourd, bottle gourd, cucumber, longmelon and squashes are the important cucurbit crops. Early crops of cucurbits are raised successfully in Sind Province, and produce starts reaching the markets of other provinces during February, fetching good prices.

In Punjab, early crops of cucurbit, particularly bitter gourd and squashes are grown under the protection of 'Sarkanda' reed. The main crop is sown during February and March. The second crop of muskmelon is sown during June in Sahiwal and Vehari districts of Punjab, while the second crop of watermelon is mainly grown during June and July in Bahawalpur and Rahim Yar Khan districts of Punjab.

Cole Crops

Cauliflower and cabbage are the main cole crops grown in Pakistan. Cauliflower and cabbage are grown during summer in hilly areas and during autumn and winter in the plains of NWFP, Punjab and Sind.

As a result of research work, several varieties have been screened and the following are the recommended varieties:

Cauliflower		
	Early crop:	Faisalabad Early
		Early 60 days
	Second early crop:	Mikado Sokigaki or
		Faisalabad Second Early
	Mid season:	Champa
		Alpha Veralto
	Late season:	Andes
		Vernon
		Snow Drift
		Chino Late
Cabbage		Golden Acre
		Copenhagen Market

Peas

The first week of October is the most suitable time for sowing of early varieties of peas like Meteor, Samariana Zard in Central Punjab, while the last week of October is the most appropriate period for sowing of main season varieties like P8 and Climax Improved.

Weed control studies on peas have revealed that weedicide E-330 at 1.5% concentration sprayed as pre-emergence immediately after sowing controlled weeds effectively.

Cowpeas

Research has shown that cowpeas can be grown successfully during the spring and rainy seasons. The best sowing time for the spring crop is the last week of February, to harvest green pods in early May or mature grain by end of May. During the rainy season the best sowing time is the third or fourth week of July, to harvesting green pods during September and mature grain during October.

Turmeric

Research has resulted in the successful introduction of turmeric into Punjab Province. The main findings were:

(1) The first fortnight of April is the best time for sowing;
(2) Seed size studies revealed that central rhizome sown as a whole gave highest yield;
(3) In mulching studies, it was found that application of about 4.8 t/ha of sugar-cane trash as mulch after planting helps in keeping the soil temperature low, conserves moisture, suppresses weeds and improves germination, growth and significantly increases yield;
(4) Turmeric can be successfully grown as an intercrop with cowpeas, okra and spring maize.

Ginger

Ginger can be grown successfully under partial shade of old guava and mango orchards on fertile, well-drained loam soils in the Sialkot, Gujranwala and Qasuri districts of Punjab Province.

Sawdust, when used as mulch, enhances the germination, growth and yield of ginger rhizomes.

Multiple Cropping

Research work to determine more productive and remunerative cropping patterns has resulted in the following recommendations:

Four-cropped patterns

Onion - Potato - *Sesbania* (Green manure) - Radish
Potato - Onion - *Sesbania* (Green manure) - Radish

Three-cropped patterns

Potato - Potato - Spinach
Potato - Tomato - Spinach
Potato - Tomato - Radish

There is a possibility of introducing these intensive types of multiple cropping to small farmers in areas having good irrigation water.

Vegetable Forcing

Research on vegetable forcing on bottle gourd and squash under low polythene tunnels and on bottle gourd and tomato under high polythene tunnels has produced valuable results. Earlier and higher yields have been obtained than with the traditional system of vegetable forcing, under the protection of "Sarkanda" reed.

Vegetable Culture Under Rainfed Conditions

Research conducted in rainfed areas has revealed that vegetables such as radish, turnip, pea, coriander and spinach can be successfully grown in high and medium rainfall areas during winter. Similarly, during rainy season, it is possible to raise successful crops of lady's finger and cowpeas.

To promote vegetable growing in rural and urban areas for family consumption, seed is produced at various departmental farms, and small kits containing seeds of seasonal vegetables are supplied at a nominal cost of Rs. 6/- per kit (Rs21 = US$1 in late 1990) in the province of Punjab. About 50,000 kits are sold annually.

Vegetable Production and Policy in Bhutan

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Introduction

The Kingdom of Bhutan lies in the Eastern Himalayas. Agriculture is the mainstay of the Bhutanese economy. It provides livelihood for about 90% of the nation's population. In 1988, arable agriculture alone accounted for 21.5% of the GDP. In the period 1982-87, this sector grew at an annual rate of 6%.

Vegetables are becoming more and more an integral part of the Bhutanese diet, and are playing an important role in the rural economy. They also make a significant contribution to the Agricultural Gross Domestic Product of the country.

Agroecology of Bhutan

Bhutan has five agroecological zones (Table 1) delineated by temperature and rainfall distribution. The great diversity in the macro and microclimate affects the type of vegetables that can be grown in the country, the areas of cultivation and the time of planting.

The soils of Bhutan are generally of medium texture thus physically favorable for most climatically adapted crops. Chemically, the soils are slightly to moderately acidic (pH 5.0-6.5) with low to very low CEC (10-20 meg). The natural levels of nitrogen and phosphorus are usually low, with moderate organic matter content.

The practice of rainfed subsistence agriculture is still the dominant farming system of Bhutan. Vegetables are rapidly gaining importance as a commercial crop in the warm temperate and dry subtropical areas of the northwest open valleys. In the north-central open valleys and in the east-central steepland, potato is the main cash crop. Potato is also becoming a popular crop in the hills of the southern fringe lowlands. Besides orchards, two cereal-based cropping systems, rice and maize, followed by the potato-based cropping pattern are the dominant cropping systems of Bhutanese agriculture. Vegetables are primarily grown in the rice- and the potato-based cropping systems in rotation and in homestead gardens.

Major Vegetables Grown

The major vegetables grown in different agroecological zones of the country are presented in order of their relative importance in Table 2.

The commercial market gardens for supplying vegetables to the major towns are not fully developed. Most vegetables, besides those listed in Table 3, are grown in homestead gardens, hence it is difficult to measure the actual areas under this type of vegetable cultivation. However, it is estimated that around 5,000 ha could be categorized as homestead gardens. More recently the vegetable cultivation in suburban areas, specifically in districts around Thimphu, the capital, is gaining more importance.

Area and Yield

The area and yield of major vegetables are given in Table 3.

Table 1. Agroecological zones.

Zone	Altitude (m)	Monthly temp (°C) max/min	Mean annual temp (°C)	Rainfall (mm)	Classification of Dzongkhags (districts)
Temperate	2500-3500	22.3/0.1	9.9	650-850	Bumthang
Warm temperate	1800-2500	26.3/0.1	12.5	650-850	Haa, Paro Thimphu, Tashigang, Lhuntshi
Dry subtropical	1200-1800	28.7/3.0	17.2	850-1200	Punakha, Wangdi, Tongtsa, Tashigang, Mongar
Humid subtropical	600-1200	33.0/4.6	19.5	1200-2500	Tashigang, Shemgang, Chirang, P/gatshel, Gaylegphug, Samchi, Chukha
Wet subtropical	150-600	34.6/11.6	23.6	2500-5500	Samchi, Gaylegphug, Samdrupjongkhar

Table 2. Major vegetables grown in Bhutan.

Crops	Temperate	Warm Temperate	Dry sub-tropical	Humid sub-tropical	Wet sub-tropical
Chilies	-	*	*	*	-
Potato	*	*	*	-	
Radish	-	*	*	*	-
Turnip	-	*	*	*	-
Beans:					
Phaseolus	-	*	*	-	-
Cowpea	-	-	-	-	*
Tomato	-	*	*	*	*
Cabbage	*	*	*	*	-
Cauliflower	*	*	*	*	-
Peas	*	*	*	*	-
Cucurbits: (Cucumber, pumpkin, bottle gourd and bitter gourd)	-	-	-	*	*
Soybean	-	*	*	*	-
Garlic	-	*	*	*	-
Leaf mustard	-	*	*	*	*
Brinjal	-	-	*	*	*
Okra	-	-	-	-	*
Chayote	-	-	-	*	*
Spinach	-	-	*	-	-

* Area of cultivation.

Table 3. Area and yield of vegetable crops.

Crop	1981 survey	1983 survey	1992 target
	Area ('000 ha)		
Potato	3.7	4.1	6.0
Chilies	0.6	1.0	1.5
Beans and pulses	4.0	3.2	6.0
	Yield (t/ha)		
Potato	6.8	7.8	9.0
Chilies	2.0	3.7	4.0
Beans and pulses	0.6	0.8	1.0

Marketing

The quantity of major vegetables marketed, according to a 1984 Ministry of Agriculture survey, totaled 24,500 t (potato 22.2 t; soybean 0.9 t; other pulses 0.4 t; chili 0.6 t; turnip and radish 0.2 t; other vegetables 0.2 t).The Food Corporation of Bhutan (FCB) facilitates the marketing of vegetables through its auction yards operated in the four major terminal markets at Samchi, Phuntsholing, Gaylegphug and Samdrupjongkhar. The FCB provides assistance to the growers who bring their produce into the auction hall for sale, including storage facilities, auctioning of the produce, collection of the sale proceeds from the buyers, and timely payments to the growers. The quantity of vegetables auctioned by FCB during the period 1987-89 is shown in Table 4.

Table 4. Major vegetables auctioned by the food corporation of Bhutan.

Crops	1987 (t)	1988 (t)	1989 (t)
Potato	9992	14377	13881
Dry chili	43	57	64
Soybean	196	198	298
Other vegetables	-	1242	961

Source: Statistical information, FCB, January 1990.

Large numbers of small-scale/homestead growers sell their vegetables in the Sunday markets in nearby towns.

Vegetable Production Policy

The national agriculture policy stresses the need to increase the production of vegetables in order to enhance the nutrition intake and also to increase the cash income of the farmers. This increase in production can be brought about by intensifying the cultivation with modern and improved cultural practices.

Production Strategy

To increase the production of vegetables through intensification and use of modern and improved cultural practices, the following strategies have been worked out by the Department of Agriculture:

(1) Research on varietal improvement, cultivation practices, integrated pest management and postharvest technology are stressed as responsibilities of all research stations.

(2) The extension network of the department is distributing leaflets, booklets, holding of exhibitions, production demonstrations, and making free distribution of sample seeds of vegetables to make farmers more aware of vegetable growing, and to increase production and productivity of vegetable crops.

(3) Credit (at low rates of interest) extended to farmers for the purchase of inputs.

(4) Pesticides are subsidized to the extent of 85%, and fertilizer transport costs are fully subsidized by the Government.

(5) Vegetable growers will continue to be given marketing assistance in terms of collection, storage and auctioning of the produce by the FCB.

(6) Seed production, storage and distribution facilities will be strengthened, to facilitate the supply of high quality seeds to farmers.

(7) The private sector will be encouraged to establish agroindustries.

Areas for Collaboration

Although there is tremendous potential to develop the vegetable industry, improved vegetable production in Bhutan is still in the initial stages of development. Therefore, collaboration with established Institutes in the region and IARC's would be of great benefit to the Bhutanese farmers. Specific areas for cooperation include:

(1) Flow of scientific and technical information;

(2) Exchange of visits between Bhutanese and regional/AVRDC scientists on matters of mutual interest;

(3) Strengthening capabilities to undertake research on vegetables;

(4) Technical backstopping from the region and AVRDC scientists on the planning and management of experiments on vegetable production, and on the interpretation of experimental data;

(5) Access to the vegetable germplasm for the Bhutanese scientists working on varietal development;

(6) Integrated pest management research, both in the field and under storage conditions; and

(7) Development of appropriate postharvest technology and quality control methodologies.

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Vegetable Research in Bhutan

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Introduction

Increasing agricultural production and productivity and the per capita income of the rural population are the major objectives of agricultural development in Bhutan. Vegetable crops have an important role to play in achieving these objectives particularly in increasing income.

Scientific research on vegetables was initiated in 1978 when an FAO/DANIDA Vegetable Seed Production Project was launched. This project was successful in screening the present-day popular vegetable varieties and in recommending package of practices for growing vegetables (Pradhan 1982a, b).

The vegetable varieties screened since 1982 that have been released for general cultivation are given in Table 1. The recommended package of practices for growing vegetables was last revised and published in March 1989 by the Research and Extension Division of the Department of Agriculture.

Table 1. Released vegetable varieties.

Vegetables		Varieties
Pea	-	Bonaville
		Frilla
		Usui
Bean	-	Borloto
		Pusa Parvati
		Kentucky Wonder
		Brothbone
		Top Crop
Cabbage	-	Copenhagen Market
		Golden Acre
Cauliflower	-	White Top
		White Summer
		Progress
Chili	-	Sha Ema
		Hot wax
Capsicum	-	California Wonder

(Continued)

Table 1. Released vegetable varieties.

Vegetables		Varieties
Carrot	-	Early Nantes No. 127
		Chantaney Improved
Radish	-	Spring Tokinashi Comet
		Minowase
		Miyashige
		Shogoem Short
Tomato	-	Roma
		Helfruch
		Nozomi
		Fusi 3
Turnip	-	PTWG
		Local Purple
Mustard	-	Him Beauty
		Takama
Japanese Greens	-	Taisai
		Neguna
Bulb onion	-	Senshu Yellow
		Nasik Red
Welsh onion	-	Kujo
Lettuce	-	Great Lake
Cucumber	-	Shabigenchu
		Santo No. 1
Spinach	-	All Green
Chinese cabbage	-	Kyoto 1
Pumpkin	-	Ramthang Brumsha
		Tetsu Kabuta
		Utsuki Red
Brinjal	-	Paro Local
		Big Round
		Pusa Purple Long
Garlic	-	Local Selection
Celery	-	Lort Lake
Parsley	-	Paramount
Broccoli	-	
Brussels sprouts	-	
Melon	-	Honey Dew
Watermelon	-	Asahi Yamato

Traditional Vegetables

The traditional vegetables cultivated in the different ecological zones, in order of their importance, are given in Table 2. In addition to these traditionally cultivated species, there are many important ones that are found in the forests. The major ones include a great variety of mushrooms, bamboo shoots, wild asparagus and ferns.

Table 2. Traditional vegetables of Bhutan.

Common name	Botanical name	Order of importance
Chili	*Capsicum annuum*	1
Radish	*Raphanus sativus*	1
Turnip	*Brassica rapa*	1
Onion	*Allium cepa*	1
Scarlet bean	*Phaseolus*	1
Dolichos bean	*Dolichos lablab*	1
Cucumber	*Cucumis sativus*	2
Pumpkin	*Cucurbita moschata*	2
Potato	*Solanum tuberosum*	2
Garlic	*Allium sativum*	2
Bean	*Phaseolus vulgaris*	2
Soybean	*Glycine max*	3
Black gram	*Vigna mungo*	3
Green gram	*Vigna radiata*	3
Brinjal	*Solanum melongena*	3
Tomato	*Lycopersicon esculentum*	3
Bitter gourd	*Momordica charantia*	3
Bottle gourd	*Lagenaria siceraria*	3
Sweet gourd	*Cyclanthera pedata*	
Pea	*Pisum sativum*	3
Cowpea	*Vigna unguiculata*	3
Yam	*Dioscorea* spp.	4
Colocasia	*Colocasia* spp.	4
Chayote	*Sechium edule*	4
Sponge gourd	*Luffa aegyptiaca*	4
Rice bean	*Vigna umbellata*	4

Presently the research on vegetables is primarily carried out at the Centre for Agriculture Research Development (CARD), Wangdiphodrang. Research activities on vegetables are gradually being made mandatory in other research centers in the country, and a vegetable research coordinator is to be appointed.

Program on Vegetables

The vegetable varieties screened since 1978 were reviewed in April 1990 by the Varietal Releasing Committee (VRC). The outcome of this review led to the official release of 51 varieties as shown in Table 1.

Research Objectives

Research on vegetables is guided by the following objectives:

(1) Screening and developing insect pest and disease-resistant varieties having wider adaptability to five different agroecological zones;
(2) Improving and developing management technologies for higher production per unit area and higher return per unit labor input;
(3) Developing cropping patterns and management technologies such that vegetables are successfully grown in the rice, potato and maize-based cropping systems;
(4) Improving and developing seed production technologies to be able to produce high quality seeds for domestic needs and for export;
(5) Developing appropriate postharvest technologies particularly on harvesting, packaging, handling and marketing;
(6) Developing integrated pest management technology with emphasis on the minimum use of chemical pesticides; and
(7) Developing production technologies towards staggering vegetable production throughout the year.

Constraints to Research

Lack of Germplasm

Screening of varieties adapted to the various agroecological zones of the country is hampered by the lack of germplasm. This is primarily due to the following factors: (a) inadequate local germplasm exploration and collection; (b) lack of a gene bank for national plant genetic resources; and (c) limited contacts and collaboration with IARCs.

Research Capability

(1) Agriculture Research Centre (ARC) - Yusipang, Thimphu-Located at Yusipang near Thimphu, representing the temperate zone.
Mandate: Research on potato and potato-based farming systems.
(2) Centre for Agriculture Research and Development (CARD), Wanddiphodrang - Located at Bajo in Wangdiphodrang, representing the warm temperate and dry subtropical zone.
Mandate: Research on rice and rice-based farming systems.
(3) Agriculture Research Centre (ARC) - Mithun, Chirang - Located at Mithun in Chirang, representing the humid subtropical zone.

(4) Agriculture Research Centre (ARC) - Bhur, Gaylegphug - Located at Bhur in Gaylegphug, representing the wet subtropical zone.
Mandate: Research on rice- and maize-based farming systems.

(5) Agriculture Research Centre (ARC) - Khangma, Tashigang - Located at Khangma in Tashigang, representing the warm temperate zone, and the dry subtropical and humid subtropical zones, with its two substations at Yayung and Rongthong.
Mandate: Research on maize, rice- and potato-based farming systems.

The number of researchers/scientists working at the above five research centers is as follows:

CARD - Wangdiphodrang - 3 nationals + 2 expatriates
ARC - Yusipang, Thimphu - 3 nationals + 2 expatriates
ARC - Mithun, Chirang - 1 national + 1 expatriate
ARC - Bhur, Gaylegphug - 1 national
ARC - Khangma, Tashigang - 2 nationals + 1 expatriate.

Lack of Qualified Personnel

Presently Bhutan does not have a single national scientist who is working full time on vegetable research. The research work on vegetables is still sporadic and by and large undertaken by expatriate staff.

Priorities for Future Vegetable Research

(1) Development of major insect pest and disease-resistant varieties which will fit into the dominant cropping systems of all agroecological zones;
(2) Development of potato varieties that have moderate to high resistance to late blight disease;
(3) Development of effective control measures for diamondback moth which is a serious problem in all cruciferous species, particularly in the seed production of cauliflower and cabbage;
(4) Development of integrated pest management for all vegetables, minimizing the use of chemical pesticides and promoting biological means of pest control;
(5) Off-season production of fresh vegetables with the promotion of plastic greenhouses, especially in the temperate and warm temperate agroecological zones;
(6) Production of temperate types of fresh vegetables in the wet subtropical zone in southern fringe lowland areas;
(7) Improved seed production technologies;
(8) Development of improved management technologies for all vegetable species in all agroecological zones;
(9) Screening of rhizobium and production of inoculum which will have effective symbiosis with all legumes;
(10) Development of postharvest technologies; and

(11) Training of national scientists working on vegetable research and development.

Collaborative Research with AVRDC

The Research and Extension Division (RED), of the Department of Agriculture (DOA), Royal Government of Bhutan, is keen to strengthen its research capabilities on vegetables through collaboration with IARCs like AVRDC. Therefore, collaboration is particularly sought on expert services and technology transfer to assist the national vegetable program in the development of vegetables that are grown in the country. In addition, development of integrated pest management, germplasm evaluation, postharvest technology, seed production technology and socioeconomic studies are other important areas requiring attention and assistance. Training of staff locally and abroad is another important area of collaboration.

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Summary of Discussions - Pakistan and Bhutan

Moderator: K.L. Chadha
Rapporteurs: Ramphal and V. Arulnandhy

Vegetable Production in Bhutan

In Bhutan, major problems of production were identified as follows:

(1) Nonavailability of high-yielding varieties;
(2) Various diseases and insect pests affecting different vegetable crops;
(3) Nonavailability of good seed in required quantity;
(4) Difficult terrain which makes quick movement of produce difficult, thus discouraging growers from taking up cultivation of perishable commodities;
(5) Weak extension service support;
(6) Low priority given to these crops in planning and financial allocation for development;
(7) Lack of suitable transportation of vegetables over long distances, and also lack of varieties which can stand long distance transportation; and
(8) Unorganized or unregulated marketing.

Future priorities or strategies identified include:

(1) Intensification of seed production programs and improvement of the delivery of inputs such as seed and fertilizer to the growers;
(2) Transfer of readily exploitable technology to the growers;
(3) Adoption of suitable improved varieties for cultivation in different zones;
(4) Regulating the marketing system;
(5) Linking production, postharvest handling with marketing; and
(6) Socioeconomic efforts to promote awareness among farmers and consumers to grow and consume larger quantities of vegetables.

Policies and Production of Vegetables in Pakistan

The area under vegetable production in Pakistan is only 1% of the total area cultivated, most of which is occupied by potato (26%), chilies (22%), garlic (2%) and tomato (7%). These crops account for 50% of total vegetable production, while all other vegetable crops, which occupy only 20% of the area, account for 50% of the tonnage.

There has been no change in the productivity of vegetables in the last 15 years, and the increase in vegetable production is mainly due to an increase in area under cultivation. With the projected 7% population growth rate by the year 2000, productivity must be increased, at least to keep pace with the growth rate. The following factors could enhance the growth of the vegetable industry:

(1) Development of the seed industry, including the multinationals;
(2) Improvement in storage facilities;
(3) Improvement in transport facilities including air and sea routes and farm-to-market roads;
(4) Firm import-export policies; and
(5) Marketing regulations to stabilize prices and supply.

After a thorough discussion the following major constraints in Pakistan and Bhutan were identified:

It was noted that major efforts in research on vegetables in Pakistan have been directed to potato. As a result of this work, potato production has gained importance during recent years, with six promising varieties: Desiree, Cardinal, Laal-e-Faisal, Patrones, Diamant and a new clone F8946913 being identified for production in different agroecological zones. October to January was found to be the safest potato seed production period because the aphid population is below the threshold level. In addition to significant progress in identification of varieties of onion, garlic, pea, cowpea, radish, okra, cauliflower, tomato, chili, brinjal, bitter gourd, musk melon, watermelon, etc., successful crop rotations and sequential cropping systems of different vegetable crops have been developed.

The infrastructure of vegetable research in Pakistan includes four federal research institutions and four provincial research institutes, in addition to four agricultural universities. The existing research programs include activities on evaluation of germplasm with particular reference to finding resistance to biotic and abiotic stresses, developing effective management of diseases and insect pests, and developing packages of practices and vegetable-based cropping systems.

In Bhutan, major programs of research cover development of promising varieties in 27 vegetable crops to develop insect pest and disease resistance, improvement of technologies for crop management, development of cropping patterns, improvement of seed production technology and postharvest technology, and integrated management of insect pests and staggering of vegetable production throughout the year.

The major problems of research in Pakistan and Bhutan are:

(1) Nonavailability of germplasm;
(2) Lack of organizational setup for collection, evaluation and conservation of germplasm;
(3) Insufficient research capability due to limited trained personnel;
(4) Limited research infrastructure for vegetable research;
(5) Nonavailability of reliable seed;
(6) Low priority in R and D efforts on these crops; and
(7) Weak linkages with extension agencies.

Based on the above constraints, the priorities for future research in these crops were identified as follows:

(1) Intensification of research on collection, evaluation cataloguing/documentation and conservation of germplasm, and free exchange of germplasm among South Asian countries;

(2) Strengthening of seed technology research on vegetables and intensification of breeders foundation and certified seed programs following a definite well-defined multiplication chain, and with fixed time-frame and targets of production;

(3) Strengthening postharvest technology research with an integrated approach of longer storage and transportability, and development of technologies for preparation of value-added products;

(4) Intensification of research on solving chronic problems of production, e.g. diseases, insect pests and abiotic factors, through resistant varieties, manipulation of crop management practices, chemical control of biotic problems and management of abiotic factors by manipulation of physical parameters; integrated pest management was emphasized for pests;

(5) Improvement of nutritional status of vegetable crops;

(6) Development of vegetable-based cropping systems;

(7) Socioeconomic research with a view to understanding need-based nutritional security programs for areas suffering from malnutrition; and

(8) Human resource development.

For collaboration with other countries and/or other international organizations including AVRDC, the following areas were identified:

(1) Exchange/strengthening of germplasm to introduce desirable genes to meet national needs and in accordance with identified priorities;

(2) Resistance breeding against biotic and abiotic stresses;

(3) Heterosis breeding;

(4) Seed production technology research;

(5) Postharvest management of perishable crops in general and vegetables in particular; and

(6) Training of scientific personnel in various research disciplines.

Vegetable Production and Policy in India

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Introduction

Vegetables play a vital role in the health and nutrition of people throughout the world, as well as providing employment and income which contribute to higher living standards. India is no exception. The country probably grows the largest number of vegetables in the world. Vegetables are excellent sources of roughage, protein, vitamins, carbohydrates and minerals required for maintaining health and curing nutritional disorders, and hence constitute an essential part of a balanced diet. Being short-duration crops, vegetables fit well in the cropping system and it is not uncommon in India to take 3-4 crops in a year in the same field. Vegetables give higher tonnage per unit area in less time than the cereals, and provide better food value. Being labor-intensive, vegetable production also offers better employment opportunities. They also have a much higher export potential than the field crops, and thus can generate valuable foreign exchange.

Agroclimatic Situation

India is a vast country bestowed with a wide range of agroclimatic conditions that enable the growing of fresh vegetables in many parts of the country. This helps to maintain a continuous supply of fresh vegetables, and also provides scope for producing off-season vegetables that are in great demand both in the domestic market as well as in neighboring countries.

India can be broadly divided into temperate (low and high altitude), subtropical and tropical regions for growing various crops. For the first time an effort has been made by Singh to delineate the agroclimatic zones for vegetable growing as follows (Fig. 1):

(1) **Temperate Zone.** In this zone, vegetable crops like tomato, cabbage, cauliflower, turnip, radish, peas, beans, capsicum, lettuce, globe artichoke, asparagus and some cucurbits are grown.

(2) **Northwestern Subtropical Zone.** Almost all kinds of vegetables can be grown in this region except pointed gourd and coccini.

(3) **Northeastern Subtropical Zone.** Vegetables like tomato brinjal, chilies, peas, dolichos bean, cauliflower and cabbage, pointed gourd and other cucurbits including melons, leafy vegetables, okra and root crops are successfully grown.

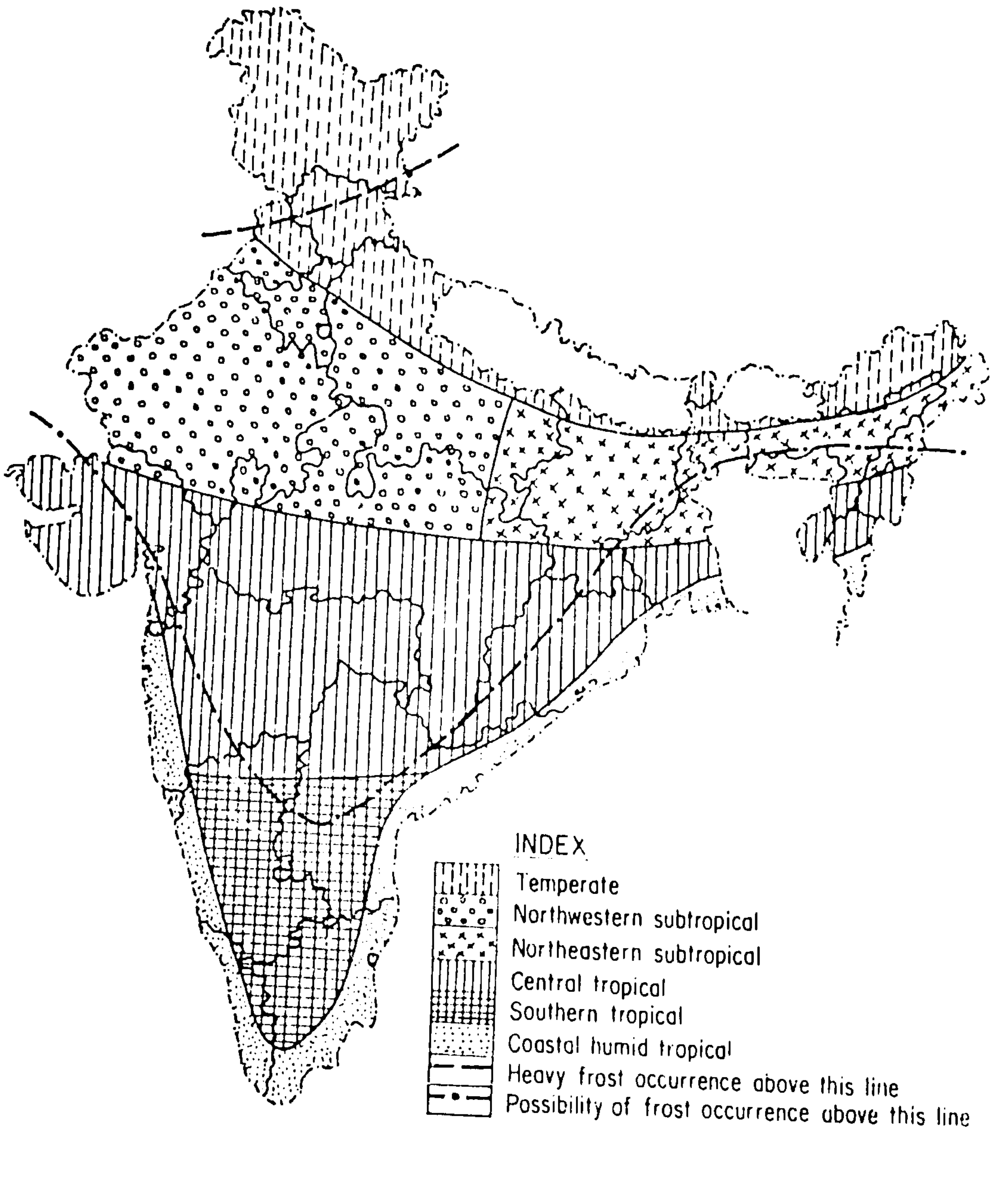

Fig. 1. Vegetable growing zones in India (Singh 1986).

(4) **Central Tropical Zone.** Almost all vegetables can be grown however onion, chilies, tomato and garlic are most important. The region is frost-free except the central part with very mild occasional occurrences.

(5) **Southern Tropical Zone.** Solanaceous vegetables, root and bulb crops, leafy vegetables, beans and cucurbits are commonly grown.

(6) **Coastal Humid Tropical Zone.** Commonly grown vegetables are sweet potato, tapioca (cassava), dolichos bean, winged bean, drumstick (moringa), curry leaves, ginger and cucurbits.

Area, Production and Productivity

In India, vegetables are grown from sea level to the snow line. Horticultural crops occupy only 6.7% of the gross cropped area in the country, however, their contribution to the gross agricultural output is 18.8%. Fruits and vegetables together cover nearly 11.6 million ha. The present area under vegetables is estimated to be about 4.5 million ha or about 2% of the total cropped area in the country. This is low in view of the large population and high demand for vegetables. This does not include areas under kitchen gardens, inter-cropping and river beds.

The present production of vegetables is about 45 million t which is far below the requirement of the rapidly growing population (15 million people are added every year). By the year 2000 India's population is expected to be one billion, requiring more than 110 million t of vegetables. This will need a planned development of area and production. Although about 119 improved varieties have been released at the national level, only 30 to 40% of the area has been reached with these varieties. The area planted and production of vegetables in the country are given in Table 1.

Most of the Indian population is vegetarian, but per capita intake of vegetables is estimated to be only about 135 g against the requirement of about 285 g for a balanced diet. In some advanced and developing countries per capita intake of vegetables is very high (e.g. Italy 593 g, Australia 346 g, Philippines 167 g and Thailand 163 g). India therefore has a long way to go to boost the production of vegetables.

In terms of production India is second only to China. China increased vegetable production from nearly 70 million t in 1975 to 90 million t in 1985, and its growth rate works out to 6.4% from 1982 to 1985. In India, however, it was only 2.5%. Low productivity, less than 10 t/ha, is the main reason for poor availability. Average yield of some vegetable crops is shown in Table 2.

Table 1. Area and production of vegetables by states.

State	Area (ha)	Production (t)	Year
Andhra Pradesh	79330	958184	1986-87
Assam	92797	384961	1985-86
Bihar	781402	7700936	1986-87
Gujarat	84000	1383000	1986-87
Haryana	40500	405000	1987-88
Himachal Pradesh	16400	56000	1986-87
Jammu & Kashmir	1500	15000	1986-87
Karnataka	227704	3532956	1987-88
Kerala	219905	3350708	1985-86
Madhya Pradesh	135916	1398114	1986-87
Maharashtra	214139	829592	1986-87
Manipur	51734	94760	1986-87
Meghalaya	23536	268641	1987-88
Nagaland	2988	32478	1985-86
Orissa	685000	5710000	1986-87
Punjab	78000	1254980	1987-88
Rajasthan	59093	171369	1985-86
Sikkim	8950	56200	1986-87
Tamil Nadu	221637	2315541	1986-87
Tripura	25250	210500	1986-87
Uttar Pradesh	772096	10045560	1987-88
West Bengal	410485	3964617	1987-88
Andaman & Nicobar	2700	6200	1986-87
Arunachal Pradesh	18439	64899	1986-87
Dadra & Nagar Haveli	285	2000	1987-88
Delhi	46920	610900	1986-87
Goa Daman & Diu	6500	55250	1987-88
Mizoram	7227	7588	1986-87
Pondichery	709	12039	1986-87
Chandigarh	-	1970	1984-85
Total	4315142	44959943	

Table 2. Average yield (t/ha) of some vegetables.[z]

Crop	Developed countries	Developing countries	World average	India: Experimental[y] plot	India: Farmers' fields
Cabbage	27.2	17.5	23.0	20-50	6.1
Cauliflower	15.8	11.1	13.3	20-35	7.4
Peas	7.6	3.8	6.4	7-11	2.8
Onion	20.4	11.2	15.0	20-50	10.6
Tomato	32.1	16.7	23.0	15-65	9.8

z FAO Year Book 1987

y Information based on All India Coordinated Vegetable Improvement Project.

Seasonal Availability

Although modern technological advances have made it possible to take 2-3 crops per year of the same vegetable from the same field, and some of the vegetables can be grown year-round, the production by and large is still season-bound. During the summer and spring seasons, leguminous vegetables like cowpea, cluster bean, french bean, and solanaceous vegetables such as tomato and brinjal, are abundantly available. During the rainy season, gourds, okra, beans and brinjal are common. The winter season is the most important for growing a wide variety of vegetable crops. All cole crops, root crops, onion, leafy vegetables, salads and peas are commonly grown and consumed in all parts of the country. However, with the new technology, seasonal barriers are being broken and off-season production of vegetables is becoming popular. Varied agroclimatic conditions also contribute to production of different kinds of vegetables. Thus many vegetables can be grown and seen in the market during any season.

Production Costs and Returns

Adequate information on production costs and returns of different vegetable crops has not been generated. However, the cost of cultivation varies from Rs. 3500/- to Rs. 25,000/-/ha (US$1 = 17.98 Rs -- late 1990), depending on the location and kind of vegetable grown, showing the capital-intensive nature of these crops. The amount of credit advanced by the institutional agencies like cooperative societies and commercial banks for cultivation of vegetables is not generally adequate to meet the requirements.

The cost of marketing vegetables is quite substantial and accounts for more than 50% of the amount spent on total inputs. Hence the marketing cost must be treated as part of the cost of cultivation for estimating and advancing credit. The dominance of the commission agent in the vegetable trade, and the higher proportion of commission charges in the marketing cost, shows the necessity for creating alternative marketing channels. To improve marketing efficiency, it is necessary to create a Vegetable Marketing Board to regulate vegetable marketing. Cooperative marketing societies of vegetables reveal that cooperatives can offer better returns to the producer provided steps are taken to check mismanagement and other possible problem areas.

The traditional vegetable growers are generally poor, and include small, marginal, and even landless farmers. Because of limited resources at their command, they are not in a position to make sure of new technologies because of lack of information, and are growing traditional cultivars with low yields. Larger middle-class progressive farmers, on the other hand, adopt the latest technology for modernizing their production with the new improved varieties and latest technology recommended for fertilizer, pesticides, weedicides, etc. This enables them to make profitable earnings from their vegetable production. Consumption of vegetables is directly related to the socioeconomic status of the people. Middle and higher income groups of people are consuming recommended and even higher quantities (200-350 g) of vegetables per capita per day, whereas the low income rural people are not able to consume even a few grams of vegetables per week.

Nutrient Management

The use of manures and fertilizers is essential for increasing the production of vegetables. At one time only organic manures were used for vegetable production in India by the traditional growers, and even now the use of manure or compost is indispensable for vegetables. Green manuring, although useful, is now very seldom used for vegetable production as no grower likes to be deprived of one crop during that period. Poultry manure is now available in large quantities and being used for vegetable growing in certain areas of Punjab, Haryana, Uttar Pradesh, Andhra Pradesh, Karnataka, and other areas.

There persists a notion that use of chemical fertilizers in vegetable production adversely affects the quality, and such vegetables do not taste good. Despite this, use of chemical fertilizers has become popular in India, although high cost is the limiting factor particularly for small and marginal farmers who constitute the majority of vegetable growers. Almost every vegetable grower in India is now aware of the usefulness of nitrogen for increased yield. In most of the Indian soils, nitrogen is deficient but phosphorus and potash are available in large quantities. However, in areas deficient in phosphorus and potassium as indicated by soil testing, about 60-100 kg/ha P_2O_5/K_2O and 25-120 kg nitrogen/ha are recommended for vegetable crops, depending on the requirement of individual crops.

The use of micronutrients in vegetable production is gradually becoming important. Although a part of the requirement is met by application of manure, compost or poultry manure, deficiencies in certain areas of the country are still common, and use of micronutrient fertilizers in such regions has been found beneficial. Sprays of 2% sulfate and borax solutions have been found to increase the yield of tomato.

Spraying of 10 and 20 ppm of calcium and 4 ppm boron solutions has resulted in increased yields and improved quality in muskmelon.

Water Management

In India vegetables are produced throughout the year with variations in the time of planting and season. In the tropics and subtropics during the rainy season (June-September) and winter season (October-January), the water requirement of vegetables is less compared with the spring-summer season (February-May). In temperate regions, occurrence of severe frost coupled with snowfall is a limiting factor in vegetable production in winter, but during the rainy season and mild summer, water requirements of vegetables are less for the tropical and subtropical regions.

Although command area development and tubewell installation facilities have been increased recently, lack of adequate and assured irrigation in various vegetable growing zones of the country has been responsible for low productivity. The cropped area of the country is about 30%, with a negligible share for vegetables, while most of them require supplemental irrigation for optimum production and high yield.

Vegetables in general are heavy users of moisture and draw a large share of irrigation resources. The need for high-yielding, short-duration varieties for water use efficiency is much more than low-yielding ones. Furrow irrigation economizes water use in vegetables. Drip or trickle irrigation has proved useful in growing tomato and okra in Maharashtra, with a saving of 56 and 69%, respectively. Similarly, drip irrigation has also been beneficial in Haryana in onion, radish, carrot and turnip. In Kerala, pitcher irrigation has successfully been adopted for growing vegetable crops like watermelon during the summer season. The technology is also becoming popular where water is not fit for direct irrigation.

Since about 70% of the cultivated area of the country is still rainfed, these areas are faced with twin problems of low productivity and unpredictable rainfall. The cropping pattern in the heavy rainfall areas shows the dominance of paddy. Tuber crops, plantation crops and some cereals like maize, ragi and other smaller millets appear in between. In areas with good rainfall during March, April and May it is possible to grow some vegetable crops, and the same can be done even during the post-monsoon period where rainfall extends over October and November. Wherever temperature conditions are milder, it may be possible to use vegetables as relay crops. Water harvesting is now considered an important tool for improvement of crop productivity under rainfed conditions. Mulching with sawdust, straw and polythene has been used to conserve moisture in such areas. Pitcher farming in rainfed areas has shown great potential for growing some vegetables like cucurbits.

Plant Protection

Weed Control

The weed menace in vegetables is worse than for other crops since they are grown mostly on fertile and well-drained soils with frequent irrigation, heavy manuring and wide spacing. Generally, the summer and rainy season vegetables suffer more due to weeds as compared to winter vegetables. Several chemical herbicides have been tested in India and recommended for use in vegetable production, but their limited availability and high cost have restricted their use on a commercial scale. So far only TOK E-25 Simazine, Grammaxone and Lasso have been used in potato at preemergence stage in Punjab, Haryana and Tarai areas of Uttar Pradesh. Use of Basalin is effective for weed control in okra, onion in Bihar, Uttar Pradesh, Punjab, and Haryana. Likewise Stomp has been found useful in peas and brinjal in Uttar Pradesh, Punjab, Bihar and Haryana. Mulching with sugarcane trash, paddy straw and water hyacinth, which are available in quantity, has effectively and economically been used in wide-spaced vegetables like tomato, brinjal, cole crops and cucurbits.

Disease Management

Almost every vegetable grown in India suffers from a number of diseases, but only some cause severe losses. Early and late blight in potato and tomato; phomopsis, fusarium wilt and little leaf in eggplant; mildews in cucurbits and peas; fruit rot in chilies, tomato and cucurbits; bacterial wilt in tomato and eggplant; purple blotch, basal rot and stemphyilium in onion; sclerotinia rot and black rot in cole crops; stem blight, anthracnose and rust in beans and damping off and viral diseases in a number of vegetables cause severe losses. Among viral diseases, mosaic and leaf curl in tomato and chilies, mosaic in beans and cucurbits and yellow vein mosaic in okra are disastrous throughout the country. Control measures for many diseases have been worked out based on research findings. Most of the diseases can be controlled with Bavistin and Dithane M-45. But still several of them, mostly the viral ones, cannot be effectively controlled and need further research work to provide a proper solution.

Insect Pest Management

Insect pests, mites, nematodes, rodents, birds, etc. are responsible for substantial losses of vegetables in India. Cole crops like cabbage and cauliflower are attacked by diamondback moth, tobacco caterpillar, cabbage butterfly, cabbage semilooper, etc. Aphids are the main pests on root and cole vegetables. Thrips are important on onion and garlic. Fruit and shoot borer is a widely distributed pest mainly on eggplant (brinjal) and a very serious one. Epilachna beetle attacks eggplant, and red pumpkin beetle is a common pest of cucurbits. Melon fruitfly is active throughout the year in various parts of the country. Spotted boll worm and jassids are serious pests of okra. Tomato fruit borer is quite serious throughout the country. Root knot nematodes seriously affect most vegetables, particularly in light soils, and cause considerable damage.

Insecticides dominate in the strategy of vegetable pest management in India. However, care is required in selecting safe pesticides to fight pests attacking vegetables, because residues left on the plants may cause health hazards to people and animals. Normally two safer insecticides, Malathion and Carbaryl, are recommended for vegetable crops. Specific recommendations on control measures, based on research work done in India on important insect pests of vegetable crops, are adopted by the growers.

Cropping Systems in Vegetables

In certain areas vegetables are cultivated in monoculture, whereas in other areas vegetables are grown in sequence with cereals, oilseeds, pulses, etc. The system of mixed and companion cropping or intercropping is also common in vegetables. A system of relay cropping, in which a rotational crop is planted at the maturity stage of the previous crop, has been developed and is being followed which increases land-use efficiency. Intercropping of okra, cowpea, guar and cucurbits during the spring season is becoming popular. Short-duration vegetable varieties are being utilized in these cropping systems.

Postharvest Handling and Processing

Handling of Vegetables

Handling of vegetables after harvesting involves several steps before reaching the consumer. Improper handling of the produce results in a reduction of the market value, keeping quality and food value. Losses can vary from 25 to 40%, depending on the type of vegetable. These losses are due to inadequate knowledge of harvesting, curing, packaging, transport and storage techniques. Most vegetables are disposed of as early as possible after harvesting, while some of them like onion, potato, garlic, sweet potato, colocasia etc., are stored for a longer period. A huge quantity of onion and potato go to waste because of improper curing. Washing of vegetables is normally done either by dipping in water or by sprinkling with water. In certain cases retailers continue to sprinkle water while selling in the market to maintain freshness. No mechanical washers and treaters have been developed to date. Waxing of vegetables, although recommended by the Central Food Technology Research Institute, Mysore, is used very rarely. Precooling is rarely practiced to remove field heat.

In practice, grading is seldom done except by wholesale and retail traders. The need for grading agricultural produce was recognized in India as early as 1937, when the Agricultural Produce Grading Marketing Act (APGM) was passed by the Government to adopt AGMARK standards which exist for a number of commodities. Indian Standards Institution has also prescribed standards in certain vegetables, but there is no proper follow-up. Use of mechanical graders, although common in some countries, is very rare in India.

The vegetable trade in India is faced with serious problems of packaging. Vegetables are normally packed in jute bags, bamboo baskets and expensive wooden boxes of varying shapes and sizes. Some vegetables are transferred as free loads in trucks, with paddy straw as the cushioning material, which results in nearly 10% spoilage during transit.

Recently some supermarkets supply vegetables in packages of known quantity in various sizes in large cities like Delhi, Bombay, etc. In recent years corrugated fiberboard (CFB) containers are used for packaging of vegetables for domestic and export markets. Experience reveals that corrugated kraft paper cartons are the best alternative to the conventional wooden boxes, bamboo baskets and jute bags.

In India vegetables are carried on head loads, on the backs of animals and bullock carts for short distances to assembly markets, from where they are transported to consumer markets mainly by road transport and rail. No proper refrigeration system, either through trucks or rail cars, have so far been developed in India for long distance shipment of vegetables.

In India vegetables are normally stc d under ordinary room or open conditions either by the grower in his house or by the trader until final disposal. In some areas of Kashmir and Himachal Pradesh field storage in trenches, pits or mounds is still practiced. Country methods of storage have been in use for storing potato and onion, but huge losses occur due to rotting and sprouting. Cold storage facilities, although insufficient, have been developed for potato, but for other vegetables they are almost nonexistent. The first cold storage with a capacity of 825 t was built in West Bengal for potatoes, followed by a chain of cold storages throughout the country; 90% of refrigeration space is utilized for storing potatoes. For nonrefrigerated storage, 20-t capacity evaporatively cooled insulated potato stores for storage for less than three months have been developed. The National Horticulture Board (NHB), in collaboration with the Associated Agricultural Development Foundation (AADF), has taken up schemes to popularize passive evaporatively cooled stores for potato. AADF has also developed improved methods for storage of onion in addition to the NAFED system. A zero-energy cool chamber has been developed at IARI for vegetables.

Processing of Vegetables

Vegetables in India are processed mainly in these forms: canned/bottled, dehydrated, frozen vegetables and tomato products. Among these, tomato products are the most common, followed by canned/bottled and dehydrated vegetables. Since we consume large amounts of fresh vegetables, canned vegetables have not gained much importance. Major requirements of canned vegetables come from defense forces and places such as expensive hotels, restaurants and for export. There is not much domestic demand, due to the high cost of cans. There is no vibrant dehydration industry in the country. The processing of peas by Hindustan Levers was followed by other units, established with Bulgarian equipment to meet export requirements for dehydrated onion and garlic. In hilly states sun-drying of some vegetables is done for personal consumption in off-periods. Frozen vegetables are receiving attention from the institutional buyers. Freezing of peas, corn, cauliflower, french beans and carrots is becoming more popular.

Maharashtra produces the most canned/bottled vegetables, followed by Himachal Pradesh and Uttar Pradesh, whereas Gujarat and Maharashtra are the major processors of dehydrated vegetables. Maximum processing of tomato is done in Karnataka followed by Maharashtra and Punjab, whereas Maharashtra and Delhi are the largest processors of frozen vegetables in the country. Pepsi Cola, a multinational company, is becoming involved in Punjab in the processing of tomato and potato.

The export and production figures for India have indicated that there is a continuous growth of frozen vegetables and tomato products, whereas canned and dehydrated vegetables have shown a fluctuating trend. Tomato paste is a potential item for export development. Recently, a leading processor exported crushed tomatoes to Australia. There is a large demand for canned French beans in Europe, particularly during off-season. Canned/frozen peas is another item of international interest. EEC countries have shown interest in dehydrated cauliflower, flower heads, stalk of cauliflower, leek green and white, celery leaf, spinach (dark green), pumpkin powder, asparagus (white powder), broccoli, parsley leaf, chives, tomatoes and red capsicum powder. Some of these are required for imparting color to dishes like spinach, pumpkin and red capsicum. Holland requires a huge quantity of small cucumbers in vinegar. Thus, there is a great scope for the export of processed vegetables. Creating a separate Ministry for Food Processing by the Government of India is a forward step in promoting this industry.

Marketing of Vegetables

An efficient marketing system is absolutely essential to help the producer in getting profitable prices. The marketing of fresh vegetables today faces a number of problems. The high degree of perishability, seasonality, bulky nature, etc. have led to numerous marketing problems like concentration of the trade in a few hands, high transport costs, huge marketing margins, etc. The marketing costs in vegetables account for more than 50% of the cost of cultivation itself, thus reducing the income to the farmers and contributing significantly to the increase in cost of production. Most of the vegetables are sold by the growers to the commission agents who are dominating the trade and realizing disproportionate profits. At present there is no other viable and attractive channel for marketing of vegetables, as the existing cooperative societies and other agencies are unable to provide efficient marketing outlets to attract vegetable growers.

An analysis of marketing costs for vegetables has shown that commission charges and transport costs accounted for 80-90% of the total marketing costs. Hence, for improving market efficiency, there is a need to reduce these two costs by controlling the activities of intermediaries by regulation of trade and by establishing more cooperative societies or by creating marketing boards. Further, market costs could be treated as a part of the cost of cultivation in advancing credit to growers.

Lately cooperative organizations have undertaken procurement, storage and marketing of vegetables. The National Agricultural Cooperative Marketing Federation (NAFED), at the national level, in collaboration with affiliated state federations and primary marketing societies, has taken up procurement and marketing of potato, onion, ginger, etc. Besides NAFED, there are about 12 state/central level societies and 275 primary marketing societies directly engaged in the marketing of vegetables. Other cooperatives that are providing good services in the marketing of vegetables are: Bangalore Horticulture Produce Marketing and Processing Society Ltd. Lalbagh, Bangalore; Nilgiris Cooperative Marketing Society, Udhagamandalam, Tamil Nadu; and Nilgiris Vegetable Growers Cooperative Marketing Society, Udhagamandalam, Tamil Nadu.

Import and Export Trade

Some unorganized export trade is in vogue to supply vegetables mainly to the Middle East, Sri Lanka, Singapore, Malaysia and other countries. Organized efforts are limited and mostly inadequate. Vegetables like chilies, onion, garlic, okra, tomato, brinjal, cabbage, cauliflower, peas, beans, etc., are being exported to the Gulf countries. Indian exports of fresh and processed vegetables and fruits increased from Rs. 647 million in 1980-81 to Rs. 1492 million in 1984-85, registering an average annual growth rate of 22% during a five year period. Export of fresh vegetables alone in 1984-85 was 0.31 million t valued at Rs. 698.5 million compared to 0.21 million t for Rs. 324.6 million in 1980-81. Thus fresh vegetable exports registered a growth of 49% by weight and over 115% by value during the five year period.

A state-level federation has been organized at Farrukhabad in Uttar Pradesh. Fresh Marketing Cooperative Society Ltd., Hyderabad, is marketing vegetables in packed form. A similar society is working at Sonamura in West Tripura. Asia's largest market of vegetables has been established at Azadpur in Delhi.

Seed Production and Distribution

Seed is the most important single input in increased quality vegetable production. Seed production and distribution in vegetable crops in India has not been properly streamlined. National Seeds Corporation (NSC), a Government of India undertaking, is unable to cope with the huge demand for quality seed. State Farms Corporation of India (SFCI) is multiplying seeds of a few vegetable crops only. Some agricultural universities have their own multiplication program. In some states, government departments of agriculture/horticulture have independent programs of vegetable seed multiplication but it barely meets their own demands to the extent of about 10-20%. Most states have established their own seed corporation and seed certification agency, but there is very little emphasis on vegetable seed production and certification. Under the National Seed Project, ICAR and the World Bank have provided considerable financial assistance to agricultural universities and state seed corporations, but again the component on vegetable seed production is small. Under the National Seed Project, 11 centers are participating in breeder seed production.

There are a number of private vegetable seed growers, estimated to be around 4000-5000, in the entire country. There are about 500 seed traders in the country but only about 25 of them are involved in the supply of good quality seeds after packing them nicely with printed and beautiful labels in paper packs or tin cans, and some of them export vegetable seeds to other countries also after obtaining permission for such trade from the concerned government ministry.

Lately hybrid seeds of vegetables have been gaining public as well as private sector attention. Superiority of hybrid varieties in vegetables with regard to high yield and quality was established in India as early as 1973. Undoubtedly, the high cost of hybrid seeds is one of the limiting factors to some extent for the popularity of these seeds. However, several growers in Maharashtra, Karnataka, Punjab, Uttar Pradesh and Gujarat states have readily adopted hybrid varieties. Now hybrid tomato covers nearly 50,000 ha while hybrid cabbage covers about 20,000 ha. The private seed industry has gone into the marketing of hybrid seeds in a big way, both for domestic use and export trade.

Role of Vegetables in Human Nutrition

Although most of the Indian population is vegetarian, the average per capita consumption of vegetables is very low. In fact it would be more appropriate to call the Indian population cerealists who supplement their cereal diet with vegetables. This is particularly true for the rural population. Leafy vegetables are known as protective foods as they are rich sources of vitamins and minerals.

Root and tuberous vegetables are rich in carbohydrates, leguminous vegetables are important for the supply of protein, and tomato, carrot, pumpkin, squash, melons, okra, salads and leafy vegetables are important for supplying vitamins and minerals.

The nutritional importance of vegetables has not been appreciated and realized by the majority of the rural population in India, which has resulted in widespread malnutrition leading to several physical maladies, diseases and disabilities in people of all ages. The importance of vegetables is being recognized after attaining self-sufficiency in food grains and, therefore, more emphasis is being put on providing nutritional security to the people by appropriate emphasis on vegetable production and consumption.

Constraints in Vegetable Production and Promotion

There are several constraints in the production and promotion of vegetables at various levels in the country:

(1) There is an inadequate organizational set-up at the central and state levels for planning and execution of vegetable production programs;
(2) Except for onion, garlic and chilies, no reliable statistics on area, production, and productivity of other important vegetable crops are available;

(3) So far there has been a very small allocation in the budget at central as well as state levels for vegetable production programs;

(4) Vegetable production and promotion programs have never been properly integrated into the various national, rural development and employment programs of the country;

(5) Lack of irrigation facilities and high price of chemical fertilizers have been the major bottlenecks in low production and productivity of vegetables;

(6) Vegetable growing is done mostly by small-scale and marginal farmers who are at the mercy of intermediaries for the disposal of their produce, due to lack of properly organized transport and marketing systems;

(7) The present agencies and organizations have not been able to meet adequate requirements of quality seed of vegetables;

(8) Hybrid varieties of vegetables have not become popular due to availability of costly seed which is beyond the reach of small growers;

(9) There is a lack of suitable high-yielding varieties to resist adverse conditions like biotic and abiotic stresses;

(10) Very little attention has been given to research under rainfed and riverbed conditions;

(11) Adequate attention has not been given by the extension agencies regarding awareness of high nutritional and socioeconomic importance of vegetables;

(12) There is lack of adequate infrastructure for prevention of huge postharvest losses of vegetables due to improper handling; and

(13) We have not been able to develop suitable varieties for processing, and to exploit the potential for export within and outside the country.

Present National Policy and Future Strategy

In fact, there has been no definite policy on vegetable production either at the national level or at the state level in the country until recently; only ad hoc schemes have been in operation. There have been no long-term central or centrally sponsored programs for vegetables. A project for identification of vegetable cultivation through distribution of minikits for small, marginal and tribal farmers and implemented by the government through the National Horticulture Board which distributed 184,000 minikits in 58 districts of 20 states/union territories. The Board also implemented a contingency plan for strengthening the supply of vegetables around drought-affected areas during 1987-88, under which 21,473 minikits were distributed in 42 districts of 12 states/union territories. This scheme also generated additional employment of 97,760 person-days. The National Horticulture Board has also carried out studies to assess the demand and supply position in 22 important cities of the country, in addition to assessment of postharvest losses through the Associated Agricultural Development Foundation. The Board has also started a market information service for the vegetable industry.

Short-term vegetable development schemes have been in operation in various states. For example in Madhya Pradesh, a scheme on development of vegetable cultivation is being implemented under which technical advice, improved seed and small fertilizer packets on cost are being distributed at the divisional headquarters.

Likewise in Karnataka, schemes on production of quality vegetable seed, increase in area, marketing, kitchen gardening, etc. are in progress. Similar short-term schemes have also been taken up in other states.

It is heartening to note that a separate division of horticulture in the Ministry of Agriculture, Government of India, was created in the Seventh Five-Year Plan, and it is headed by a Horticulture Commissioner. Incidentally, Dr. K. L. Chadha, presently Deputy Director General (Horticulture) took over as the first Horticulture Commissioner of the country. The role of the Horticulture Commissioner is to plan, advise and monitor horticultural development in the country, and vegetables are naturally an important component of the whole process. In the states, this responsibility lies with the directors of horticulture or agriculture. National Seed Corporation and state seed corporations, government undertakings, have been entrusted with the responsibility of producing quality seeds of vegetables in close collaboration with seed certification agencies established under the Seed Act of the Government of India 1966. These corporations are not able to meet the demands of the country with regard to foundation and certified seeds.

The Indian Council of Agricultural Research has been responsible for planning, guiding and monitoring vegetable research, including breeders' seed production, in the country. It has established research institutes, national centers and coordinated projects on vegetables, potato, tuber crops, spices, etc. throughout the country. A happy feature is that ICAR has created an independent division of horticultural crops, for the first time, headed by a Deputy Director General (Horticulture), assisted by three Assistant Directors General, one of whom is responsible for vegetable and tuber crops. This has added the required importance to vegetable research which was neglected in the initial stages.

A New Policy on Seed Development has been evolved and recently implemented by the Government of India. The thrust of the new policy is to provide high quality seeds for the farmers, available anywhere in the world to maximize the yields and to increase the farm incomes. In short, the new seed policy emphasizes the following (1) importation of high quality seed; (2) a time-bound program to strengthen/modernize plant quarantine facilities; (3) effective observance of procedure for quarantine/postentry quarantine (PEQ); and (4) incentives to encourage the domestic seed industry.

Policy of vegetable research has been directed to work on solving chronic production problems through development of improved disease and pest resistant, short-duration and widely adaptable varieties to fit into various cropping systems in different agroecological situations, and development of appropriate agrotechniques and plant protection measures. Seed technology research and standardization of the technology for export-oriented production has to be given special attention. Budget allocation for vegetable development at the national level is accorded a low priority since it is a state subject. However, the states have been advised to make appropriate/adequate budget provisions for promotion of vegetable production during the Eighth Plan. Budget allocation in the Eighth Plan proposed tentatively for central sector on vegetable development is of the order of Rs. 300 million against Rs. 1 billion for fruits and Rs. 2.5 billion for all horticulture (1 US$ = Rs. 17.98 - late 1990).

Specialization and human resource development specifically for vegetables in the state departments of agriculture get low priority. However, this is accorded a fairly high priority in the states having separate directorates of horticulture.

Different vegetables receive different priorities in different agroclimatic zones of the country. Commercial vegetables like brinjal, tomato, peas, cole crops, onion and garlic, etc., are grown throughout the country, whereas crops like pointed gourd, amaranthus, snake gourd, round melon and ivy gourd are of regional importance only and are grown in limited areas of specific regions.

A national policy on agriculture is in the offing. A document has been prepared by the Government of India. It is still to be passed by the parliament and implemented. It is hoped that interest on vegetable production, postharvest technology and export will be protected fully under this policy. In the future agricultural policy resolutions emphasis has been laid on diversification of agriculture, providing nutritional security, improvement of quality of life and raising the socioeconomic standard of the farming community, as well as more employment generation. In this task vegetables have to play a major role and have to be suitably incorporated into different farming systems.

Future strategies and thrusts will have to be developed in order to make the country self-sufficient and to meet the requirements of the fast-growing population for reasonable nutritional security and income standards.

(1) We have to aim at a target of increasing vegetable production in the future as indicated in Table 3.

Table 3. Area, production and yield of vegetables.

Duration	Area (million ha)	Production (million t)	Yield (t/ha)
Present	4.5	48.5	10.0
Short-term (1990-95)	6.0	75.0	12.5
Long-term (up to 2000)	8.0	120.0	15.0

(2) A proper system of collection of reliable statistics of area, production and productivity of at least a dozen important vegetables will have to be adopted by the concerned agency at both central and state levels.

(3) Special schemes for boosting vegetable production around big cities managed by state governments and voluntary agencies may be started. In addition, schemes for popularization of vegetable cultivation in the interior villages,

tribal areas, riverbeds and other ideal locations in nontraditional areas are considered essential.

(4) There is a need for improving and strengthening the seed-producing agencies for better quality seed production and supply. Breeders' seed production programs by institutes and agricultural universities need to be augmented. Hybrid seed production at lower cost should be encouraged and NSC, SFCI and AADF should also be involved in this venture in addition to the private seed industry. Concept of specialized vegetable seed villages should be advocated. In fact, the time has come when there should be a separate corporation at the national level to deal exclusively and extensively with vegetable seeds.

(5) Extension programs on improved technology of vegetables have to be strengthened. Extension workers need to be fully trained in vegetable production technology. Vegetable production programs should also be linked with other rural development programs. Awareness programs on nutrition gardens, kitchen gardens, and school and community gardens need greater emphasis. In fact, a separate Vegetable Extension Agency within the state department of horticulture for providing assistance to vegetable growers from a single window would be ideal.

(6) Irrigation potential has not been properly exploited for vegetable production. More tubewells should be installed and water-saving devices like drip irrigation should be encouraged.

(7) Rainfed and riverbed vegetable production should be promoted and research on these aspects should be intensified.

(8) Greater attention will have to be given to integrated nutrient, waste and pest management for attaining higher production and productivity of vegetables.

(9) Research on production technology of hybrid vegetables and seeds, development of varieties rich in nutrients, improved shelf-life, resistance to diseases, insect pests, drought, heat and frost, etc. will need more emphasis and concerted efforts.

(10) There is good scope for entering the international trade in fresh vegetables and processed products. This will involve development of suitable varieties of vegetables for export as per specifications and requirements of the importing countries. Postharvest technology including development of value-added products as a whole needs considerable improvement.

(11) Breeding yield barriers in vegetable crops through application of emerging areas of science such as biotechnology, bioengineering, tissue culture, etc. should be given due importance in research and multiplication of planting materials.

(12) Finally, good support from the government and promotion policies favorable to research, development, trade and export of vegetables will help in meeting the challenges ahead.

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Vegetable Research in India

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Introduction

Nearly 60 vegetables are grown in India. The major vegetables include:

Solanaceous Crops:	Brinjal, tomato, chilies, sweet pepper (Capsicum).
Cole Crops:	Cabbage, cauliflower, knol khol.
Okra:	
Bulbous vegetables:	Onion, garlic
Cucurbits:	Longmelon, muskmelon, snapmelon, watermelon, cucumber, pumpkin, summer squash, bitter gourd, bottle gourd, pointed gourd (parwal), ridge gourd, round gourd, snake gourd, sponge gourd, waxgourd (ashgourd).
Root vegetables:	Carrot, radish, turnip.
Leguminous vegetables:	Broad bean, cluster bean, cowpea, dolichos bean, french bean, peas.
Leafy vegetables:	Amaranthus, beet leaf (Palak) fenugreek, spinach.
Salad vegetables:	Lettuce.

India is the second largest producer of vegetables in the world, next only to China, with an estimated production of about 48.5 million t from an area of 4.5 million ha. India produces the largest number of vegetables in the world. However, the daily per capita consumption of vegetables in India is only 135 g which is quite low.

In recent years, systematic efforts have been made to upgrade vegetable production technology. A major research and development effort is still needed to achieve our target for the supply of 200 g of vegetables per capita per day to an estimated population of 1 billion by the year 2000. However, our efforts to date are still inadequate due to priority given to food grain production.

Research Infrastructure

Institutions/Programs

Research on vegetable crops in India was initiated by the Indian Council of Agricultural Research (ICAR) during 1947-48 with the approval of a Plant Introduction Scheme at the Indian Agricultural Research Institute (IARI), New Delhi. Simultaneously, ICAR started various schemes in different states (e.g. Himachal Pradesh, Jammu and Kashmir, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh and West

Bengal). The Government of India also established a Vegetable Breeding Station at Katrain in Kulu Valley, Himachal Pradesh, in 1949. This station was transferred to IARI in 1955 and has carried out intensive research on temperate vegetables and their seed production.

Systematic research on vegetables was organized with the creation of the Division of Horticulture at IARI in 1956-57. However, it received a real boost with the establishment of the Indian Institute of Horticultural Research (IIHR), with a full-fledged Division of Vegetable Crops at Bangalore in 1968. A separate Division of Vegetable Crops and Floriculture was also started at IARI, New Delhi, in 1970. In 1982, the floriculture work was separated from the Division of Vegetable Crops which was assigned research work exclusively on Vegetable Crops. Besides IARI, IIHR and their Regional Stations at Katrain, Ranchi and Godhara, the Central Institute of Horticulture for Northern Plains at Lucknow has also been given a mandate to work on vegetable crops of the region. As well, Vivekanand Parvatiya Krishi Anusandhan Shala, Almora, Central Agricultural Research Institute, Port Blair, and ICAR Research Complex for Northeast Hill Region Shillong are also carrying out some research work on vegetable crops to meet regional needs.

The establishment of 26 agricultural universities in 17 states from 1960 onwards gave a further boost to vegetable research, which is being carried out by their horticulture departments and in nine cases by separate departments of vegetable crops.

An All India Coordinated Vegetable Improvement Project (AICVIP) was also started by ICAR in 1970-71 (Fourth Plan), to provide a national grid for testing of technologies developed by various research institutes and agricultural universities through an interdisciplinary, multilocation research approach. The project was started with seven main and 10 subcenters. Three centers were added during the Fifth, two in the Sixth and two in the Seventh Plan. At present there are 23 centers working under this project. This project was upgraded as a Project Directorate of Vegetable Research during the Seventh Plan and is undertaking multidisciplinary, multilocation research at 23 regular centers besides 22 voluntary centers. The project is presently located in Delhi but it is proposed to shift it to Varanasi, Uttar Pradesh.

In addition to this, a number of short-term, time-bound and result-oriented ad hoc schemes on area-specific problems of selected vegetable crops are being supported by ICAR at various central institutes and state agricultural universities. There is also one foreign assisted project on postharvest technology of some fruits and vegetables. A project on protected cultivation and greenhouses will be implemented with USAID support.

Most vegetable research has been carried out in India by public institutions. However, in recent years there has been an effort to undertake R and D activities by some private companies with foreign collaboration. Some private companies conducting research include M/S Indo-American Hybrid Seed Co. Bangalore; M/S Mahyco Jalna, Maharashtra; Nath Seeds, Aurangabad, Maharashtra; Suttons & Sons, Calcutta, West Bengal; Bejo Sheetal Hybrid Seed, Jalna, Maharashtra; Biogene Bangalore; Karnataka & Unicorn Group in Hyderabad, Andhra Pradesh.

Budget

Budget allocations to different groups of horticultural and other important food crops are given in Table 1. The amount represents allocations only to ICAR programs and is not comprehensive since expenditures on vegetable research by other institutes/agricultural universities have not been included. Investments in vegetable research are insignificant when compared to cereals, and rank fourth highest amongst horticultural crops next to fruit, tuber crops and plantation crops.

Table 1. Budget for research on vegetables vis-a-vis other crops.

Crops	Expenditure in Seventh Plan (1985-1990) (in million RS)	Suggested allocation for Eighth Plan (1990-1995)
Cereal crops	1457.31*	3311.68
Commercial crops	497.42	1040.72
Oilseeds	154.16	511.79
	Horticulture Crops	
Fruits	168.74	594.20
Vegetables	78.03	269.81
Potato & tuber crops	201.33	499.69
Floriculture & medicinal plants	29.30	127.77
Plantation crops	196.27	549.59
Spices	39.25	138.40
Postharvest technology (Fruits & vegetables)	43.06	69.80
Total Horticulture	**756.02**	**2250.27**

* 1US$ = 17.98 Rs.

Personnel

The total number of people deployed for research on different horticultural crops is given in Table 2. A total of 505 persons are engaged in vegetable research, 163 of whom are scientists, the others being technical, administrative and support staff.

Table 2. Existing personnel for research on vegetable crops vis-a-vis other crops (as of 1 April 1990).

Field Crop	Total	Scientific
Cereal crops	9139	2213
Commercial crops	2919	688
Oilseeds	1122	419
	Horticulture Crops	
Fruits	1076	306
Vegetables	505	163
Potato & tuber crops	1295	347
Floriculture & medicinal plants	173	88
Plantation crops	1201	232
Postharvest technology (Fruits & vegetables)	212	71
Total Horticulture	**4675**	**1283**

Research on Vegetables

The major objective of research on vegetables in India is improving production per unit area, by solving chronic problems of production through: breeding high yielding, disease and pest-resistant varieties; heterosis breeding; standardization of agrotechniques for different agroecological situations; disease and insect pest management; and postharvest studies with a view to reducing losses. Twenty-three vegetables, namely, amaranthus, bitter gourd, bottle gourd, brinjal, cabbage, carrot, cauliflower, chilies, cowpea, cucumber, dolichos, French bean, garlic, luffa, muskmelon, okra, onion, peas, pointed gourd, pumpkin, sweet pepper, tomato and watermelon have been included in the national research program on vegetable crops. The salient research achievements in vegetable research are given below.

Crop Improvement

New Varieties Released. The evaluation of indigenous and exotic germplasm introductions, and their hybridization, resulted in the selection of over 30 superior varieties of different vegetables during the 1950s. Of these varieties, Pusa Sawani of okra, Pusa Ruby and Pusa Early Dwarf of tomato, Pusa Purple Long of brinjal and Bonneville of garden peas still continue to be the main vegetable varieties due to their high yield potential and consumer preference. As a result of multidisciplinary, multilocation testing of new research materials during the last 20 years, 11? improved varieties in 16 major vegetable crops have been identified and recommended for cultivation in various agroclimatic regions of the country (Table 3). These include 20 varieties of tomato, 22 of brinjal, 13 each of onion and cauliflower, 12 of garden pea, 9 of chilies, 8 of muskmelon, 4 each of watermelon, pumpkin and okra, 3 of French bean (bush type), 2 of garlic and 1 each of Dolichos bean, cabbage, carrot, cowpea and capsicum.

Table 3. Vegetable varieties released at the national level up to 1990.

	Solanaceous Crops
1. Brinjal	
Long:	ARU-1C, ARU-2C, Azad Kranti, H-7, K-202-9, Kt-4, NDB-25, Pant Samart, PH-4, Pusa Kranti, Pusa Purple Cluster, Pusa Purple Long.
Round:	Arka Navneet, BB-7, BWR-12, H-8, Jamuni Gol Baingan, Pusa Hybrid-6, Pant Rituraj, T-3
Small round:	Aruna
Green:	Arka Kusumkar
2. Tomato	
Determinate:	Bt-1, CO-3, HS-110, KS-2, La-Bonita, Punjab Chhauhara, Punjab Kesri, Pusa Early Dwarf, Pusa Gaurav, S-12, Sel-7.
Indeterminate:	Arka Saurabh, Arka Vikas, Pant Bahar, Pant T-2, Pant T-3, Pusa Ruby, Sel-120, Sioux
3. Capsicum:	Kt-I
Chilies:	Andhra Jyoti, Bhagyalakshmi, J-218, K-2, LCA-206, Musalwadi, Pusa Jwala, Sel-I, X-235.
	Cole Crops
1. Cauliflower	
Early:	Early Kunwari, Pusa Early Synthetic, Pusa Deepali, 235-S, Pant Ghobi-3
Mid Season:	Pusa Synthetic, Improved Japanese, Pusa Shubra, Pant Shubhra
Late:	Pusa Snowball-I, Pusa Snowball-2, Pusa Snowball-K-1, Snowball-16
2. Cabbage:	Pusa Mukta
	Leguminous Crops
1. Cowpea:	Pusa Komal
2. French Bean:	VL-Boni, Arka Komal, Pant Anupma
3. Pea:	
Early:	Arkel, Jawahar Matar-4, Early December PM-2
Mid Season:	Bonneville, Jawahar Matar-I, JP-4, Lincoln, P-88, PRS-4, Pant Uphar, VL-3
4. Dolichos	Deepaliwal

(Continued)

Cucurbitaceous Crops

1. Muskmelon:	Arka Jeet, Arka Rajhans, Durgapura Madhu, Hara Madhu, Hybrid M-3, Punjab Hybrid, Pusa Madhuras, Pusa Sharbati
2. Pumpkin:	Arka Chandan, Arka Suryamukhi, CM-14, Pusa Vishwas
3. Watermelon:	Arka Jyoti, Arka Manik, Durgapura Meetha, Sugar Baby

Bulb Crops

1. Onion	
Red:	Agrifound Dark Red, Arka Kalyan, Arka Niketan, N-2-4-1, N-257-9-1, Punjab Selection, Pusa Madhvi, Pusa Ratnar, Pusa Red, VL-3
White:	Pusa White Flat, Pusa White Round, S-48
2. Garlic:	G-1, G-41

Root Crops

1. Carrot:	Pusa Yamdagni

Other Crops

1. Okra:	P-7, Parbhani Kranti, Sel-2, Sel-10 (IIHR)

F_1 Hybrids. Heterosis breeding in vegetable crops in India has received serious attention only in recent years. As a result progress in developing and popularizing hybrid varieties has been slow. The first F_1 hybrids of tomato (Karnataka) and capsicum (Bharat) were released for commercial cultivation in 1973 by a private seed company, M/S Indo-American Hybrid Seeds, followed by 18 other hybrids in nine vegetable crops. Of the 21 F_1 hybrids in eight vegetable crops developed so far by public research institutions, the nine hybrids listed below have been recommended for commercial cultivation:

Brinjal:	Arka Navneet, Azad Hybrid and Pusa Hybrid-6
Muskmelon:	Punjab Hybrid and M-3 Hybrid
Watermelon:	Arka Jyoti
Bottlegourd:	Pusa Meghdoot and Pusa Manjari
Capsicum:	KT-1

In addition to F_1 hybrids, two synthetic cauliflower varieties, Pusa Synthetic and Pusa Early Synthetic have also been recommended for release. However, the F_1 hybrids developed have not been fully exploited due to inadequate facilities for their seed production.

Disease and Pest Resistant Varieties

Research on breeding for disease/pest resistance has resulted in the release of 24 varieties. Pusa Sawani variety of okra developed as resistant to yellow vein mosaic virus is the first example of successful disease resistance breeding in vegetable crops in India. A list of resistant varieties of different crops released so far is given in Table 4.

Agrotechniques

A large number of agronomic practices have been developed to grow almost all vegetable crops under varied agroclimatic conditions. Under the All India Coordinated Research Project alone 34 agronomic recommendations relating to spacing, nutritional requirements, irrigation and weed control in 11 vegetable crops (brinjal, cabbage, cauliflower, chilies, muskmelon, okra, onion, peas, radish, tomato, and watermelon) have been made. For chemical control of diseases and insect pests, conclusive recommendations have been made in 11 vegetable crops (bottle gourd, brinjal, cauliflower, chilies, muskmelon, okra, onion, peas, tomato, turnip and watermelon). Thus 55 measures against major diseases and insect pests have been standardized.

Technology has been developed and perfected for the production of vegetable seeds in general, and for temperate vegetables in the hilly regions of the country in particular. Techniques for postharvest management are also being developed.

Table 4. Vegetable varieties resistant to diseases and insect pests.

Crop	Variety	Disease/Insect pest	Source
Brinjal	BWR-12	Bacterial wilt (*Pseudomonas solanacearum*)	IIHR-Bangalore
	Pant Rituraj	- do -	GBPUAT-Pantnagar
	Pant Samrat	Bacterial wilt (*P. solanacearum*) Phomopsis Blight (*Phomopsis vexans*) Shoot & fruit borer & jassids	GBPUAT-Pantnagar
	Pusa Purple	Bacterial wilt	IARI-New Delhi (*P. solanacearum*)
	BB-7	- do -	OUAT-Bhubaneswar
	Pusa Phairav	Phomopsis blight (*P. vexans*)	- do -
Cabbage	Sel-8	Black rot (*Xanthomonas campestris*)	IARI-Katrain

(Continued)

Crop	Variety	Disease/Insect pest	Source
Cauliflower	Pusa Shubhra	Black rot	IARI-New Delhi
	Pusa Snowball K-1	Black rot	IARI-Katrain
Chili	Pusa Jawala	Leaf curl (CMV & PVY)	IARI-New Delhi
Cowpea	Pusa Komal	Bacterial blight (*Xanthomonas vignicola*)	IARI-New Delhi
Muskmelon	Arka Rajhans	Powdery mildew (*Sphaerotheca fuliginea*)	IIHR-Bangalore
Okra	Sel-10	Y.V.M. virus	IIHR-Bangalore
	Sel-2	Y.V.M. virus	NBPGR-New Delhi
	P-7	Y.V.M. virus	PAU-Ludhiana
	Parbhani Kranti	Y.V.M. virus	MAU-Parbhani
Pea	PRS-4	Powdery mildew	GBPUAT-Pantnagar
	PM-2	Powdery mildew	GBPUAT-Pantnagar
	JP-4	Powdery mildew & rust Rust (*Uromyces pisi*)	JNKVV-Jabalpur
Tomato	BT-1	Bacterial wilt	OUAT-Bhubaneswar
	Pant Bahar	Verticillium wilt (*Verticillium* sp.) & Fusarium wilt (*Fusarium oxysporum*)	GBPUAT-Pantnagar
	Sel-120	Root knot nematode (*M. incognita M.ameria & M. javanica*)	IARI-New Delhi
Watermelon	Arka Manik	Anthracnose (*Colletotrichum Lagenarium*) Powdery mildew (*Sphaerotheca fuliginea*) Downy mildew (*Pseudoperonospora cubensis*)	IIHR-Bangalore

Impact of Vegetable Research and Management

Development of a large number of improved varieties with wider adaptability and standardization of their production technologies for various agroclimatic conditions has made it possible to produce vegetables in wider areas and has improved the prospects of their supply as follows:

- **Garden** pea variety **Arkel** has revolutionized the production of early peas in all pea-growing areas;
- **Cauliflower** variety **Pusa Early Synthetic** has adapted to warm climatic conditions of Tamil Nadu and has made it possible to grow cauliflower commercially in this nontraditional area;

- **Watermelon** variety **Sugar Baby** has spread fast in the entire northern and eastern areas of India and has benefited the growers with better remuneration and the consumers with superior quality;
- **Watermelon** variety **Akra Manik** has made some headway in the southern and southwestern parts of the country;
- **Okra** variety **Pusa Sawani** bred for resistance to yellow vein mosaic virus prone areas/seasons replaced all other local varieties from cultivation throughout the country;
- **Tomato** variety **Sel-120** has made it possible to achieve high yields of quality produce in root-knot nematode-infested soils;
- In **Onion** identification of variety N-35 and development of technology for kharif onion has enabled farmers to get two crops of onion annually in northern India, where it used to be only a winter/spring crop;
- With appropriate choice of suitable varieties for specific seasons we can now grow **radish** year-round; and
- Similarly with the release of cold-tolerant variety **Pusa Sheetal** we can now grow **tomatoes** year-round.

Development and perfection of technology for quality seed production of temperate vegetable crops in general, and cauliflower and cabbage in particular, have reduced most of the imports of seed for these crops from European countries, except for the seeds of some new hybrids/varieties.

Constraints to Vegetable Research

Biotic

Introduction of Germplasm. Germplasm is one of the basic requirements of a crop improvement program. Though systematic efforts have been made to introduce germplasm in different crops, there are still several gaps. We do not have varieties ideally suited for processing in tomato, peas, onion, etc. High total soluble solids (TSS) varieties with high nutritional value and longer shelf life have to be developed in many vegetables. Chilies with high oleoresin content need to be developed. Also, varieties with wider adaptability suited to varied agroecological situations need to be developed. Many diseases and insect pest problems of a number of vegetable crops have not yet been solved, and resistant varieties provide the only successful answer. Nonavailability of suitable germplasm to breed varieties to meet all of these requirements in most vegetable crops is a serious problem.

Erosion of Germplasm. Germplasm of some species is continuously being eroded through natural and biological factors. With the development of okra variety **Pusa Sawani** all local cultivars of okra were eliminated from cultivation, and thus the entire germplasm/variability of cultivars of okra in the country was lost.

Evaluation of Germplasm. Proper evaluation, documentation/cataloguing and conservation of germplasm suffers badly at the hands of the scientists, since they accord comparatively low priority to it compared with breeding work, even though proper evaluation of germplasm provides the most important and indispensable base for all breeding programs.

Disease and Insect Pests. Several diseases and insect pests seriously affect vegetable production. Varieties resistant/tolerant to these need to be developed. Integrated management of diseases and insect pests in different vegetable crops also needs to be developed systematically.

Qualified Personnel. Facilities for postgraduate education of a reasonably high standard exist in India at IARI, New Delhi, and several state agricultural universities. However, there is a dearth of well-qualified scientists trained specifically in the fields of resistance breeding against pests and diseases, and abiotic stresses, biotechnology, and greenhouse technology. Even commercial F_1 hybrids in important vegetable crops such as cabbage, carrot and onion are lacking due to inadequately trained personnel.

Abiotic

Financial. Although vegetables constitute the largest group of about 60 crops providing essential nutrition and protective food, the allocation of funds for research on these crops has not been commensurate with their importance. The reason is that the priorities of the country have been to achieve self-sufficiency in food grain production. However, even among various horticultural crops, the allocation of funds has not been commensurate with the importance of vegetable crops.

Abiotic Stress. Drought, high humidity, heat, cold, frost, and soil factors like salinity and alkalinity are important abiotic stresses limiting vegetable production. Significant progress in research on these aspects has not been possible so far, since the initial work concentrated on developing high yielding, pest- and disease-resistant varieties. Lack of suitable germplasm for these purposes has also been a constraint.

Seasonal. There is a limited period available for evaluation of performance of certain crops such as early peas and French beans, and this period also favors pathogens like *Fusarium*, *Rhizoctonia*, *Pythium*, etc. During winter, frost becomes a major problem for a number of vegetables, whereas high heat during summer does not permit flowering in important summer vegetables like tomato and brinjal, thus limiting their hybridization and evaluation.

Socioeconomics

Requirement of Technology Development. Vegetable growers are generally small-scale, poor and marginal farmers. Therefore, vegetable production technology has to be developed keeping the needs of these farmers in view, while also meeting the requirements of quality and taste of middle-class society who are the major consumers of vegetables. Research to date has stressed development of technology for increasing yield, and has not kept in view the limitations of the growers.

Organizational Limitations

Lack of Institutional Support. Since there is no institution entirely devoted to vegetable research in the country, multidisciplinary research has not been possible, and adequate work on cytogenetical, physiological and biochemical studies of these crops has not been undertaken. Therefore, besides poor progress on incorporation of multiple disease resistance and development of integrated disease and pest management, there has been no breakthrough in solving the problems of abiotic stresses. Seed technology research has also suffered in the absence of an institution responsible for research on these crops. There is little biotechnological work on vegetable crops. Multicrop institutes do not give adequate priority to vegetables.

Funding and Personnel Needs

Funds

Against an expenditure of Rs. 78.03 million during the Seventh Plan (Table 1), tentative allocation for vegetable research in the Eighth Plan is Rs. 269.81 million. Although inadequate, this is a quantum leap, since the projected allocation is three times that of the earlier plan. In the tentative Eighth Plan allocation, 73.4% of the funds earmarked are meant for expenditure on salaries, travelling grants and meeting day-to-day contingent expenses essential for research and on chemicals, glassware, etc. The remaining 17.6% is earmarked for strengthening research infrastructure, 6.9% for equipment and only 2% for other facilities such as library, furniture, fixtures, etc.

Personnel Needs

Due to priority attention having been given to achieving food security in the past, the personnel deployed for vegetable research has not been adequate. There is, however, a realization in the country and a greater emphasis awaits horticultural crops, including vegetables. Diversification of agriculture is already a priority item of our agricultural policy.

The number of staff during the Seventh Plan was 505 including 163 scientists. For the Eighth Plan 328 new staff positions have been proposed of which 58 would be scientists. This will bring the total staff strength for vegetable research during the Eighth Plan to 823 of which 221 will be scientists.

Human Resource Development

Human resource development has received significant attention and an enviable infrastructure now exists in India for this purpose. IARI at New Delhi is the leading institution with a status of a university which grants postgraduate education in different agricultural disciplines to international standards. In addition, 26 state agricultural universities are giving training in olericulture at graduate and postgraduate levels. Of these, nine universities have separate departments of vegetable crops. Additional personnel needs are likely to be met from this national effort. Scientists are also being sent abroad for training in research in these crops and in different disciplines. Specific areas of interest for training of our scientists are multiple resistance breeding against diseases and insect pests, and abiotic stresses; heterosis breeding; seed production technology; biotechnology; protected/controlled environment vegetable production; and vegetable forcing.

Research Priorities

While significant progress has already been made there are still several problems to be tackled. For this, the following research priorities have been identified for the Eighth Plan.

Crop Improvement

(1) Breeding for resistance to biotic factors such as diseases and insect pests for:

Tomato:	leaf curl virus, TMV, bacterial wilt, Phytopthora blight, fruit borer
Brinjal:	fruit and shoot borer
Okra:	yellow vein mosaic and pod borer
Chilies: capsicum	virus and pest complex
Onion:	purple blotch, Stemphylium rot and thrips
Cucurbits:	downy mildew, powdery mildew, CMV, fruit fly
Cole crops:	*Sclerotinia, Alternaria* and soft rot
Peas:	powdery mildew
Beans:	*Septoria*, mosaic virus and bruchids.

(2) Breeding for resistance to abiotic stresses e.g., drought, salinity, alkalinity and salt tolerance.

(3) Heterosis breeding in onion, tomato, cabbage, cauliflower, cucurbits and brinjal.

(4) Breeding for nutritional and processing qualities in vegetables, e.g. tomato, onion, peas and garlic (dehydration).

(5) Use of biotechnology for incorporation of resistance to diseases/pests/ abiotic stresses.

(6) Intensification of research on seed production of temperate, tropical and sub-tropical vegetables and intensification of breeders' seed production program.

Crop Production

(1) Export-oriented research on vegetables, e.g. onion, chilies, okra, peas and tomato.

(2) Developing efficient cropping systems.

(3) Research on growing vegetables in protected environments.

(4) Research on off-season vegetable production and underexploited vegetables.

(5) Studies on insecticidal residues.

Collaboration

Bilateral

Bilateral collaboration in research on vegetable crops can be considered in mutually identified areas which may benefit the participating countries. Already India has collaborative programs in potato and sweet potato with Centro Internacional de la Papa (CIP). In vegetable crops, areas of collaboration that can be considered are exchange of germplasm, exchange of research management teams, exchange of information, training, import of essential research equipment not available locally and consultancy services.

Collaborative Network

Several formal and informal network programs are being proposed at various fora and by various organizations. In 1986 FAO proposed an informal collaborative network for vegetable research. Similarly in 1989 Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, also proposed a formal network for research on snapbeans.

Nonformal networks in the countries of South Asia have limited chances of success. Formal collaborative networks have much better chances of success. A multinational network on multilocation testing/trials in vegetable crops under the research program for collaboration among SAARC countries has been approved in which all SAARC countries will be participating.

Other Alternatives

Another alternative could be collaborative research on problems of common interest under a Memorandum of Understanding (MOU) signed by AVRDC and the interested countries.

Role of AVRDC

Although AVRDC is an international research organization devoted to vegetable research and development, the major crops covered under its mandate are few namely, tomato, Chinese cabbage, chilies, sweet potato, beans, soybean, mungbean, etc. Of these, only tomato, chilies and Chinese cabbage are typically vegetable crops. Accordingly the role played by AVRDC so far in vegetable crop improvement has been limited. Therefore, it is necessary that the mandate of AVRDC be expanded urgently with a view to covering most of the important vegetable crops grown in Asian countries, and make it an institution for effective research on a wide variety of vegetable crops, assuming international leadership in this area. It would perhaps also be necessary to locate subcenters in countries where a large number of vegetable crops can be grown.

Since AVRDC's program covers only a few crops, the activities of this center at present do not serve the Indian interests. Tomato is an important crop of AVRDC, and India has already a very comprehensive research program on this crop in its national institutes and agricultural universities. Chinese cabbage is not a commercial crop in India. For sweet potato, India has an MOU with CIP. India is also developing linkages with CIAT for research on beans and cassava. For other vegetable crops India is already developing collaboration with SAARC countries on multilocation testing/trials in vegetable research. The possibility of developing linkages or collaborative research programs with AVRDC will be meaningful if AVRDC expands its mandate and geographical focus.

Summary of Discussions - India

Moderator: S.P.R. Weerasinghe
Rapporteurs: Z. Alam
A. Haque

Production and Policy

India is a vast country with varied agroclimatic conditions and produces vegetables from sea level to the snow line. Most of India's population is vegetarian. Per capita consumption is about 135 g. Average yield of 10 t/ha is very low. Present production is way below the requirement of the huge population.

Constraints

(1) Limited fertilizer use due to high price.
(2) Inadequate supply of good quality vegetable seeds.
(3) Lack of adequate irrigation facilities, 70% is rainfed.
(4) Enormous postharvest losses occur, ranging from 25% to 40% due to improperly organized marketing, storage, grading and transport systems. Traditional means of transport are still used.
(5) Lack of awareness about improved technology of vegetable production among small growers through extension agencies.
(6) Low budget allocations for development programs.
(7) Very little research on vegetables grown under rainfed and riverbed conditions.

Steps for Improvement

(1) An independent National Horticulture Board has been established to promote vegetable production, handling and marketing.
(2) New seed policy for import of high quality seeds from anywhere in the world.
(3) A National Policy on Agriculture has been drafted.

Key Issues

(1) Biological factors
(2) Socioeconomic factors
(3) Marketing infrastructures
(4) Production (key inputs) constraints
(5) Human resource development

Research

Nearly 60 vegetables are grown in India, of which 35-40 are economically important. Research on vegetables was initiated by ICAR during 1947-48 at IARI. Systematic research on vegetables was organized with the creation of Division of Horticulture at IARI in 1956-57. Presently vegetable research is being carried out at four central institutes, one national research center and 26 state agricultural universities. National Coordinated Research Program provides a national grid for multilocation testing of technologies by various institutions. Vegetable research is carried out by 163 scientists. About 119 varieties of different vegetables have been released/recommended. Of these 24 varieties are resistant to different diseases and insect pests which have made significant impact in revolutionizing vegetable production. Several agrotechniques and plant protection measures have been standardized and recommended.

Key Issues

(1) Biological (germplasm erosion, diseases, insect pests).
(2) Abiotic factors (limited funds, physical,environmental and soil factors and seasonal problems).
(3) Socioeconomic factors.
(4) Limitations of infrastructure.
(5) Personnel needs.
(6) Organizational limitations

Future Research Priorities

(1) Breeding for disease and insect resistance.
(2) Breeding for abiotic stresses (drought, salinity, alkalinity and salt tolerance).
(3) Heterosis breeding.
(4) Breeding for nutritional and processing qualities.
(5) Use of biotechnology for vegetable variety improvement.
(6) Intensification of research on seed production.
(7) Exchange of information.

Future Priorities on Crop Production

(1) Export oriented research.
(2) Developing cropping systems.
(3) Forced vegetable production.
(4) Insecticidal residues research.

Role of AVRDC

(1) AVRDC should expand its mandate and include more vegetables commonly grown in other regional countries for developing meaningful linkages and collaborative research programs.
(2) AVRDC's assistance for developing national research.
(3) Repository for major vegetable crop germplasm.

Vegetable Production and Policy in Bangladesh

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Introduction

Bangladesh has an area of 144,000 km^2 inhabited by 112 million people. Thus it has one of the highest population densities (775 people/km^2) in the world. The cultivable area of 9.17 million ha is mostly flat terrain comprised of deltaic areas of three large rivers. Almost two-thirds of this land goes under water during the rainy season in July-September. Only some homesteads remain above water during this time. Soils are mainly alluvial and favorable for vegetable production. However, it is the depth of flooding and residence time of the water which decide the cropping pattern.

There are three distinct seasons. The cool season is from November to February which is characterized by cool temperatures (12-28^{o}C) and no or little precipitation. Summer is from March to May with a little rainfall and temperatures as high as 40^{o}C. Then comes the monsoon from June to October, with high rainfall, humidity and temperature (25-35^{o}C). On an average 2,000 mm of rain per annum falls on 80% of the land during this period. The country has been divided into 30 agroclimatic zones with 88 subzones.

Status of Vegetable Production

More than 40 different kinds of vegetables are grown in Bangladesh. Popular summer vegetables such as teasle gourd, pointed gourd, bitter gourd, pumpkin, ash gourd, ribbed gourd, string beans, lady's finger, stem amaranth, Indian spinach, plantain, papaya, and brinjal are mostly indigenous. The winter vegetables such as tomato, brinjal, cabbage, cauliflower, broccoli, radish, carrot, beet, hyacinth bean, pumpkin, bitter gourd, and spinach are mostly the European types. The temperate vegetables that are grown in the cool season generally do not produce seeds under field conditions.

Total area under vegetable production during 1987-88 was 152,550 ha of which 57,600 was under summer vegetables and 94,948 ha winter vegetables. Thus winter vegetables contributed about 70% of total vegetable production of 939,000 t in 1987-88. However, vegetable production including potato and sweet potato was 2.79 million t in 1987-88 from an area of 327,050 ha (Table 1). This has been the trend of winter vegetable production compared to summer production every year. Similarly, the area under winter vegetables consistently remains higher than that of summer vegetables. Production of summer vegetables is constrained by high rainfall, humidity and temperature, while vegetable production in winter is favored by suitable climate. There is, therefore, seasonal fluctuation on the availability of fresh vegetables in the market, i.e. a surplus in winter and a deficit in summer. Also there is an acute shortage of vegetables in the market in two slack seasons: one from mid March to April and another from October to November, due to transition from one season to another.

Table 1. Area and production of summer and winter vegetables including potato and sweet potato.

Vegetable	1985-1986 Area ('000 ha)	1985-1986 Production ('000 t)	1987-1988 Area ('000 ha)	1987-1988 Production ('000 t)
Summer vegetables	54.4	281.1	57.6	281.9
Winter vegetables	89.1	622.5	95.0	674.2
Potato	108.5	1102.8	123.4	1275.7
Sweet potato	55.9	612.0	51.1	557.5

Vegetable production in Bangladesh is far below the requirements. This leads to low consumption. Present consumption is only 25 g/day/head, or 70 g/day/head, if potato and sweet potato are included. Daily per capita vegetable consumption is very low in Bangladesh compared to some Asian countries (FAO 1986). One adult should consume a minimum of 200 g of vegetables per day. To meet the daily requirement of vegetables, our production must be tripled. Therefore, assuming 20% for export, total demand for vegetables would be about 10 million t.

Vegetable Production for Export

There is a demand for both fresh and processed vegetables especially in the Middle East and European markets. There is yet no industry for processed vegetables either for local or export markets. However, export of fresh vegetables started in the early 1970s. Fresh vegetables, mostly indigenous types such as pumpkin, bottle gourd, bitter gourd and aroids are found to have better export potential. During 1983-84 to 1986-87 export value of fresh vegetables increased from 78.8 to 531 million taka (35 taka = US$ 1, late 1990).

Constraints to Vegetable Production

(1) There is a lack of high-yielding and well-adapted varieties (e.g. on-farm trials indicate that the present average yield of tomato can be increased from 7.5 to 60 t/ha in farmers' fields by planting the high-yielding variety Manik and adopting improved management practices.

(2) There is also a shortage of quality seed, particularly for the summer vegetables. There is need for 250 t of seeds of different vegetables annually for the existing hectarage under vegetable production. About 4% of this requirement is met from the production of public sector organizations, 10% is imported, and the remaining requirement is met by farmer-to-farmer exchange and local seed dealers. Therefore, quality and diversity of improved varieties of seeds are not assured.

(3) There is need for appropriate production technologies. More research is needed to generate and package technologies for the vast majority of indigenous vegetables. Fertilizer and water use and integrated pest management practices are yet to be worked out.

Vegetable production in the saline belt and Barind tract is limited for want of suitable varieties and proper production technologies. Vegetable production on a commercial scale is possible in these areas, provided location-specific technologies are developed. Suitable varieties and production technologies are not available for slack and rainy season.

There is a shortage of land for vegetable production during the rainy season. This can be overcome by encouraging intensive production of vegetables in the homestead.

(4) There is also a lack of technologies for postharvest handling, marketing and storage facilities.

(5) A strong technology transfer program is required. Although this area did not receive much attention, the present research and extension program has a major focus in this area.

(6) People's preference for vegetables needs to be encouraged through a program of public awareness.

(7) There are inadequate credit facilities available.

(8) And finally, there is a shortage of trained people.

Policy for Vegetable Improvement and Development

(1) There has been a deficit of staple food in Bangladesh for several decades, so the development program has long emphasized cereal crop improvement. In the meanwhile, the population has more than doubled. There is a shortage of fruits and vegetables, which are good sources of vitamins and minerals, often lacking in the daily diet, and the cause of many health problems. There is a growing realization of the importance of increasing vegetable production in the country, and this is reflected in the Third Five Year Plan and the present Fourth Five Year Plan which started in July 1990. Now instead of self-sufficiency in cereals alone, a nutrition-based self-sufficiency in food has been planned.

(2) The government has duly recognized that technology generation cannot happen in a vacuum. There must be a concerted effort to generate knowledge-based technology, and hence research should be strengthened. So, the Horticulture Division of the Bangladesh Agricultural Research Institute (BARI) has been strengthened to establish one Horticulture Research Centre having provision for additional scientific personnel and physical and laboratory facilities. The Bangladesh Agricultural University has also begun a few projects on the improvement and development of vegetables.

(3) We are fully aware that mere infrastructure or physical facilities cannot strengthen research. Trained people are the key to success in research output. Unfortunately there is a shortage of resource and training facilities within the country.

(4) Vegetable production has been reported to be highly cost-effective and labor-intensive as well. It is necessary to encourage private investors to come forward in this kind of enterprise for which bank loans should be made available. This kind of action can help fight malnutrition in the country.

(5) Vegetable production is a seed-based industry. There is lack of quality seeds of high-yielding varieties. In 1989 vegetable seeds worth 90 million taka were imported (Anon. 1990). Government is determined to produce the desired quantity of good quality seeds of recommended varieties. Two vegetable seed production farms have been established and are being strengthened with FAO help. It is a 5-year program to provide expertise, funds, equipment and training to strengthen vegetable seed production. However, these farms will produce foundation seeds only. There are already two organized seed industries in the private sector. More are being encouraged.

(6) There is export potential for fresh vegetables. Some indigenous vegetables are being exported and the export earnings are rising every year. In the winter when vegetable production is seemingly impossible or very costly in temperate Europe, we have a very favorable climate and cheap labor for production of vegetables. It might be possible to expand export of winter vegetables to a greater extent.

However, to sustain exports, specialized vegetable farming is envisaged and being encouraged within the private sector, with assurances of technical backup and bank loans.

(7) Vegetable production in the homestead has a special significance in the socioeconomic context of Bangladesh. Here more than 60% of farmers are landless, with limited resources other than their homestead. On the other hand, land is scarce in general and particularly during the rainy season, so very little land except on homesteads is available for vegetable production. There are 13 million homesteads in the rural areas which are built on relatively high land, and thus they remain free from normal flooding. Intensive vegetable production on these homesteads is possible throughout the year. It will promote the involvement of women, encourage more consumption of vegetables and may be a source of income generation for the family.

A vegetable production model at Kalikapur Farming System Research Site demonstrated that more than 500 g of vegetables per day could be produced year-round in a home garden of 36 m^2. On the basis of this production it would be possible to produce 2.4 million t of vegetables on 13 million rural homesteads. In other words, this would satisfy about 30% of the total fresh

vegetable requirements of Bangladesh.
This Kalikapur model of home garden production of vegetables was tried in 2,000 homesteads of 20 upazilla (subdistricts) during the Third Plan period. Government was convinced of its usefulness, and has proposed extending this program in 20,000 homesteads of 200 upazilla.

(8) Marketing of vegetables particularly at peak harvest season is still a challenge. Construction of good marketplaces near concentrated production centers, construction of holding houses at both dispatch and receiving points, and arranging speedy transportation in refrigerated compartments of the railway are suggested. Apart from these infrastructure/physical facilities, no clear understanding of marketing mechanisms has emerged. However, the government is fully aware of the problems and is actively working on the issues.

(9) A technology transfer program for the expansion of vegetable production is currently receiving higher priority.

AVRDC's Future Role

Bangladesh has very recently signed a Memorandum of Understanding with the Thailand Outreach Program of AVRDC. This provides for one scientist on a long-term basis to help strengthen the vegetable research program. Bangladesh can participate in the outreach program of AVRDC. AVRDC can help in the exchange of information, germplasm and scientific personnel.

Vegetable Research in Bangladesh

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Introduction

Bangladesh is predominantly an agricultural country. Agriculture contributes about 50% of GDP and 80% of the total export earnings. The total cultivable land is around 9.17 million ha, having a cropping intensity of 154.5%. Average size of landholding of most farmers is less than 0.5 ha. Rice is grown on nearly 78% of the area, while vegetables including potato and sweet potato occupy only 3.3%.

Vegetable Production and Consumption

A wide range of vegetables are grown in Bangladesh. The summer vegetables are mostly indigenous whereas most of winter vegetables are of European origin. In 1987-88, the total area under vegetables was 152,550 ha of which 57,600 ha was under summer vegetables (Table 1) and 94,950 ha was under winter vegetables (Table 2). Winter vegetables contributed more than 70% of the total vegetable production of 939,000 t in 1987-88. However, vegetable production including potato and sweet potato was about 2.79 million t in 1987-88 from an area of 327,656 ha (Table 3). Production of vegetables in the cool season is hazard-free and blessed with a favorable climate. During summer, vegetable production is affected by floods, cyclones and other factors associated with high temperature, humidity and rainfall.

Vegetable production in Bangladesh is far below requirements. The present consumption is only about 25 g/day/person and that would be about 70 g/day/person with potato and sweet potato. Daily per capita vegetable consumption is very low in Bangladesh compared to some Asian countries (FAO 1986), including Thailand (164 g), China (269 g), Japan (348 g), India (167 g) and Burma (151 g). According to nutritionists, an adult should consume about 285 g of vegetables per day. So, in order to meet vegetable requirements of the present population, vegetable production must be tripled. That means total vegetable demand would be about 10 million t assuming 20% for export.

Table 1. Area, production and yield of summer vegetables during 1987-88.

Vegetables	Area ('000 ha)	Production ('000 t)	Yield/ha (t)
Pumpkin	4.3	24.0	5.6
Brinjal	8.7	45.0	5.2
Pointed gourd	3.8	19.6	5.1
Lady's finger	3.2	9.1	2.9
Ribbed gourd	4.2	16.8	4.0
Bitter gourd	4.0	14.9	3.9
Aroids	10.2	66.7	6.5
Ash gourd	3.8	22.1	5.9
Cucumber	3.1	13.0	4.3
Yardlong bean	2.1	5.6	2.7
Indian spinach	2.1	10.6	5.2
Snake gourd	2.1	8.7	4.2
Stem amaranth	3.2	14.5	4.5
Others	2.9	11.3	3.9

Source: BBS 1989.

Table 2. Area, production and yield of cool season vegetables during 1987-88.

Vegetables	Area ('000 ha)	Production ('000 t)	Yield/ha (t)
Tomato	10.9	81.0	7.4
Brinjal	17.7	119.0	5.7
Cauliflower	7.4	58.1	7.8
Cabbage	7.4	64.4	8.7
Pumpkin	6.2	42.6	6.9
Bottle gourd	7.2	59.7	8.6
Radish	17.7	152.6	8.6
Beans	7.2	32.8	4.6
Spinach	3.6	16.2	4.6
Others	9.6	47.8	5.0

Source: BBS 1989.

Table 3. Area and production of summer and winter vegetables including potato and sweet potato.

Vegetable	1985-86		1987-88	
	Area ('000 ha)	Production ('000 t)	Area ('000 t)	Production ('000 t)
Summer vegetables	54.4	281.1	57.6	281.9
Winter vegetables	89.1	622.5	95.0	674.3
Potato	108.5	1102.8	123.4	1275.7
Sweet potato	55.9	612.0	51.1	557.5

Status of Vegetable Research

Vegetable research did not receive attention until 1966 when a Vegetable Section was created under the then Horticulture Division of the Agricultural Research Institute, with the provision of three scientific personnel. A project entitled Bangladesh Vegetable Research and Development Centre was sponsored by the Bangladesh Agricultural Research Council (BARC) in 1975, which ended in 1979, with limited success. Another project, the Citrus and Vegetable Seed Research Centre, was initiated by the Bangladesh Agricultural Research Institute (BARI) in 1977 with the help of JICA, which ended in 1983. It made a considerable contribution in upgrading vegetable research in Bangladesh by arranging a training program for the working scientists and providing expert services. This center has been able to develop a few improved varieties which were subsequently released. BARI, which was established as an autonomous body in 1976, also provided expanded scope for vegetable research.

The activities of the Vegetable Section, since its inception in 1966, were very much restricted to evaluation of some local germplasm, and the exotic varieties of different vegetables, seeds of which were to be imported. There were some agronomic studies. In the past a large number of varieties were evaluated and recommended. Some of these are now well adapted by the growers. On the basis of our recommendation the National Seed Board approved 139 varieties of 37 different vegetables in 1985.

In spite of limited resources, BARI has undertaken research on vegetables as follows:

(1) Varietal improvement

(a) Collection and evaluation of local and exotic germplasm for selection of widely adapted superior varieties;
(b) Development of early and late varieties of different vegetables to extend the period of their availability; and
(c) Initiation of a breeding program to develop high-yielding varieties that

are tolerant to common pests and diseases.
(2) Development of improved production practices.
(3) Studies on common pests and diseases, and their control.
(4) Studies on soil-water-fertility relationship.
(5) Studies on rotation of vegetables including intercropping and relay cropping to ensure year-round supplies, particularly for the home garden program.
(6) Development of production technologies of quality vegetable seeds and their preservation.
(7) Studies on postharvest handling and marketing of vegetables.
(8) Studies on the potential of producing vegetables for export.

A collection of large numbers of germplasm/land races of local vegetables has been made. A few varieties of tomato, brinjal, cabbage, radish, aroids, sweet potato and leafy vegetables have been developed and released through the National Seed Board (NSB) (Table 4). Quite a good number of advanced lines of different vegetables are in the pipeline. A few of these will be released by the NSB very soon (Table 5). Two hybrid watermelon varieties have been developed which compare favorably with the popularly cultivated Japanese F_1 Top Yield variety. In addition, models have been developed for intensive year-round vegetable production on homesteads. Vegetable-based cropping systems and improved technologies for production of quality seeds of a few vegetables have also been recommended. Some information on pest and fertilizer management practices has been generated.

Table 4. Main characteristics of vegetable varieties developed and released by BARI.

Crop	Variety	Year of release by NSB	Main characteristics
String bean	Chinese yardlong string bean	1985	High yield, suitable for year-round production, free from major pests and diseases, yield ranges from 8.2 to 15.6 t/ha depending on planting season. September planting gives highest yield.
Radish	Tasaki San Mula-1	1983	Ready for harvest in 45 days, remains marketable up to 65 days without loss of quality, produces seeds abundantly under field conditions, root yield 75 t/ha.
Leafy vegetables	Gimakalmi *(Ipomoea reptans)*	1983	Suitable for summer and rainy season production. Both leaves and petioles are edible. First harvest starts 30 days from sowing and subsequent harvests at 20-day intervals. Yield is 40-45 t/ha in four harvests. Seed yield ranges from 1.2 to 1.5 t/ha during cool season.

(Continued)

Table 4. Continued.

Crop	Variety	Year of release by NSB	Main characteristics
	Batisak *(Brassica chinensis)*	1984	Suitable for year-round production, harvestable in 45-55 days, leaf yield 40-50 t/ha, seed yield 600-800 kg/ha in cool season.
	Chinasak *(B. parachinensis)*	1984	Suitable for year-round production, requires 35-45 days for harvest, yield 25-30 t/ha, seed yield 750 kg/ha in cool season.
Brinjal	Uttara	1985	Having high degree of tolerance to fruit and shoot borer, fruits are purple, 18-20 cm long, 150-200 fruits/plant, yield 60 t/ha.
Cabbage	Provati	1985	Early variety, head 2 kg, harvested in 70-80 days from transplanting, producing seed 500-600 kg/ha under field conditions, head yield 70-80 t/ha.
Tomato	Manik	1985	Resistant to bacterial wilt, fruits attractive and good to taste, yield 60-70 t/ha.
	Ratan	1985	Have high degree of tolerance to bacterial wilt, fruits are attractive, yield 60-70 t/ha.
Aroids	Bilashi (Mukhi Kachu)	1988	Cormels are long (6-8 cm), smooth and attractive, free from acridity, yield 30 t/ha.
	Latiraj (Pani Kachu)	1988	Plants are 50-60 cm tall, smooth and attractive, free from acridity, yield 30 t/ha.
Sweet potato	Tripti	1985	Light yellow fleshed, low in carotene (300 ug/100g), yield 40-45 t/ha.
Kamalasundari		1985	Orange fleshed, soft and rich in carotene (5,000 Ìg/100 g), yield 35-40 t/ha.
	Daulatpuri	1988	Developed from local germplasm, firm, white-fleshed, yield 35-40 t/ha.

Table 5. Characteristics of some advanced vegetable lines.

Crop	Line	Characteristics
Radish	Pinky (1-13-228)	Edible roots - 30 x 7 cm and pink, soft leaves ready for harvest in 50-55 days but remains marketable up to 75 days without loss of quality, root yield 60 t/ha, seed yield 1 t/ha.
Brinjal	Shufala (11-1-324)	Fruits purple long - 23 x 3 cm, 100 fruits/plant, yield 55-60 t/ha.
	Hybrid-1	Purple fruits - 19 x 4 cm, 120 fruits/plant, yield 80 t/ha.
	Hybrid-2	Dark purple fruits, 70 fruits/plant, yield 80 t/ha.
Watermelon	WM002 (F_1)	Fruits are light green and oblong - 23 x 19 cm, each fruit weighs 10 kg, flesh red having 11.8% TSS.
	WM003 (F_1)	Fruits are light green and oblong - 23 x 19 cm, each fruit weighs 10 kg, flesh red having 11.8% TSS.
Hyacinth bean	HC0084	Plants are free from virus, pods - 10.5 x 1.5 cm green and soft, first harvest starts in 3rd week of October, yield 11-12 t/ha.
	HC0010	Plants are free from virus, pods - 10 x 2.5 cm fleshy and soft, first harvest begins in mid November, yield 18-20 t/ha.

Constraints to Vegetable Research

Some of the constraints to vegetable research in the country are:

(1) Lack of trained personnel;
(2) Lack of funds for systematic collection, documentation and evaluation of local germplasm;
(3) Lack of cooperation and collaboration with international research institutes, and research institutes of neighboring countries for exchange of ideas, information and germplasm; and
(4) Inadequate personnel and financial support.

Research and development institutes involved in vegetable improvement:

(1) Bangladesh Agricultural Research Institute (BARI), through its Division of Horticulture and regional and special crop research stations, has been carrying out a vegetable improvement program for many years. However, BARI has now established a Horticulture Research Centre with the assistance of the Asian Development Bank to strengthen research activities on fruits and vegetables. The Division of Horticulture is being merged with the Horticulture Research Centre (HRC). Vegetable research will now be taken up by the Olericulture Division of HRC and implemented through its Central Research Station and four regional horticulture research stations.

(2) Bangladesh Agricultural University, Mymensingh, has also been carrying out research on vegetables as a part of their postgraduate degree program and through contract research projects.

(3) BARC provides training facilities and funds. It also provides research support through a contract research program and technical support in the form of expert services and commodity supply.

AVRDC's Future Role in the Region

AVRDC should have an outreach program in each of the cooperating countries. Further, it should provide leadership in establishing a cooperative research program among the countries. It may also help in personnel development for the working vegetable scientists of the member countries, by arranging both long-term academic training and short-duration courses. AVRDC may help national vegetable research and development programs by sending their scientists to help build up research programs and their implementation. AVRDC should expand its activities to some of the important summer vegetables like teasle gourd *(Momordica dioica)*, pointed gourd *(Trichosanthes dioica)*, bitter gourd *(Momordica charantia* including var. *muricata*) and brinjal *(Solanum melongena)*.

Reference

FAO 1986 Production Yearbook. Food and Agriculture Organization of the United Nations, Rome, Italy.

Summary of Discussions - Bangladesh

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Production and Policy

Due to heavy rains and the consequent widespread flooding in the rainy season in Bangladesh, vegetable cultivation is extremely difficult. This results in a shortage of green vegetables, making it necessary to import from other countries. Although local vegetable production is far below the required amounts, Bangladesh is also looking towards the export of vegetables to the Middle East and to Europe. In fact, in 1989 Bangladesh exported vegetables worth more than 78 million takas. There is also a shortage of quality seed supply, resulting in a high dependence on imported vegetable seed.

Research

Vegetable research received attention from the government only in 1966, with a gradual growth in support over the years. Agriculture contributes about 50% to the GDP and 80% of the total earnings. The total cultivable land is 9.17 million ha with average holdings of less than 0.5 ha. Rice is grown on 78% of the cultivable land, while vegetables including potato and sweet potato occupy 3.3%. The area under vegetable is 152,550 ha and under summer vegetable 57,600 ha. Vegetable production in Bangladesh is far below the requirements, with the present consumption being only about 25 g/day/head.

Varietal improvement

(1) Collection and evaluation of local germplasm for selection;
(2) Development of late and early variety of different vegetables;
(3) Initiation of breeding program to develop high-yielding varieties;
(4) Development of improved production practices;
(5) Studies on common pests and diseases; and
(6) Studies on soil and fertility relationship.

Constraints to vegetable research

(1) Lack of trained people;
(2) Inadequate funding; and
(3) Lack of cooperation and collaboration with international institutes and research institutes.

AVRDC should have an outreach program in each of the countries. It could also help in personnel development for the working vegetable scientists. AVRDC should expand its activities to some important summer vegetables like teasle gourd, bitter gourd and brinjal.

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Vegetable Production and Policy in Nepal

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Introduction

Nepal is a land of extremes. Topography varies from 60 m above sea level to the highest peak of the world, Mount Everest, at 8,848 m. The total land area is about 147,180 km^2, of which 29,590 km^2 (20%) is under cultivation. Running from east to west, the country can be divided into three well-defined topographical belts. These cover the Tarai (plain area in Nepal) in the south with an elevation of 60 to 300 m; the Hills in the middle with an elevation of 300 to 5,000 m, and the Mountains in the north with an elevation of 5,000 to 8,848 m. These three zones comprise 23, 43, and 34% of the land area, respectively.

Nepal has an average width of 240 km from south to north with a climate that varies from almost tropical in the Tarai to alpine in the Mountains. Temperature in cultivated areas ranges from 15 to 41°C. The annual rainfall ranges from 250 to 2,800 mm. Most of the rain falls during June-September.

Nepal's population is growing annually at the rate of about 2.7% and has reached almost 19 million. There is no additional land for cultivation. The increasing population continuously exerts more pressure on the available cultivated land. Population density is 598 persons/km^2 with 1,053 persons/km^2 in the hills and 364 persons/km^2 in the Tarai. Out of the total population less than half are economically active.

Agriculture is the most important sector of Nepal's economy. It generates more than 91% of national employment and contributes 53% to the GDP. Agriculture produces 80% of the exports.

In Nepalese agriculture, a typical farming system is comprised of crops, livestock, and forestry as integral parts. However, farming is generally staple food-based. It is rice-based in the Tarai, rice- or corn-based in the Hills and millet- or potato-based in the Mountains. Over the past decade, agricultural production has recorded impressive growth. Paddy, maize, and wheat production has increased by 3.9, 5.4 and 6.2% per year, respectively. Likewise, production growth in millet and barley has been 3.8 and 8.6% per year, respectively. Production of cash crops such as sugarcane and oilseed also has grown strongly at the rate of 5.9 and 3.8% per year respectively. More importantly, impressive annual growth in yield has been achieved for crops like paddy (2.4%), potato (2.3%), and sugarcane (4.4%).

The horticulture sector as a whole has also performed well, mainly through positive growth in vegetable and potato production. Although the vegetable area comprises only about 5% of the total cultivated land in the country, this subsector plays an important role in small-scale farming mainly because vegetable cultivation is more labor-intensive and vegetable crops are more profitable than field crops.

Importance of Vegetables

Nutrition

The minimum nutritional requirement for one person in Nepal has been specified as 2,250 calories, of which 1,964 calories (87%) will be provided from food grain, pulses and potato, and the remaining 286 calories (13%) by other products like vegetables, fruits, milk and milk products, meat, fish and eggs.

Per capita daily vegetable consumption is expected to reach 175 g by the year 2000, which is below the recommended level of 285 g/person/day. Comparable figures for 1984-85 in Rekhi et al. (1989) are: China 200 g, India 123 g, Indonesia 54 g, and Maldives 93 g.

In developing countries where malnutrition and under nutrition is common, the consumption of vegetables is very low, despite the fact that vegetables and pulses are the cheapest sources of vitamins and proteins. More attention needs to be paid to increasing vegetable production in the developing countries.

Socioeconomics

Due to an increased level of understanding of the concept of a balanced diet and rapid urbanization, the demand for vegetables is increasing every year. Because of transport problems, vegetables grown in most rural and remote areas are for local consumption. To meet the increasing demand for vegetables in urban areas, commercial vegetable growing was practiced by the traditional vegetable growers. These farmers grew vegetables around Kathmandu (main consumption city) and other urban areas through intensive, small-scale cultivation. Since the rate of industrialization and urbanization was rapid, the price of land increased in the cities and towns, resulting in a reduction in area under vegetable cultivation. To exploit this opportunity of higher demand and price of vegetables, commercial vegetable production grew rapidly. Growers started producing off-season vegetables as well, taking advantage of the country's varying agroclimatic conditions and the developing transport media. Such production pockets developed along the roadsides, covering areas less than 5-6 hours walk to the roadhead. Commercial scale vegetable growing is picking up in Tarai along the east-west highway, and off-season production along the north-south crossroads in the hills, valley and inner-valley regions.

Compared to food grain production, returns from vegetable production are much higher. The main reason is that the naturally varying agroclimatic conditions are exploited and the production techniques adopted by farmers are specialized. The comparative status of this argument is presented in Table 1.

Table 1. Gross incomes from vegetable and food grain production (1988-89).

Area	Crops	Gross income/ha (NRs)*	Remarks
Naubise-Dhading	French bean	60000	Irrigated
	Sweet pepper	70000	"
	Eggplant	40000	"
	Cucumber	50000	"
	Tomato	60000	"
Daman, Palung-Makwanpur	Radish	40000	Unirrigated
	Cauliflower	55000	"
	Pea	40000	"
Kathmandu Valley	Cauliflower	48000	Irrigated
	Radish	25000	"
	Pea	40000	"
	Early cabbage	50000	"
Nawalpur-Sarlahi	Tomato	30000	Unirrigated
	Sweet pepper	80000	"
	Tropical cauliflowers	50000	"
	Watermelon	40000	"
Nepal Average	Paddy	23000	Irrigated
	Wheat	14000	"
	Mustard	13000	Unirrigated
	Millet	10000	"
	Maize	13000	"

* US$ 1 = NRs. 29.00 (15 June 1990).

Small-scale Farmers' Participation in Vegetable Farming

Because holdings are small (1.5 ha in Tarai and 0.5 ha in Hills), farming in Nepal is of a subsistence type. Since it has become increasingly difficult for the farmers in the hills to solve their livelihood problems, people migrated from hills to cities and Tarai in search of employment. Vegetable cultivation could be one of the solutions to the unemployment problem. Experience has shown that vegetable farming provides better employment opportunities and higher incomes than traditional food-grain production.

In the development of vegetable cultivation, it has been seen that, during initial stages, the farmers having larger holdings were attracted towards vegetable cultivation due to higher returns. However, as soon as the program started to expand with the easy access of inputs and technical knowhow, the small-scale farmers' participation increased. This resulted in increased demand for labor, making the program unattractive to the large-scale farmers. This was mainly because the holdings of the large-scale farmers were operated using hired labor and that of small-scale farmers were family-operated. As the underemployed family labor moved towards full employment, the return from vegetable cultivation, though not economically profitable, was better than the returns from the others.

Vegetable Production Program

The Vegetable Production Program was launched as a Special and General Program in Nepal. Out of 75 districts, a special program has been launched in 31 districts. Such programs are conducted mainly in the vicinities of district headquarters, cities, towns and highways. This program is fully supported by improved seeds. Other support to the program includes demonstrations, field days, farmer observation tours and training, loans and other agricultural inputs such as fertilizer and plant protection materials.

The General Program was launched in other accessible areas of the country. It is supported partly with improved seeds, farmer training, fertilizers and plant protection services.

Besides these programs, a sizeable vegetable area comes under the 'least priority' program. This program receives limited extension support from the government. This area also benefits indirectly through technology dissemination in adjoining special and general program areas. Farmers manage necessary inputs on their own. In addition, production in the remote areas and kitchen gardens are also included under this program.

The acreage and production under each of such programs are summarized in Table 2.

Table 2. Vegetable production in Nepal.

Production program		Unit	End of Sixth Five Year Plan (1984-85)	Seventh Five-Year Plan Period	
				Beginning (1985-86)	End (1989-90)
Special	Area	ha	3200	3665	5032
	Production	t	32000	40755	75830
General	Area	ha	18000	18911	23748
	Production	t	126000	142580	223282
Least priority	Area	ha	117000	116010	111704
	Production	t	585000	599199	671088

Source: Vegetable Development Division.

Estimated Value of Production

Hectarage, volume and approximate value of production of some vegetables are presented in Table 3. Cauliflowers and cabbages are the highest selling vegetables in Nepal in terms of both volume and value. Table 3 presents the statistics of documented volume of production only. These figures may even be higher if the local production in remote areas could be estimated. The prices quoted are average value based on previous experience and are the farmgate prices.

Table 3. Hectarage and production of popular vegetables in Nepal[z].

Popular vegetable	Area (ha)	Production (t)	Avg. price from previous experience (NRs/t)	Approx. value of production (NRs '000)
Cauliflower	19267	150280	1800	270504
Cabbage	15514	150490	1500	225735
Radish	7331	66712	500	33356
Onion	8001	110015	1600	176024
Peas	6688	10060	1700	34102
Tomato	10530	72657	750	54492
Broad leaf mustard	7495	45720	1000	45720
Eggplant	9283	64985	600	38991
Chilies	9513	13320	3900	51948
Beans	5991	47930	1300	62309
Pumpkins	4109	36970	800	29576
Okra	7244	50700	700	35490
Sponge/bottle gourd	5116	49625	600	29775
Others	24418	90736	750	68052

[z]Based on the program of 2046-47 (1987-90).
Source: Vegetable Development Division.

Vegetable Seed

Vegetable seeds in Nepal are produced by government farms and contract farmers. Government farms produce very little improved (certified) seed, and the balance of their production is nucleus and foundation seeds. Most of the improved seeds are produced by contract farmers. Contract farmers are in the vicinities of the government farms. They produce seed under the guidance of government farms, which are coordinated centrally by the Vegetable Development Division. Actual and future productions are presented in Table 4.

Table 4. Vegetable seed production in Nepal.

Sector	Production years					
	Achieved production (t)				Expected production (t)	
	1975-76	1980-81	1987-88	1988-89	1989-90	1999-2000
Govt. farm	9	9	11	11	16	26
Private	1	15	70	120	194	865

Source: Vegetable Development Division.

Vegetable Export Earnings

As a result of all the efforts in vegetable development, Nepal has become almost self-sufficient in vegetable production. In some areas the production is actually surplus and marketing has become a problem. A large portion of the vegetables produced in some Tarai districts are exported to India. Major vegetables exported to India are tomato, onion, green peas, radish, pointed gourds, and cauliflower. Similarly, green chilies, cabbages, green peas, garlic, onion, bean, tomato, eggplant and sweet pepper are exported to Tibet. During 1986-87 the value of such exports was estimated at NRs 263,000 (Department of Food & Agricultural Marketing Services 1988, Handbook of Agricultural Statistics).

On the other hand, vegetable seeds produced in Nepal have started gaining popularity in foreign countries. Vegetable seed exports in different years are presented in Table 5.

Table 5. Vegetable seed export.

Years	Quantity (kg)	Major seeds
1987-88	500	Radish
1988-89	9763	Radish, eggplant
1989-90 (expected)	20000	Radish, eggplant

Source: Vegetable Development Division.

Constraints to Vegetable Production

Constraints to vegetable production in Nepal can be grouped into four categories as follows:

Financial

(1) Inadequate infrastructural development for the maintenance of vegetable varieties;
(2) Lack of air-conditioned storage for the preservation of germplasm;
(3) Insufficient storage facilities to preserve the carry-over seeds from deterioration;
(4) Lack of greenhouses for proper testing of materials;
(5) Inadequate technical literature for rapid transfer of technology;
(6) Insufficient vegetable processing industries.

Personnel

(1) Shortage of trained farm- and field-level staff for the execution of the vegetable seed production programs;
(2) Lack of trained field level technicians for vegetable crop extension services;
(3) Shortage of technicians among the seed merchants, as well as in the government's Agriculture Inputs Corporation.

Technological

(1) Lack of high-yielding varieties;
(2) Difficulty in the maintenance of large numbers of varieties;
(3) Insufficient quantities of quality seeds;
(4) Quick deterioration of carry-over seeds;
(5) Lack of quality control seeds sold by the private sector;
(6) Limited knowledge of postharvest technology;
(7) Poor education level of growers, preventing the adoption of new technology.

Management

(1) Insufficient production of seeds in high demand;
(2) Seeds not available in time due to inefficient distribution system;
(3) Lack of organized vegetable markets;
(4) Poor marketing system with limited market of fresh vegetables;
(5) Poor coordination among different agencies involved in vegetable development programs;
(6) Lack of feedback of production information from the field, which has hampered progress, evaluation and thus future programming;
(7) Lack of reliable statistics on area, production, productivity, and per capita consumption.

Resource Allocation for Research

Agricultural research requires a well-defined strategy of agricultural development in the country. There has been a tendency for most of the research to be done according to the interests and training of individuals. If objectives of research are not clear, then the findings may not be relevant to the farmers' needs.

Returns from research can be maximized only when the farmers' problems and research efforts are linked. However, in Nepal, farmers, research workers, and planners tend to work independently according to their organizational objectives, although they are interdependent in terms of their functional targets. To create a functional linkage among them, a program of testing agricultural research findings in the farmers' fields should be developed. It is further emphasized that research should not be on conventional experimental plots designed to discover new practices, but the application of a known technology that farmers need immediately.

Resource Allocation

Agricultural research was initiated in Nepal many years ago, yet the research infrastructure has only been established since the early 1960s. Research activities should be problem-oriented and duplication must be avoided. In Nepal, however, there is overlapping and duplication in research effort both within and between institutions, due to the lack of an integrated plan to guide the establishment of experimental farms.

Recent Development

In 1987 a new agency, the National Agriculture Research Center (NARC) was established under the Ministry of Agriculture. All research proposals are now approved by NARC before implementation, which we hope will prevent duplication and inappropriateness in future research.

Financial Allocations

The financial allocation for vegetable research for 1989-90 is given in Table 6.

Table 6. Financial allocation for vegetable research (1989-90) (NRs. million).

Country's total budget	20242
Share of agriculture in the total budget	1419
Total research budget	127
Total horticultural research budget	1
Total vegetable research budget	0.3
Percentage of total horticulture budget for vegetable research	29%
Percentage of total research budget for vegetable research	0.26%
Percentage of total agriculture budget for vegetable research	0.023%
Percentage of total agriculture budget for total research	0.089%
Based on 1988-89 Gross Domestic Product Accounts (NRs. million)	
Total GDP	77052
Agricultural GDP	40742
Nonagricultural GDP	3631
Percentage of total GDP shared by agriculture = 52.9%	

Source: National Agricultural Research Center Budget Estimates for 1989-90, Ministry of Finance.

Personnel

There are 12 staff at the masters level (one is working on a PhD) and 13 at the BSc level working on vegetable research and development in Nepal (mid 1990).

National Policy on Vegetables

Government policy on vegetables is based on the national agriculture development plan and its vegetable development component.

National Agricultural Development Plan

In view of past developments, problems envisaged and the country's future needs, the agricultural development plan in Nepal has the following objectives: (1) to increase food production in accordance with the rise in population at the same time increasing the level of consumption; (2) to increase the production of vegetables, fruits, fish, meat and milk to attain self-sufficiency; (3) to increase the exportable and import-substituting goods to increase income and employment opportunities; and (4) to increase the production of raw materials for further development of agro-based industries in the country.

Vegetable Development Plan

The vegetable development plan is based mainly on the objective of producing an adequate quantity that can meet the basic needs of the people by the year 2000. The focus of the plan is to increase the consumption level of 50.9 kg/person/year in 1989-90 to 64 kg by 2000. This means that the total production of vegetables has to increase from 970,200 t in 1989-90 to at least 1.5 million t by 2000. These projected production increases are presented in Table 7.

Table 7. Projections of the vegetable production program.

Vegetable Production Program		Five Year Plan		
		End of seventh plan (1989-90)	End of eighth plan (1994-95)	End of ninth plan (1999-2000)
Special:	Area (ha)	4800	9600	14300
	Production (t)	72000	201600	378000
General:	Area (ha)	24000	30551	34000
	Production (t)	228000	381890	510000
Least Priority:	Area (ha)	117000	100352	92200
	Production (t)	670200	722534	756045

Source: Vegetable Development Division.

Policy on Vegetables

(1) To meet the projected needs, an increase in production of 667,646 t is required. However, there is little or no potential to bring additional land under cultivation. Therefore the increase in production will have to come through increases in the level of productivity. Increase in productivity will be attained in two ways: one is through technological advancement including the development of high-yielding varieties. Another will be through the improvement in irrigation and supply of other inputs. Expected increases in productivity are presented in Table 8.

Table 8. Vegetable production and productivity in different plan periods.

Production	Unit	Productivity in Five-Year Plan End of the plan period 7th (1989-90)	8th (1994-95)	9th (1999-2000)
Special	t/ha	15.0	21.0	26.0
General	t/ha	9.5	12.5	15.0
Least priority	t/ha	5.8	7.2	8.2
Average	t/ha	6.9	9.2	11.6
Percentage increase in average productivity:			33.3	68.1 over that in 1989-90 26.1 over that in 1994-95

Source: Vegetable Development Division

(2) To strengthen research to develop high-yielding and hybrid varieties;
(3) To support varietal maintenance and hybrid seed production;
(4) To develop postharvest technology to minimize losses of fresh produce and improve their shelf-life;
(5) To develop cold storage facilities;
(6) To create new markets and marketing facilities;
(7) To prepare national scientists through higher education and training;
(8) To exploit indigenous vegetables such as yam, colocasia, chayote, amaranthus, sweet potato, cassava, etc.;
(9) To exploit national ecology for off-season production;
(10) To develop and support vegetable processing industries;
(11) To encourage export of fresh vegetables and vegetable seeds;
(12) To develop a sound vegetable seed industry in the country to meet local needs as well as export demand;
(13) To promote private participation in the production and distribution of vegetable seeds.

Future Directions

Vegetable Production

Among the many problems faced by the Nepalese people, an important one is malnutrition. Increased consumption of fruits and vegetables would help alleviate this problem. With this in mind government plans and policies in the future will be aimed at increasing vegetable production so that the minimum requirement of vegetables as envisaged by the basic needs program will be met first. Second, future efforts will be to further increase vegetable production so that consumption in Nepal will reach a par with the average standards of other Asian countries.

Organizational Development

Horticulture is an important sector of Nepalese agriculture. Varying agroclimatic and ecological conditions make the mid-hill belt more suitable for horticulture crops. With increasing national and international demand for horticultural products, activities in this sector grew substantially. As a result, the production program in the then existing Department of Agriculture became complex. It was realized that a horticulture component needed to be established as a separate organization, so the Department of Horticulture was given official recognition in June 1990. The Department will expand its activities in all 75 districts of the country in a few years starting with 37 districts. It is expected that with the new organizational setup, rapid progress in the horticulture sector will be achieved.

Horticulture Development

A master plan for horticulture development is being prepared with assistance from the Asian Development Bank. Future programs will be guided by this study, after it is completed and critically analyzed.

Opportunities for Cooperation

The following areas offer opportunities for future cooperation between Nepal and other SAARC countries and international institutions like AVRDC:

(1) Short-term observation tours for senior officers, and training and study tours for junior officers and staff could be arranged under the SAARC cooperation program;
(2) Short-term training for lower level technicians in temperate vegetables in Nepal and other types of training for Nepalese technicians on tropical vegetables in SAARC countries could also be arranged;
(3) Exchange of periodicals and journals;
(4) Exchange of vegetable germplasm and research materials;
(5) Exchange of knowledge through exchange of experts;
(6) Coordinated multiplication research programs could speed up the development of new technologies;

(7) Among the SAARC countries, Nepal has the advantage of having all types of agroclimatic conditions suitable for fresh and seed production of almost all types of vegetables. These could be of great importance to trainees and researchers for short visits and training. The establishment of a regional training center on vegetable crops would be most welcome in Nepal.

Reference

Rekhi, S.S., Shah, B.B., and Aryal, S.B. 1989. Vegetable development in Nepal; present status, future strategy and constraints. Paper presented at International Expert Meeting on Horticulture and Bee Keeping Development in the Hindu Kush Himalaya, Kathmandu, Nepal.

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Vegetable Research in Nepal

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Introduction

Development efforts in vegetable production began in the 1940s with cabbage seed in the Balaju Nursery (Kathmandu District). In 1947-48, a vegetable seed store in New Road, Kathmandu was open. In 1952, improved vegetable varieties were first introduced and were put under trial for assessment. However, it was not until 1960, when several horticultural farms were established in the different agroclimatic regions, that vegetable research, seed production and distribution were done for vegetable development purposes in Nepal.

In 1972, the Vegetable Development Division was established within the then Department of Agriculture which marked the start of an intensive vegetable development program in Nepal.

After evaluating vegetable development activities, the progress achieved, and the country's needs, a Vegetable Seed Production Project (FAO) was started in 1981. With financial as well as technical help from the project, the Vegetable Development Division and farms under it were equipped for advanced research on vegetable crops.

The research outcomes were valuable and the program developed rapidly. However, there was some duplication and inappropriateness in the research. With a view to alleviating such problems, in 1987 a National Agriculture Research and Services Center (NARSC) was established.

With the growing demands for horticultural products in Nepal, the vegetable as well as other sectors of horticulture grew to such an extent that it became difficult to manage the whole of horticulture under the then Department of Agriculture. On 15 June 1990 the Department of Horticulture was established under the Ministry of Agriculture.

Important Vegetables in the Country

There are over 200 types of vegetables grown commercially in Nepal. Among them, more than 50 types are common. Such a wide range of cultivation is due to an availability of tropical to alpine climates in the Kingdom. Some common vegetables grown in Nepal are:

Cauliflower (*Brassica oleracea* var. *botrytis*)
Cabbage (*Brassica oleracea* var. *capitata*)

Broccoli (*Brassica oleracea* var. *italica*)
Tomato (*Lycopersicon esculentum*)
Eggplant (*Solanum melongena*)
Hot pepper (*Capsicum annuum*)
Sweet pepper (*Capsicum grossum*)
Radish (*Raphanus sativus*)
Turnip (*Brassica campestris* var. *rapa*)
Carrot (*Daucus carota*)
Onion (*Allium cepa*)
Garlic (*Allium sativum*)
Pumpkin (*Cucurbita moschata*)
Squash (*Cucurbita pepo*)
Bottle gourd (*Lagenaria siceraria*)
Bitter gourd (*Momordica charantia*)
Watermelon (*Citrullus vulgaris*)
Chayote (*Sechium edule*)
Cucumber (*Cucumis sativus*)
Garden pea (*Pisum sativum*)
French bean (*Phaseolus vulgaris*)
Broad bean (*Faba vulgaris*)
Cowpea (*Vigna sinensis*)
Broad leaf Mustard (*Brassica campestris* var. *rugosa*)
Swiss chard (*Beta vulgaris* var. *cicla*)
Spinach (*Spinacia oleracea*)
Cress (*Lepidium sativum*)
Beet spinach (*Beta vulgaris*)
Fenugreek (*Trigonella foenum-graecum*)
Coriander (*Coriandrum sativum*)
Asparagus (*Asparagus officinalis*)
Ginger (*Zingiber officinale*)
Turmeric (*Curcuma longa*)
Potato (*Solanum tuberosum*)
Okra (*Abelmoschus esculentus*)
Colocasia (*Colocasia esculenta*)
Yam (*Dioscorea alata*)
Sweet potato (*Ipomoea batatas*)

National Priorities in Research

Long-term Priorities

(1) Development of improved varieties suitable to the farming systems in Nepal;
(2) Development of a package of improved production technologies in the areas of vegetable agronomy, pest and disease management and seed production to obtain maximum output from a given variety;
(3) Production of high quality seeds of temperate vegetables for export to neighboring countries; and
(4) Development of appropriate processing technologies.

Short-Term Priorities

(1) Collection, conservation and utilization of local genetic resources, supported by continued introduction of appropriate germplasm from exotic sources;
(2) Use of hybrid seed production technologies in important vegetable technologies and under varying agroecological conditions;
(3) Development of off-season production in important vegetables to ascertain supply during lean seasons;
(4) Development of crop production technologies with emphasis on time and method of planting, plant production, weed control, and fertilizer management and pest management;
(5) Generation of appropriate postharvest technologies for vegetable processing;
(6) Varietal purification and maintenance; and
(7) Integration of vegetable cultivation with other components of Nepalese farming systems.

Implementation Strategy

As envisaged in the long term plan of Nepal, the level of vegetable consumption has to be increased to 64 kg/person/year by the year 2000 to meet minimum nutritional requirements. The per capita consumption in 1989-90 was approximately 51 kg/person/year with a total production of 970,200 t. To bring this figure to 64 kg/person by 2000, and adjust for the expected increase in population, requires a total production of at least 1,515,000 t. Since there is no additional land to bring under cultivation, the increase in production has to come mainly from increases in cropping intensity and increases in productivity per unit area. Average vegetable production during 1989-90 has been estimated at 5.9 t/ha. To meet the expected level of increased productivity this has to increase to 11.65 t/ha by the year 2000. We plan to achieve this increase in productivity through the following technological advances: (1) variety development and maintenance, (2) development of improved agronomic practices, (3) development of technology for off-season production, and (4) development of hybrid varieties and their seed production.

Due to the prevalence of a wide range of agroclimatic conditions in Nepal, a multilocational research program is necessary in the following areas: Dhankuta, Pakhribas, Khumaltar, Lumle, Rukum and Dadeldhura which represent midhills, Marpha and Dolpa representing highhills, and Sarlahi representing southern plains.

Recent Developments

Prior to the creation of NARSC in November 1985, crop research and extension were combined under the Department of Agriculture. The Seventh Five-Year Plan (1985-90) explicitly recognized the need for an efficient research system, so the government created NARSC as a separate entity responsible for all research under the guidance of the National Agricultural Research Board (NARB).

Mandate

NARSC was created to achieve the national goal of increasing agricultural production and productivity by implementing coordinated research programs to develop technologies applicable to the diverse environmental needs of Nepalese agriculture, and facilitating the process of technology transfer through on-farm research.

Objectives

Specific objectives of NARSC are:

(1) To formulate, coordinate, implement, monitor and evaluate all research programs approved by NARB;
(2) To eliminate duplication of research activities, improve research facilities and their utilization, improve fiscal and personnel management, develop research plans with short-term and long-term objectives and improve overall research efficiency in pursuit of appropriate technologies;
(3) To strengthen the research outreach programs of the stations by collaborating with extension programs to focus on the needs of the small-scale farmers through a farming systems approach;
(4) To publish research results and information on new technologies in appropriate forms for the use of extension personnel, farmers and administrators; and
(5) To strengthen the linkages with international agricultural research centers and with the relevant national centers.

Constraints to Vegetable Research

Abiotic Factors

The country's total funds for vegetable research are quite inadequate, and do not allow long-term research that could lead to important technological advancements.

Research facilities are inadequate, and stronger management skills are required to manage budgets, giving scientists more control over their budgetary allocations. The pay scales for scientists are far too low and need upgrading as well.

The research institutions and individual scientists are not able to keep up with research activities elsewhere because of inadequate access to international journals.

There are about 25 MSc and BSc level people working on vegetable research and development in Nepal. The number is far too low given the many diverse regions and crops to be covered. Further training and upgrading of existing staff are needed.

There is poor linkage between the various research institutions within the country.

Biotic Factors

Varietal development is the most important activity in agricultural research in Nepal. The collection of a wide range of germplasm in the gene bank is very important to guard against varietal deterioration. Because of the lack of germplasm and inadequate local exploration and collection, varietal development work is hampered in Nepal. International sources are not adequate because traditional vegetables are most widely cultivated.

Diseases, insects and weeds are the main problems encountered in the field, and their control is difficult and costly, using up large portions of our operating funds.

Vegetable Research Training Needs

(1) Development of hybrid varieties.
(2) Maintenance of parent (inbred) lines.
(3) Seed production technology.
(4) Postharvest handling.
(5) Vegetable processing.
(6) Processing, packaging and storage of vegetable seeds.
(7) Handling of seed processing units.
(8) Maintenance of the quality of carry-over seeds.
(9) Greenhouse technology.
(10) Farm management.
(11) Health hazards involved in use of pesticides.

Funding for Vegetable Research

Additional investments in vegetable research should be directed to the following:

Personnel Development

So far in Nepal research on vegetables s predominantly adaptive, with dependence on AVRDC and developed countries for germplasm and production technologies. If Nepal cannot develop high-level researchers and support personnel, the quality of research will not improve. Vegetable breeding, vegetable production agronomy, seed production technology, plant protection and farm management personnel are needed.

Job-Entry Training

Graduates at the BSc level should be given 3-4 months additional training before beginning work in vegetable research.

Adequate Libraries

The libraries on the research farms are poorly stocked with scientific journals and magazines. For this reason, researchers are unable to keep up with recent advances in research, and may pursue lines of study already done elsewhere. The research farms and stations should therefore be provided with the most valuable and relevant scientific journals and magazines.

Germplasm Preservation

Air-conditioned stores are required to save on costs of producing seeds of the collected germplasm every year. These are particularly needed for cross-pollinated vegetable crops where the isolation and distance are problems, and seeds of each of the intercrossing crops/varieties can be produced in different years while keeping the other crops and varieties of the same group in the air-conditioned stores.

Germplasm Collection Centers

There is no officially recognized center for germplasm collection in Nepal. For germplasm collection, evaluation and preservation, there should be at least three centers: one in Tarai (the southern plain belt), the midhill, and the highhill belts (the northern mountainous belt). These centers should be supported by all-weather screenhouses to facilitate year-round research activity.

Sustaining Funding

Sustained funding over a number of years is essential for long-term research projects like germplasm collection, evaluation, preservation and varietal development.

Interaction with AVRDC

Chinese Cabbage

Chinese cabbage lines and varieties received from AVRDC have been tested, and the results are promising, especially for the hybrid variety ASVEG #1.

Hybrid seed production of ASVEG #1 was tried at the Vegetable Research and Seed Production Center, Khumaltar. Hybrid seed production of ASVEG #1 is possible for both domestic use and for export.

Tomato

To develop an F_1 hybrid variety, a study was conducted to determine the general and specific combining abilities for earliness, disease tolerance and high yields. Among 15 different varieties in the study, four lines (T-2, T-5, T-6 and CL 1131) were received from AVRDC. The study is continuing and results have not yet been analyzed.

Subregional Cooperation

In the complex areas of research like breeding for disease resistance, hybrid and processing type varieties, germplasm preservation, etc., Nepal can benefit from subregional cooperation. These areas may require pooling of regional resources.

Rather than having all types of research institutes in one country, subregional cooperation can reduce the number and costs of such establishments by having specific institutes in the most relevant country. Resources saved can be used for other sectors of development. This also applies to training and personnel development.

AVRDC's Future Role

AVRDC can play an important role in three areas: (1) collecting, developing and supplying of research materials; (2) as a center of information; and (3) as a center for personnel development through training. The above functions of AVRDC should be continued, with further expansion of its activities.

Such expanded activities should include establishment of subregional research and training centers. The collection of literature on vegetables should be readily accessible to country libraries and individual researchers. AVRDC could organize annual scientific meetings among different country researchers to help regional scientists keep in touch with the latest developments in vegetable research.

Summary of Discussions - Nepal

Chairman: **D.K. Wangchuk**
Rapporteurs: **Altaf Hussain**
H.S. Gill

The paper on vegetable production and policy referred to the typical topography of Nepal, with about 20% of the land area under cultivation. The climate varies from tropical to alpine The present population of 19 million is growing at 2.7% per year. Agriculture generates employment for 91% of the people and contributes 53% to the gross domestic income and 80% of exports. The importance of vegetables in Nepal, and the government's plan to increase the present yearly level of vegetable consumption from 50.9 to 64 kg per person by the year 2000 was emphasized. The high returns from vegetable production, compared with cereal crops, was also highlighted.

Quality seed production had increased to 131 t by 1989-90. Limited availability of funds and trained people are the main constraints. The policy on vegetables, which includes strengthening of research support for varietal maintenance, hybrid seed production, postharvest technology to improve shelf-life, development of cold storage facilities, training, involvement of the private sector in production and distribution of vegetable seeds and to encourage fresh export of vegetables were outlined. Future directions to increase vegetable production in Nepal were indicated, highlighting opportunities for cooperation between research and extension workers to promote vegetable development. The idea of establishing a regional training center for vegetable crops was introduced. The opportunities for cooperation between international organizations in short-term training, exchange of research information, germplasm, research material, exchange of experts and a coordinated seed program were also emphasized.

Vegetable Research

The history of vegetable development in Nepal was briefly described. Almost 200 types of vegetables are grown but 50 of these are the most important.

The varied climate of the country is suitable for growing a wide range of vegetable crops. Fifteen areas in the country have been identified as suitable for seed production, especially of temperate vegetables.

Long-term priorities of research are development of improved varieties along with standardization of improved technology. Production of high-quality seed for local use as well as for export is also important.

Recent developments in vegetable research include the creation of the National Agriculture Research Center (NARC) in 1987, which is responsible for all research under the guidance of the National Agricultural Research Board. It has a mandate to achieve the national goal of increasing agricultural production and productivity, from the present 970,200 t to 1,515,000 t in the year 2000. This will bring the annual per capita consumption to 64 kg from the present 50 kg. Nepal hopes to achieve this target by improving the productivity per unit area through application of improved technology.

Several abiotic constraints to vegetable research have been identified, such as inadequate funds, shortage of scientific literature, and a shortage of trained people. The important biotic constraints include lack of germplasm and prevalence of pests, diseases and weeds.

Training needs of research staff in breeding, seed production technology, postharvest handling and processing have also been emphasized.

In the future more funds for research should be provided for personnel development and germplasm banks, and the availability of funds for research must be assured.

During discussion of vegetable forcing under polythene tunnels, it was stated that research work on this was started some years ago and is now becoming popular with the growers. Previously the polythene was imported from Japan, but is now available at lower cost from India. The government is also encouraging kitchen gardens by distributing free seeds. Postharvest losses of 30-40% were reported. These losses can be minimized by developing better postharvest technologies.

The following major points emerged:

(1) Lack of trained personnel. There are no PhD-level scientists working on vegetables in Nepal. Establishment of a training center in Nepal was suggested.
(2) Low priority of vegetable research in national planning.
(3) There is a need to popularize protected cultivation to supply vegetables throughout the year.

Session II
Special Topics

Demand and Supply of Vegetables and Pulses in South Asia

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Vegetables are important in the human diet because they supply carbohydrates, proteins, vitamins and minerals. Adequate production and supply become highly significant for the developing countries of South Asia in view of widespread malnutrition in this part of the world. Since both food and nutritional security are very important considerations and requirements for these countries, special efforts on intensification of production and supply of vegetable crops are necessary. Vegetable crops not only provide nutritional security but are also capable of producing more than five times the quantities of food per unit area, when compared to cereal crops. With such a high yield potential, production of vegetables may contribute significantly to solving the food problems of the nations deficient in supplies of food. Animal food products rich in protein are neither cheap nor easily available. Leguminous vegetables and pulses, except mushrooms, are the most common alternatives to supply easily digestible vegetables protein for the human diet.

Pulses are an important alternative to vegetables for supplementing the vegetarian diet of a majority of the population in these countries. Their consumption contributes an additional supply of protein. Since pulses are not perishable common people in these countries depend more heavily on them rather than on vegetables. Pulses in South Asian countries in general, and in India in particular, are therefore the most dependable substitutes for vegetables.

Population in South Asia

Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka constitute the South Asian region. These countries are among the most populated regions of the world, with over 1.08 billion people (Table 1). To provide this increasing population with quality food and a balanced diet is a gigantic task. In India, for example, the population by 2000 is expected to reach 1 billion. It would be difficult to keep pace witn cereal production even after the achievement of several breakthroughs in our traditional agriculture. Since vegetables have a capacity to produce over five times the amount of food per unit area, and these along with pulses are also important in providing a much needed nutritional security, the South Asian region/countries will need to depend more heavily on vegetables and pulses to eradicate hunger, malnutrition and disease and to provide the masses with a balanced diet.

Table 1. Population of South Asian countries (in millions).

	1980	1988
Bangladesh	88.2	109.6
Bhutan	1.3	1.5
India	688.9	819.5
Nepal	14.9	18.2
Pakistan	85.2	115.0
Sri Lanka	14.8	16.9
Total	893.3	1080.7
World	4414.8	5114.8

World Production

Vegetables

Total production of vegetables in the world in 1988 was 426.2 million t (Table 2). World production of vegetables increased by 20.8% during 1980-88. China, the largest producer of vegetables in the world, accounted for 113 million t in 1988-89, followed by 48.5 million t for India, the world's second largest producer. The total production of vegetables in South Asian countries (Table 3) has increased from 44.5 million t to 53.9 million t during the decade, an increase of only 16.5%. India's share of the present total world production of vegetables is 48.5 million t which is 89.7% of the total vegetable production of South Asian countries and only 11.4% of world production. India increased its production by just 14.6% only during the 1980s.

Table 2. Global vegetable production (million t).

	1979-80	1984-85	1988-89
China	79.6	99.7	113.0
India	40.0	45.4	48.5
USSR	29.2	31.8	33.8
USA	24.6	28.1	27.9
Japan	15.5	15.4	15.3
World	352.8	402.5	426.2

Table 3. Vegetable Production in South Asia (million t).

	1979-80	1984-85	1988-89
Bangladesh	1.1	1.2	1.3
Bhutan	0.01	0.01	0.01
India	40.6	48.5	48.5
Nepal	0.2	0.3	0.3
Pakistan	2.1	2.8	2.9
Sri Lanka	0.5	0.9	0.9
Total	44.5	53.6	53.9
World	352.8	418.2	426.19

Pulses

Total world production of pulses was 58.6 million t in 1989 (Table 4). Asia leads all other continents in pulses with a production of 25.6 million t, of which India's share is 13.7 million t, making it the leading country in the world for pulse production. Whilst Asia contributes about 43.7% of the world's total pulse production, India produced 23.4% to that total, 53.6% to Asia's production in 1989.

Table 4. World pulse statistics (1989).

	Area (million ha)	Productivity (kg/ha)	Production (million t)
World (total)	72.3	813	58.6
Africa	11.3	590	6.7
Asia	38.5	663	25.6
North and Central America	4.2	870	3.6
South America	6.3	536	3.4
Europe	3.7	2083	7.6
Australia	1.5	1140	1.7
India	23.3	589	13.7

In the six South Asian countries total pulse production in 1988 was 12.2 million t; 11.2 million t was produced by India. Production of pulses in South Asia is presented in Table 5. The contribution of the countries in the region other than India has been quite small.

Table 5. Pulse production in South Asian countries (million t).

	1979-80	1986	1988
Bangladesh	0.228	0.191	0.188
Bhutan	0.002	0.003	0.004
India	10.509	13.311	11.229
Nepal	0.126	0.146	0.153
Pakistan	0.595	0.792	0.552
Sri Lanka	0.026	0.043	0.039
Total	11.486	14.486	12.165
World	40.807	52.594	54.652

Pulse production in these countries, including India, has fluctuated almost uniformly, and has remained practically static during 1980-88. India's pulse production has varied between 10.5 and 13.3 million t during 1980-88. Major pulse crops grown and their production in India during 1988-89 are given in Table 6.

Table 6. Production of pulse crops in India (1988-89).

Crop	Production (million t)
Cicer arietinum (gram)	5.06
Cajanus cajan (arhar/pigeon pea)	2.66
Vigna mungo (urd/blackgram)	1.59
Vigna radiata (mongo/greengram)	1.42
Macrotyloma uniflorum (kulhi)	0.57
Vigna aconitifolia (moth bean)	0.05
Lens culinaris (masur/lentil)	0.66
Lathyrus sativus (kesau)	0.43
Pisum sativum (dry peas)	0.43
Phaseolus vulgaris (dry bean)	3.50

Demand and Supply

Vegetables

Against a demand of 85.3 million t of vegetables annually, India is producing 48.5 million t meeting nearly 50% of the requirements of its population. Similarly Sri Lanka is also producing about 50% of its demands as its production is 0.9 million t against a demand of 1.8 million t. Present demand of Pakistan for vegetables is about 12 million t, but the supply is only 2.9 million t or about 25% of its requirements. Demands of other countries of South Asia are: Bangladesh, Bhutan and Nepal, 11.4, 0.2 and 1.9 million t, against supplies of 1.3, 0.01 and 0.3 million t, respectively.

The demand calculated is based on the recommended optimum quantity of 285 g/person/day. Since vegetables are highly perishable, and to allow for losses, 10-15% more than the demand estimates must be produced. Therefore, production requirements of vegetables of these countries would be: Bangladesh 13.1, Bhutan 0.2, India 102, Nepal 2, Pakistan 13.8 and Sri Lanka 2 million t, respectively.

Pulses

The demand and supply of pulses is similar to the situation with vegetables. India, the largest consumer of pulses, demands about 22.6 million t annually. Against this the supply is only 11.2 million t, meeting about 50% of the total requirements. Bangladesh and Pakistan follow next in their demand of pulses, with requirements of 3.2 million t each. Against these demands their supplies are only 0.19 and 0.6 million t respectively. Nepal's demand is 0.5 million t and the supply only 0.15 million t. Demands of Bhutan and Sri Lanka are 0.04 and 0.5 million t against their supplies of about 0.004 and 0.04 million t, respectively. Although India is able to meet about 50% of the demand, supply improved to 56% in 1989. Nepal was able to supply 28.9%, Pakistan 17.4%, Bhutan 10%, Sri Lanka 8.5%, and Bangladesh only 5.9% of their demands.

Per Capita Consumption

Diet experts recommend a daily supply of 285 g of vegetables and 80 g of pulses for a balanced diet. Consumption of vegetables and pulses in South Asia is given in Table 7. The highest per capita consumption of both vegetables and pulses is in India. Sri Lanka follows closely with the other South Asia countries showing a very low per capita supply/consumption.

Nepal is the second highest consumer of pulses in South Asia with an average per capita/day consumption of 23 g, second only to India's 40 g. These data emphasize that consumption of both vegetables and pulses in South Asia is extremely low, especially when compared with the average consumption of 280 g in China and 564 g in the USSR. However, it should also be noted that consumption of pulses is not sufficiently high throughout the world; the average consumption being only 29 g. Australia's daily per capita availability of 264 g of pulses is the highest in the world. Massive efforts are needed to bridge the wide gap between demand and supply of vegetables and pulses.

Table 7. Per capita consumption (g) of vegetables and pulses in South Asia (consumption/person/day).

	Vegetables	Pulses
Bangladesh	32	5
Bhutan	19	8
India	135	40
Nepal	42	23
Pakistan	69	13
Sri Lanka	120	6
China	280	13
USSR	564	97
World	250	29

Constraints

There are several problems in the region which limit progress in improving the supply and consumption of vegetables and pulses, including:

(1) Low productivity of these crops in the region due to lack of widely adaptable, high-yielding varieties and hybrids;
(2) Short-duration varieties to fit into different cropping systems are too few in vegetables and lacking in pulses;
(3) Nonavailability of seeds of improved varieties to the growers, which leads them to cultivate local, traditional, low-yielding varieties;
(4) Limited extension service support, particularly for vegetables, so that new technology is not reaching the farmers;
(5) Low priority accorded to vegetable development programs, compared to cereals and other crops, limiting the developmental efforts because of inadequate funding;
(6) Several diseases and insect pests affect these crops which lead to reduction in both yield and quality. Neither resistant varieties nor efficient integrated disease and insect-pest control measures have yet been developed;
(7) Both eating habits and lack of disposable income prevent people from eating more vegetables and pulses;
(8) Fast population growth compels governments to give priority to the production of cereal crops;
(9) The perishable nature of vegetables, and the labor-intensive operations discourage growers from taking up vegetable production;
(10) Pulses are mostly grown in unirrigated areas in low fertility soils, resulting in lower production. Only around 7% of the area under pulses is irrigated;
(11) Nonavailability of dependable statistics on area and production is a major handicap in planning for research and development, particularly for

vegetables. Production targets can not be fixed without such information;

(12) Seasonal variation of these crops in general, and pulses in particular, discourages the growers;

(13) Lack of an organizational setup for development programs on these crops is responsible for the low priority in planning, extension and financial allocations;

(14) Integration of production, processing and marketing is lacking which leads to poor marketing systems, particularly for vegetables.

Strategy for Increasing Production and Supply

The following strategies are suggested for increasing the production and supply of vegetables and pulses in the region:

(1) Identification of superior, high-yielding, short duration, disease- and insect-pest resistant varieties and hybrids capable of growing and giving optimum yields under low fertility and rainfed conditions;

(2) Intensification of seed production of high-yielding, superior varieties and hybrids and improvement of supply of seeds and other inputs to the growers;

(3) Creating a strong organizational setup for planning, development and extension service for these crops in general and vegetable crops in particular. This organization may need to develop a data base and undertake all activities for the development of these crops;

(4) Increasing financial allocations for implementation of R and D programs on vegetables and pulses, and making provisions for appropriate incentives to the growers;

(5) Initiating efforts to educate consumers and farmers on the importance of vegetables and pulses in providing nutritional security and reducing malnutrition;

(6) Intensifying efforts of extension/developmental agencies to increase production and consumption of vegetables in rural areas, since most vegetable production at present is concentrated around cities/towns;

(7) Linking vegetable production with storage/postharvest handling and utilization infrastructure, and integration of production with processing and marketing;

(8) Delivering new and improved technologies including disease and insect-pest management systems, improved varieties through extension bulletins in local languages and suitable demonstrations in the farmers' fields;

(9) Providing appropriate places for these crops in diversification of agriculture, and fitting them into different farming systems; and

(10) Implementing new need-based schemes for the development of these crops, with targets for achieving production and yield levels within a fixed time schedule.

Transition of the Vegetable Seed Industries in Some South Asian Countries

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The seed industries in most developing countries have been dominated by the public sector where heavy investments have been made in seed production, distribution, and in personnel development. However, the sustainability of the investments and the efficacy of seed supply to the farmer have been often questioned, with the result that increasing trends toward commercialization have become evident. Private sector investments in the South Asian countries are slow in seeds of staple crops such as rice or wheat, which are voluminous and expensive to handle. Vegetable seeds, which are low volume but high value, have attracted private investment. In fact, vegetable seeds perform a catalytic function in the transition of seed industries from public sector-dominated enterprises toward private sector involvement and commercialization.

The spheres of activity of local seed companies vary. For example, in Thailand, companies are involved in both local seed production and importation of vegetable seeds. They also package and distribute the seeds. A similar situation is evident in India and Nepal after the liberalization of their seed policies. In Sri Lanka, the private sector is not involved in production, but in the importation and distribution of vegetable seeds. This paper focuses on the changes occurring in four countries and discusses the strategies for improving the supply of vegetable seeds.

The per capita production and consumption of vegetables in Asia, particularly in countries other than Taiwan, Korea, and Japan, is the lowest in the world (Asian Development Bank 1988). However, all income groups require and desire vegetables as supplementary foods. The demand for vegetables in developing countries is expected to increase by 3.4% per year to the year 2000 (Asian Development Bank 1988). During the period 1981 to 1986, Asian countries India, Cambodia, Indonesia, Lao PDR, Maldives, Pakistan, Sri Lanka and Vietnam showed annual vegetable production growth rates between 3 and 5.9%. The annual production in these countries caters to both the increasing local demand and foreign markets (Asian Development Bank 1988).

Most countries in the region will continue to import at least some of the vegetable seed requirements to satisfy local demand. Sri Lanka, which has a phenomenal annual growth rate (5.9%) in vegetable crop production, will be dependent on increasing quantities of imported seed because of limitations in local production.

Two reasons that limit vegetable production in these countries are identified as seed shortage and poor quality of the available seed. The constraints to vegetable seed production and efforts to overcome these are discussed here.

Most of the commercially available vegetable seeds in the tropics are imported from developed countries. However, there are tendencies and opportunities for developing countries to enter the world trade in improved seed. Hybrid seed production which was monopolized by developed countries is also changing hands. These trends are slow, and the bulk of seeds imported by developing countries will continue to be supplied by developed countries. Seed programs designed to increase production to meet the demand for local varieties and toward import substitution of exotic vegetables vary in strength.

Vegetable Seed Production

The wide agroecological zones in Nepal offer great opportunities to grow a multitude of crops and their seeds. For example, the cool, dry trans-Himalayan situation is conducive to the production of high quality seed of cabbage, carrot, turnip and beet root.

A healthy blend of private and public sector organizations is emerging and has boosted vegetable seed production with donor assistance. The FAO assisted the launching of a seed improvement program for vegetable seeds in 1981. The Agriculture Inputs Corporation (AIC), a public sector company, has organized contract seed production with farmers. The Asian Development Bank has provided agricultural loans. Private entrepreneurs have also invested in contract production to meet local demand for vegetable seeds as well as for export. Technical expertise, quality control services and custom seed cleaning facilities are provided by the Government Vegetable Development Division.

Sri Lanka

Although the agroecological zones are conducive to the production of seeds of most vegetable crops, the shortage of land and related isolation problems hamper local production. Self-pollinated species such as beans could be grown with very little concern for varietal mixing. Most of the seed for local vegetable crops is grown in the mid-country at elevations ranging from 50 to 500 m on state farms and on contract. Hidden subsidies on locally grown vegetable seeds bar private sector involvement in production. Although pledges by research groups to supply elite seed to companies for multiplication were publicized, additional incentives including tax concessions are being requested prior to any investments.

The state offers certification services and custom-cleaning facilities for seed. A private dealer network has shown interest in retailing the government-produced seed which is offered at 10% commission. The shyness evident in the involvement of the private sector in seed production may also be due to the lack of a clear and stable seed policy. Public confidence in seeds retailed by the state is overwhelmingly high, so the private sector has to surmount an image barrier. Proposed seed legislation could help build confidence and assure the quality of the seed retailed by both the private and state sectors, and help develop a healthy seed industry. Donor assistance from several sources has developed seed production in the state sector.

Vegetable Seed Production in India

The vegetable seed production program in India is emerging as a dynamic pursuit with a large potential in the future world seed trade. The diversity in climate, land availability and low cost of production offer immense possibilities. A predominantly state-owned seed enterprise has evolved during the past 17 years to accommodate the private sector through major policy changes. Public institutions provide loans to the private seed sector. Varieties developed by the public sector have been used by the private sector for direct multiplication as well as for further improvement and multiplication as new varieties. A plant variety protection act is under discussion.

At least 40 private seed companies are active in the country. Partnerships with well-known multinational companies exist for varietal improvement and multiplication. However, investments by foreign companies in breeding programs are insignificant when compared with investments by the public sector.

Concern is expressed about the adverse effects on traditional vegetable seed varieties that had been produced for many years being edged out because of new introductions and seed imports.

Vegetable Seed Production in Pakistan

The topography of Pakistan which varies from the highest mountain ranges in the world to plateaus at sea level allows seed production of a multitude of vegetable species. However, seeds of most cool season crops are imported from many countries while other seeds are either saved by the farmers themselves or are purchased from the local market.

The Department of Agriculture (DOA) is the largest producer of seeds of both summer and winter crops, but accounts for only 4% of the total vegetable seed requirements in the country. The private sector's contribution is less than half of the DOA's production and is almost wholly the production of one company.

Certification of vegetable seeds is restricted to the production by the FAO Pilot Seed Project at Quetta and by the Punjab Seed Corporation at Khanawal. The quality of the imported seed has been lamentable and strict seed quality control is needed.

The government is concerned about the low production of vegetable seeds within the country and the large annual expenditure on seed imports. Further investments to improve production within the state sector are being realized with donor assistance through the Italian Technical Assistance Project and a UNDP project.

Production of F_1 hybrids is in operation on a limited scale. A more dynamic seed policy to improve the supply of vegetable seeds has been prescribed.

Problems Associated with Seed Imports

Increasing quantities of vegetable seed must be available to sustain the increasing annual growth pattern in vegetable crop production in Asian countries, other than Hong Kong and Singapore, which have negative growth rates in vegetable production (Kamiya 1988). Countries with limitations in local seed production cope by importing increasing volumes of seed. Therefore, strategies to improve seed supply either through importation or local production require emphasis.

The increasing demand for imported high performance hybrid varieties by the more advanced farmers must also receive consideration. However, the following concerns about seed importation, which could have long-term economic and political repercussions, cannot be ignored:

(1) The danger of introducing new pests and diseases cannot be underestimated. The potato cyst nematode was introduced in Sri Lanka in seed potato in the early 1980s and large-scale infestation of crucial potato-growing areas is a current critical problem.

(2) Imported varieties may not ideally suit the local growing environment. Some varieties which initially express adaptability tend to succumb to pests and diseases in later seasons. Therefore, substantial expenditure for varietal screening must be incurred by the state before recommendation to farmers.

(3) Hybrids are in vogue and farmers have to continue to purchase the expensive seeds every season resulting in a drain on foreign exchange.

(4) Most of the imported seed is standard seed which is cheaper than certified seed, but poses problems of varietal purity in spite of expenditures using foreign exchange.

(5) Local seed production programs may be adversely affected by fierce competition by imports.

(6) Degradation of quality during shipping, handling, repackaging and temporary storage prior to distribution of imported seed.

(7) Seed price instability due to fluctuation of foreign exchange rates, freight charges, etc.

(8) Danger of embargoes imposed by exporting countries. For example, India has an embargo on onion seed exports which affects crop production in neighboring countries.

(9) Delays in arrival of seeds of crops which have to strictly fit a cultivation calendar.

(10) Fears of monopolization of imports by large companies and seed price escalation.

(11) Concerns about traditional varieties being eliminated by imported ones.

Future Strategies to Increase Vegetable Seed Supply

The formulation of vegetable seed policies should take into consideration the limitations within countries for seed production, the need to keep pace with changing technology and the growing demand for high quality seeds.

The inherent deficiencies within the public sector in improving seed supply must also be realized in formulating seed policies. The expertise of the private sector in distribution and retail, and management efficiency should be combined with the production technology in the state sector to improve the seed industries in developing countries. Broad policy changes are a prerequisite to seed policy changes to incorporate collaborative activities between the state and private companies within the country or outside. The private sector must be provided with additional incentives to invest because seed production is more risky than crop production.

The gains realized in some countries where vegetable seeds have catalyzed private investments in production should consolidate the achievements by strengthening public programs in plant breeding, quarantine and seed certification.

In countries where limitations of land availability affect seed production, attempts could be made to produce at least some of the high value seeds.

Selections for better seed-yielding lines of popular varieties, and hybrid variety development, should be undertaken for profitable local seed production.

Technology transfer is a slow process and most developing countries will face a widening gap when compared to developed countries especially in vegetables which are the first target crops for improvement through biotechnology. Developed countries are harnessing genetic material to create crops that have the potential to cause quantum jumps in productivity. These would be of great importance to boost productivity in countries in Asia where land is becoming increasingly scarce and population growth rate is high.

Summary and Recommendations

The vegetable seed industries in South Asian countries are in a state of transition, with India exhibiting vast transformations toward commercialization while Sri Lanka and Pakistan show the need for clear seed policy guidelines to improve their industries Nepal, with its limitations in terrain and land availability, has an emerging private sector seed production industry.

The question of inadequacies in both the quantity and quality of available seeds must be addressed. A balanced seed industry with active collaboration between the state and private sectors could help to increase the supply of locally produced vegetable seeds. Strengthening of seed quality control is imperative to screen increasing quantities of locally produced and imported seeds.

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Biotechnology Developments in Tropical Vegetables

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Biotechnologies such as recombinant DNA technologies, including gene splicing, monoclonal antibodies, tissue culture, embryo transfer, etc. have proved to be such powerful tools that already about 15% of the resources available for agricultural research support the use of these technologies in investigations, and in their development into tools for use by the agricultural industries. Biotechnologies are under development to mitigate environmental pollution that originates in agriculture, for improving the ability of crops to withstand and to overcome unfavorable soil and climatic conditions and attack by pathogens, pests and weeds. Biotechnologies are used to assure adequate harvests, improve the safety and quality of our food supply and expand markets and create new uses for agricultural products.

The tools of plant cell culture are increasingly being applied to a wide range of biotechnology ventures, and in particular to the propagation and genetic improvement of crops. For this, approaches and technologies must be specifically adapted to the differing problems and potentialities of each crop and to differing responses of plants. This paper gives an overview of recent developments in biotechnology in vegetables, where plant tissue and cell culture techniques have been most effectively used.

Vegetables as a group constitute one of the largest agricultural commodities in the world. Vegetables are among the most beneficial plants in terms of human nutrition, as they supply necessary vitamins, minerals and proteins. The primary goals of the in vitro propagation of vegetable crops include (1) production of large numbers of plantlets from species in which plant development from seed is difficult, (2) clonal propagation of a large number of genetically identical plantlets, (3) production of virus-free materials, (4) crop improvement through various techniques of genetic modification, (5) enhanced axillary branching using stem tips and lateral buds as the explants, and (6) adventitious shoot formation.

Clonal Propagation

It is possible by conventional breeding to produce one whole shoot from one cutting under perfect natural conditions. Thus the asexual multiplication of rare and elite varieties of crops has to be handled with great care. It is possible through tissue culture techniques to produce millions of identical shoots from one portion of a plant within a very short span of time. Thus, rare genotypes can be multiplied and conserved.

Disease Elimination

A reasonable assumption is that all plants that are propagated asexually by traditional methods (e.g. by cuttings, grafting, bulbs, tubers, etc.) are often infected with one or more pathogens, particularly viruses and other agents. Plant tissue culture is also an asexual method of breeding plants. The superiority of the technique is warranted by the fact that perfectly healthy clones could be produced by the technique of meristem culture. The philosophy of the methodology is that the terminal 2-3 mm portion of plants (meristems) are almost free from viruses, because cell divisions in such parts are very rapid and active. Virus particles, on the other hand, divide comparatively slowly after heat treatment and lag behind. Such meristems could be made to grow into complete healthy shoots, on nutrient media, under controlled environmental conditions.

Plant Breeding

Plant breeding by tissue culture could save time, space and money. These techniques car be used to aid traditional means of breeding. Embryo culture can be used to overcome incompatibility barriers that exist in nature, while ovule, ovary, pollen and anther culture are being employed to reduce the breeding cycle by producing homozygous lines in the first or second generation. Cell and protoplast culture are new developments for an efficient screening system for mutations. Homozygous mutations can occur even in somatic tissue culture giving this technique an edge over conventional mutation breeding (Larkin and Scowcroft 1981).

Axillary Branching

The advantage of this type of micropropagation is that very little callus is formed and the degree of genetic abnormalities is often reduced. Once the explants are established and axillary bud development enhanced, the cultures can be subcultured for many generations, resulting in increased shoot formation. Shoots can be excised after elongation and generally rooted either in vitro or in a growth chamber or greenhouse environment. Vegetable crops that have been micropropagated using these techniques include asparagus, broccoli, brussels sprouts and sweet potato.

Adventitious Shoot Formation

Adventitious shoot formation has also been used to propagate vegetable crops in vitro. Lettuce and cabbage are examples of vegetable crops in which adventitious plantlets have originated directly from the primary explant. Adventitious plantlet formation from callus has been reported with asparagus, broccoli, brussels sprouts, chives, cabbage, carrot, garlic, kale, lettuce, pepper, potato, tomato and sweet potato. The disadvantage of adventitious plantlet formation is that genetic variability often increases, especially when the plantlets are derived from callus. The genetic variability generally tends to increase as the length of time the callus remains in culture increases. The genetic variability commonly observed in these cultures includes variation in phenotypic expression, yield variability and loss of organic potential, and is generally the result of chromosome abnormalities and or ploidy changes in chromosome number.

State of the Art

Asparagus

Asparagus is a cross-pollinated species in which plants are either male or female. The heterozygotic male plants crop more heavily than females, but propagation by seeds normally results in the production of equal numbers of male and female plants. Homozygous female and all male or super male plants have been produced from haploids derived from anther culture. These plants can be of low vigor, and are usefully propagated by tissue culture as the parents for the production of high-yielding F_1 hybrid male progeny. The high cost of planting large areas with clonal material has been said to make the use of tissue culture uneconomical for the production of asparagus plants for field planting (Holdgate 1977), but new clonal hybrid cultivars have been released in France, and tissue culture propagation is used in the USA. Some commercial laboratories list asparagus amongst the plants which they usually propagate. Asparagus has been propagated through shoot tip culture. Genetic variability through callus culture has also been reported. Using conventional methods *Asparagus officinalis* has low regenerative potential, thus very limited numbers of progeny can be obtained. Only the in vitro techniques have proven to be suitable methods for cloning special selections of parent plants or cultivars in large quantities. Complete plantlets have been obtained using explants from stem tips from which meristems and shoot splices have been taken.

Brassicas

The genus *Brassica* includes several important vegetable crops and also oilseed rape (*B. napus*), turnip rape (*B. rapa* var. *silvestris*) brown or Indian mustard (*B. juncea*) and yellow or white mustard (*B. hirta* or *Sinapis alba*). Although the oilseed crops cannot be classified as vegetables, their response to tissue culture is similar to that of their genetic relatives. Brassicas are easily grown and manipulated in vitro, and methods are available to obtain anther-derived haploids and to propagate most cultivated forms. The rapid production of clones from selected plants is already proving advantageous to breeding programs. Tissue culture allows parental plants to be maintained without continued selfing and as soon as the parents of a new worthwhile hybrid combination are identified they can be increased in number rapidly for commercial seed production in the field. Dunwell and Davies (1975) produced several hundred plants from inbred varieties of brussels sprouts (*B. oleracea* var. *gemmifera*).

Chinese cabbage (*B. campestris* ssp. *pekinensis*) has been propagated by shoot tip culture using axillary bud explants. Cauliflower (*B. oleracea* var. *botrytis*) has in its edible curd several thousand apical meristems. Under normal circumstances a small number of these give rise to flower buds, while the remainder abort. Walkey and Woolfit (1970) obtained a potentially limitless number of shoots by tissue culture. Virus-free plants have been produced by this method (Walky et al. 1974; Crisp and Gray 1975), and it also assists in the selection of lines that are free from bracketing and purple discoloration.

Carrot

Carrot is a cross-pollinated outbreeding crop and so vegetative propagation could be of value to multiply and maintain inbred varieties intended as parents in the production of F_1 hybrid seeds. Carrot has been used as a model system for in vitro morphogenesis because of its relative ease of regeneration. In view of voluminous publications available on this vegetable commodity, it is beyond the scope of this paper to discuss the details. Suffice it to mention that for many purposes plant propagation is best affected through somatic embryogenesis.

Celery (*Apium graveolens*)

Celery is used exclusively for its flavor and texture enhancement. Nutritionally they provide only digestive fiber, and essential oils, and steroids that occur in seeds, but these have not yet been exploited commercially. Uniform stands of celery at optimum densities are extremely difficult to produce. Seeds characteristically show slow and variable germination, and small seed and seedling size results in high susceptibility to microenvironmental fluctuations. Available germplasm for genetic studies and crop improvement is extremely limited.

Although there is no practical conventional method, selections can be cloned by tissue culture. The ease with which embryogenesis can be attained has stirred interest in the possible use of tissue culture to multiply superior cultivars of celery for direct field planting instead of sowing seeds. Although the technology is available, a commercial advantage from vegetative propagation has not been established. For all the research and rhetoric of the past 10-15 years, in vitro culture currently enjoys surprisingly little application in agriculture. Conditions are ripe for the successful application of in vitro cloning for field transplant production.

Cucurbits

Tissue culture has been considered as an alternative method for propagating expensive hybrids of cucurbits (triploid watermelons) for field planting, since propagation by conventional methods is slow and inconvenient. Both shoot tip culture and callus culture have been used.

Onion

Plants of the onion family are outbreeding and lines developed from self pollination generally have less vigor than their more heterozygous counterparts. In vitro propagation for maintenance and rapid multiplication of chosen lines, e.g. male steriles, could be of considerable advantage in onion breeding. An efficient method for enhanced multiplication rates through direct regeneration and shoot tip cultures have been reported. Up to 60,000 plants could be obtained from a single bulb in one year, and a vast majority of the plants produced by this method were true to type.

Garlic

Garlic is sexually sterile and is normally vegetatively propagated from cloves and bulbs. All commercial garlic varieties are virus-infected. An advantage in using tissue culture for propagation, therefore, lies in the possibility of producing and maintaining virus-free stocks.

Leek

Until fairly recently, the only method used for the vegetative multiplication of leeks was the production of bulbils of flower head after cutting away the flower. Bulbil formation can now be induced through in vitro methods with both roots and shoots initiated in the callus, but only inconsistently. It is, however, possible to obtain a large number of shoots from callus derived from leaf meristematic tissue. Shoots were grown into plantlets and successfully transferred to greenhouse conditions.

Rhubarb

Concealed virus infections which reduce the vigor of rhubarb plants can be removed effectively by meristem tip culture (Walkey 1986). Shoot tip culture can be used to propagate virus-tested stocks.

Tomato

Tomato is a systemic host for many plant viruses, some of which, e.g. tomato mosaic virus, can be transmitted through seed tissues or carried in the seed coat to reinfect seedlings. It is therefore another example where tissue culture might be used to propagate virus-free plants. Regeneration from callus to induce variability for the enrichment of germplasm source and shoot tip culture is possible. Plantlets can be readily regenerated from callus cultures of many cultivars of tomato.

Pepper

F_1 hybrid peppers are generally vigorous, early and very productive. However, the cost of hybrid seed is high. Production requires manual pollination as peppers are normally cross-pollinated. An efficient method of micropropagation would be useful to pepper growers for the maintenance of inbred breeding lines. The direct vegetative propagation of hybrid peppers for direct field planting is unlikely to be cost-effective unless it is possible to devise less labor-intensive in vitro techniques than shoot tip culture. As with tomato, the in vitro regeneration of shoots from callus cultures of pepper seems to be relatively easily accomplished. A high frequency of shoot formation in callus of three different cultivated red peppers has been reported.

Aubergine or eggplant

Eggplants can be severely damaged by root-knot nematodes. Somatic embryogenesis was induced at high frequencies in callus from leaf explants and in cell suspensions. It is also possible that genetic resistance to these organisms might be transferred from a sexually incompatible wild solanum species through protoplast fusion.

Potato

Potato is the first major food crop where biotechnology has been successfully applied (Bajaj 1986). The in vitro produced disease-free plants, somaclones, haploid and somatic hybrids, plants resistant to blight, viruses, nematodes, herbicides and the microtubers produced in test tubes have been moved from the laboratory to the field and propagated on a large scale in various countries. The in vitro technology combined with traditional practices has enabled the commercial production of disease-free seeds (microtubers). Efforts are being made to refine methods for the long-term storage of germplasm through cryopreservation, and possibly through the development of a synthetic seed. Genetic manipulations through cell culture and recombinant DNA technology are underway to improve the nutritional quality, and to increase the energy yield of potato. These developments have far-reaching implications not only in the improvement of present-day potato, but also for the induction of genetic variability which would enable the synthesis of novel future potatoes. Some of the achievements and prospects are enumerated as follows:

1. Virus-free genetic stocks;
2. Propagation through microtubers;
3. Haploid breeding and early release of varieties;
4. In vitro mutations;
5. Somaclones for breeding new varieties;
6. Somatic hybrids and cybrids;
7. Pomatoes and topatoes;
8. Resistance to early and late blight;
9. Resistance to common scab;
10. Resistance to viruses and nematodes;
11. Resistance to herbicides;
12. Resistance to frost, drought and adverse soil;
13. High nutrition potato;
14. Potatoes for fuel energy;
15. DNA libraries and cloning;
16. Conservation of germplasm;
17. Synthetic seed for storage;
18. International exchange of germplasm; and
19. Postharvest technology.

Commercial Laboratories

Companies or organizations in many countries are now propagating plants commercially or semicommercially by tissue techniques. Historically, commercial micropropagation began with the multiplication of orchids, and progressed to deal with other herbaceous and then woody plants. Most of the plants produced in vitro are used directly by the nursery trade. In general plant tissue culture laboratories fall into the following categories:

(1) Those that propagate plant material primarily for an associated nursery or horticultural businesses;
(2) Laboratories propagating plants for plant breeding and seed businesses;
(3) Those using plant tissue culture techniques for plant improvement that would be of value to plant breeders.

There are probably about 120 operational establishments worldwide engaged in general micropropagation work. Although the majority of these are still concerned with the propagation of herbaceous ornamentals, there is an increasing trend towards the propagation of woody perennials (both ornamental and fruit species), vegetables and other crop plants. Commercial laboratories where vegetables are propagated include: Neo Plants Ltd (UK) - this laboratory specializes in the propagation of all kinds of plants for both horticulture and agriculture. Vegetables handled at present include potato, cauliflower, brussels sprouts and cabbages; Fennel Orchid Company (USA) - this company has a micropropagation service laboratory undertaking customs contract work for other nurseries. Crops propagated include vegetables, orchids, and aroids; Native Plants Inc. (USA) - vegetable crops propagated include asparagus, onion and sweet potato.

Conclusion

Biotechnology offers a bright future and considerable scope for the improvement of most tropical vegetables. Such techniques can be safely used in conjunction with conventional breeding practices to boost vegetable production.

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Vegetable Genetic Resources Conservation in South Asia: IBPGR Activities

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Introduction

South Asia is an important region for crop genetic diversity. The region harbors unique and important variability for a range of globally important vegetable crops which have been domesticated and/or diversified here. Examples are *Allium* species, eggplant, okra and several cucurbits, such as *Cucumis, Luffa, Momordica*, and *Trichosanthes*. For all the cultivated species in the above genera, related wild species do naturally occur in this part of the world as well. Furthermore, other vegetables such as *Cucurbita* spp., *Benincasa* spp., *Sechium edule, Capsicum* spp., *Lycopersicon esculentum* and leafy brassicas have developed a considerable diversity after their introduction to South Asia.

As elsewhere in the world, in South Asia diversity is being seriously threatened by genetic erosion. Changing agricultural patterns, introduction of new food habits, release of modern varieties and replacement of traditional crops by introduced ones are a few reasons for the erosion. Vegetables are no exception to this development. In view of these factors, the International Board for Plant Genetic Resources (IBPGR) has been actively involved in the collection, conservation and documentation of vegetable crops in the South Asian region.

IBPGR's Organizational Structure

During the first decade or so IBPGR focused on collecting threatened germplasm, establishing standards and methods for collecting, conserving and documenting plant genetic resources, and promoting the formation of a coordinated international network of genebanks for their safe storage. Based on the outcome of reviews of the past achievements and the ever changing needs to conserve and utilize plant genetic resources (PGR), the Consultative Group on International Agricultural Research (CGIAR) approved an expanded mandate. This expansion allowed IBPGR to form a research program and to strengthen its field program.

These changes required a different structure of IBPGR's program which includes the following elements:

(1) Administration - the overall administration of and support and assistance to all IBPGR activities, operations, committees, etc;

(2) Technical Services - provision of technical support and information to all staff and the scientific community; public affairs, publications and library;

(3) Global Genetic Resources Network - the development of and support to the genetic resources centers at various levels of the network. This important category includes development activities with the PGR centers, including fostering base and active collections, and the management and transfer of data;

(4) Germplasm Acquisition - monitoring degree of genetic erosion, collecting endangered germplasm, filling existing gaps in collections and facilitating germplasm distribution. The latter includes among others the establishment of germplasm handling units;

(5) Germplasm Characterization and Evaluation - the development of standardized procedures to record, process, store and distribute data and information during the characterization and evaluation of germplasm. Data acquisition, data analysis and application, and evaluation strategy are the program elements;

(6) Training - the development of conceptual, technical and managerial skills through postgraduate training, specialized technical short courses, individual training and intern fellowships;

(7) In vitro Culture Research - the effort to develop in vitro techniques for the collection, conservation and exchange of germplasm of species for which conventional methods are difficult or not applicable. This component includes collecting and tissue culture technology, disease indexing and therapy, cryopreservation, genetic stability, and a pilot study for in vitro genebanks;

(8) Genetic Diversity Research - the effort to enhance our understanding of the origin, evolution and variation patterns of crop genepools. This includes species mapping, ecogeographic studies, development of biochemical methods of description, research on wild relatives in priority crop genepools, and on core collection concepts; and

(9) Seed Conservation Research - the effort to establish and implement standards for seed storage ensuring maintenance of viability and genetic integrity. This component includes study of physiology of stored seeds, genetic stability, dormancy, regeneration and genetic integrity, nondestructive disease indexing and viability testing.

Recently, the global activities on active and base collections were critically examined, taking into account that the number of national plant genetic resources programs has increased steadily, that the number of germplasm collections has increased to almost 700 and that the expected coordination between base and active collections did not function satisfactorily. This led to the development of the crop germplasm network concept in which curators, users and researchers play an active role, thus fostering the utilization of germplasm in crop improvement programs.

IBPGR Regional Offices

Considering the global mandate of IBPGR, the ever increasing number of national programs and germplasm collections, it was found necessary to further strengthen the interaction between IBPGR and these centers. Therefore, new offices were created and others reinforced. The previous Regional Office for Southeast Asia was transferred from Bangkok to New Delhi, extending the region to South Asia and opening an office for Southeast Asia in conjunction with the rotating Chairmanship of the Regional Committee for Southeast Asia (RECSEA). At present this office is at Los Baños, Laguna, Philippines. In both subregions, i.e. South and Southeast Asia, an Associate Coordinator assists the Coordinator, especially with their specific knowledge and experience of the region. They are national employees of the IBPGR.

The main tasks and functions of IBPGR Regional Offices are:

- Advise, assist and stimulate national programs on PGR in their endeavor to conserve and utilize germplasm;
- Initiate, coordinate and/or catalyze regional activities, especially in the field of collecting, conserving, characterizing as well as training;
- Participate in scientific work to strengthen national efforts, including hands-on demonstrations, maintenance of IBPGR standards for germplasm conservation, monitoring degree of genetic erosion, gathering information and periodical assessment of PGR activities;
- Liaise with international agricultural research Centers (IARCs), FAO Commission on Plant Genetic Resources, bilateral funded genetic resources projects, and relevant nongovernmental organizations;
- Participate in and/or coordinate regional meetings, workshops, training courses and assist in their organization;
- Coordinate and facilitate activities executed by responsible staff in the headquarters, provide scientific evaluation of all project proposals submitted from the region to IBPGR for support, identify relevant project approaches and needs, and assist existing centers in formulating such proposals when and if required; and
- Establish and update computerized data bases for major plant genetic resources activities, scientific personnel involved, achievements, etc., in the region.

IBPGR's Collection Activities in South Asia

Since its inception IBPGR has been actively supporting the collection of threatened and/or required germplasm of a wide range of vegetable species in South Asia. Numerous collecting missions to all South Asian countries have been conducted with direct or indirect IBPGR support. Presently, IBPGR supports the National Bureau of Plant Genetic Resources (NBPGR) at New Delhi to collect okra and eggplant in South Asia.

Details of the collected material of the major vegetable crop genepools, which include in several cases related wild species, are presented in Table 1. Most of this collected germplasm has been duplicated in other genebanks around the world for safety reasons. These numbers do not necessarily represent the actual vegetable germplasm holdings for the individual countries since several countries have active national plant genetic resources programs which have also collected germplasm independently. The entire holdings, as far as they have been reported to IBPGR, have been published in detail (Bettencourt and Konopka 1990) for South Asia and are summarized in Table 2.

Table 1. IBPGR-supported vegetable germplasm collection in South Asia.

Collected germplasm genepools	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka	Total No. of Accessions
Allium	-	23	88	-	51	8	-	170
Brassica	-	27	2	5	270	3	10	317
Capsicum	-	18	1	53	67	2	48	189
Cucurbita spp.	-	10	-	14	167	1	41	233
Other Cucurbitaceae								
Benincasa	-	-	-	4	12	-	2	18
Citrullus	-	-	-	21	7	7	5	40
Cucumis	-	7	6	18	138	4	53	226
Lagenaria	-	-	-	1	14	-	12	27
Luffa	-	2	1	26	31	-	23	83
Momordica	-	1	-	3	86	-	37	127
Miscellaneous	-	-	1	9	32	-	6	48
Eggplant	201	1	650	31	29	-	49	961
Okra	35	-	831	13	-	7	96	982
Tomato	-	1	1	-	21	-	21	44
Miscellaneous spp.	-	34	2	54	143	47	-	280
Total Acc.	236	124	1583	252	1068	79	403	3745

Table 2. Vegetable germplasm collections in South Asia (number of accessions, as reported to IBPGR, with the number of species given in parentheses).

Crop genepool	India	Pakistan
Abelmoschus spp.	810 (7)	15 (1)
Allium spp.	2067 (2)	35 (1)
Amaranthus spp.	3839 (8)	
Brassica	2957 (3)	15 (1)
Capsicum spp.	258 (4)	15 (?)
Cucurbitaceae	280 (14)	132 (3)
Lycopersicon spp.	950 (1)	-
Solanum spp.	554 (5)	-
Miscellaneous vegetables	855 (8)	17 (2)
Total	12570	229

Other Vegetable Genetic Resources Activities

In the early days IBPGR was concerned with creating the necessary awareness in a wider public to conserve the quickly eroding genetic diversity of our crop genepools, including the vegetables. The concern resulted in a general publication on tropical vegetables and their genetic resources (Grubben 1977).

The next phase in IBPGR's activities regarding vegetable genetic resources was already much more specific and resulted in a series of publications on crop-specific aspects of vegetable genetic resources. They include *Abelmoschus* (Charrier 1984), *Capsicum* (IBPGR 1983), Cucurbitaceae (Esquinas-Alcazar and Gullick 1983) and tomatoes (Esquinas-Alcazar 1981).

More recently, IBPGR started strategic research on plant genetic resources aspects such as ecogeographic distribution of species of a crop genepool. At present, a publication on the systematics and ecogeographic studies of the *Allium* genepool is in preparation.

The production and publication of descriptor lists is meant to contribute to the required standardization of data which need to be maintained by each genebank. IBPGR encourages the collection of data in four categories: (1) accession; (2) collection; (3) characterization; and (4) (preliminary) evaluation. Details on descriptors for each of these categories are included in the internationally agreed descriptor lists. So far, lists have been published for the following vegetables: *Brassica campestris* ssp. *pekinensis* (IBPGR and AVRDC 1987), *Brassica* and *Raphanus* (IBPGR 1990, in preparation) and eggplant (IBPGR 1988). Furthermore, in the aforementioned publications of *Abelmoschus*, *Capsicum* and Cucurbitaceae descriptor lists were included as well

One of the important conservation activities of IBPGR was the establishment of a network of genebanks which accepted regional or global responsibility for long-term conservation of crops that produce storable seeds. Details on the genebanks that agreed to conserve germplasm of vegetable crops are listed in IBPGR annual reports (IBPGR 1990). Furthermore, two genebanks in Israel and Czechoslovakia have agreed to maintain active collections of short- and long-day species of *Allium*, respectively. To make the concept of a global network of base collections more viable, IBPGR has recently started to support crop germplasm networks which bring curators, researchers and breeders together to decide collectively on priorities for plant genetic resources activities. One such network might be established during a planned International Okra Genetic Resources Workshop in New Delhi where about 30 okra scientists will meet.

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Summary of Discussions - Special Topics

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The status of production of vegetables and pulses in South Asia was reviewed and sharpened the focus on the demand and the availability of these commodities to the people of the region. The highlights of the paper are:

(1) The total production of vegetables in this region is about 54 million t. India is the largest producer of vegetables contributing 90% of total production of vegetables.

(2) The total production of pulses is about 12 million t out of which 11 million are produced in India.

(3) At a rate of 285 g/person/day the annual demand for vegetables in South Asia totals 112 million t/year, but the region is meeting only 48% of requirements.

(4) The requirement for pulses, at a rate of 80 g/person/day is 30 million t/annum. The regional production of pulses meets only 40% of requirements.

(5) The constraints in boosting productivity of vegetables and pulses in the region were emphasized. The participating countries were urged to launch programs to increase productivity of these commodities to cater to the needs of the region.

The current status of the vegetable seed industry in some of the countries of this region was reviewed. The highlights of the paper are:

(1) Most of the seed programs are carried out by the public sector, and the participation of the private sector is sporadic and scanty.

(2) Some of the countries of the region have taken up commercial production of seeds, and incentives are being given to induce the private sector to participate.

(3) Seed production programs in the region, however, do not meet all requirements, and most of the countries depend upon imports of quality seed from abroad.

(4) The import of quality seed has created a number of problems, particularly the introduction of new diseases and weeds.

(5) Greater emphasis needs to be given to seed production within the countries to overcome constraints associated with imports.

The need for nonconventional methods of breeding for crop improvement vis-a-vis tissue culture technology was emphasized. Tissue culture is rapid and can assist in producing materials that are disease-free. The highlights of the paper are:

(1) Tissue culture technology has been used to breed disease-free basic seeds of important vegetables, particularly potato in Pakistan. The contribution to seed production from this source is 40 t of disease-free quality seed.

(2) Tissue culture technology has proved highly useful for introducing genetic variability.

(3) Pakistan has built a network of tissue culture laboratories for breeding a number of crops for improvement in quality of seed.

IBPGR's programs of collection of base material for conservation of germplasm were introduced. IBPGR offered the services of their organization to the scientists of the region for crop improvement, and emphasized the need for establishing a network for conserving the germplasm in vegetable crops.

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Appendix

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