PRESENT STATUS AND FUTURE PROSPECTS OF VEGETABLE RESEARCH AND DEVELOPMENT IN INDIA

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ABSTRACT

The present production of vegetables in India is estimated to be around 48 million tons from an area of over 4 million hectares against a requirement of 73 million tons. Several production constraints result in low yields per hectare and insignificant share in the exports.

Systematic research on vegetable crops in India has been conducted from 1956-57 onwards, in ICAR Institutes and Agricultural Universities. The All India Coordinated Vegetable Improvement Project started in 1970-71 provided a national grid for testing the technologies developed by various research institutions, under different agro-ecological situations. At present 25 vegetable crops have been included in the national research program. Ninety three improved varieties in 15 vegetable crops including six F1 hybrids and 17 pest resistant varieties have been recommended for cultivation in various agro-climatic regions of the country through organized coordinated efforts. Technologies for cultivation of various vegetables under different agro-climatic situations have been standardized to bring about marked increase in productivity. Seed production technology particularly for temperate vegetables has been standardized to make the country self-reliant in the production of these seeds. However, there are still some distinct gaps which need to be plugged. As such, priority areas of thrust for research on vegetables are redefined in every Five Year Plan.

Introduction

India lies entirely in the northern and eastern hemispheres. The country extends in the tropical zone from latitude 8.4° North to 37.6° North and from longitude 68.7° East to 97.25° East (Chand, 1986). According to the estimates of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, the total geographical area is about 3.29 million and total cropped area about 1.76 million. Singh (1986) reported an area of around 4 million hectares approximately under vegetables which corresponds to about 2% of the total cropped area in the country.

Present status of production

Varied agro-climatic conditions round the year in India make it possible to grow a wide variety of vegetable crops all the year round in the entire length and breadth of the country. Singh (1986) listed over 60 vegetables grown in India.

Dependable statistics on area and production of vegetables in India are not available. Chadha (1988) reported an area of 4.50 million hectares under vegetable crops with a total production of 41.20 million tons in 1984-85, while FAO estimates estimated the production at 38.9 million tons in 1979-80, 44.70 million tons in 1984-85 and 48.27 million tons in 1987-88. The information available on area, production and yield of some important vegeta-

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Table 1 Yearwise area, production and average yield of important vegetable crops in India during the current decade

Area (A) in million hectares.
Production (P) in million tons.
Yield/hectare (Y) in tons.

Crop		1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88
	A	0.020	0.020	0.020	0.020	0.020	0.020	0.021	0.021	0.022
Beans	P	0.040	0.041	0.042	0.042	0.042	0.043	0.045	0.046	0.046
	Y	2.00	2.05	2.10	2.10	2.10	2.15	2.14	2.19	2.10
	A	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Cabbage	P	0.45	0.47	0.47	0.48	0.48	0.49	0.49	0.49	0.49
	Y	5.63	6.00	6.00	6.00	6.00	6.13	6.13	6.13	6.13
	A	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Cauliflower	P	0.64	0.66	0.65	0.65	0.66	0.67	0.68	0.68	0.68
	Y	8.00	7.33	7.22	7.22	7.33	7.44	7.56	7.56	7.56
	A	0.85	0.84	0.80	0.82	0.80	0.80	0.88	0.83	0.74
Chillies	P	0.51	0.51	0.53	0.54	0.55	0.63	0.71	0.63	0.57
	Y	0.59	0.60	0.66	0.65	0.68	0.78	0.80	0.76	0.77
	A	0.06	0.05	0.05	0.06	0.07	0.08	0.06	0.06	0.06
Garlic	P	0.21	0.20	0.20	0.25	0.27	0.28	0.19	0.21	0.22
	Y	3.50	4.00	4.00	4.16	3.85	3.50	3.17	3.50	3.70
	A	0.244	0.251	0.250	0.235	0.270	0.278	0.281	0.267	0.280
Onion	P	2.499	2.504	2.648	2.527	2.699	3.099	2.863	2.720	2.790
	Y	10.23	9.96	10.56	10.33	9.98	11.14	10.20	10.19	9.96
	A	0.086	0.088	0.090	0.090	0.090	0.091	0.092	0.093	0.094
Peas	P	0.250	0.255	0.255	0.255	0.255	0.256	0.260	0.260	0.261
(Gardenpea)	Y	2.91	2.90	2.83	2.83	2.83	2.83	2.83	2.80	2.80
	A	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Tomato	P	0.73	0.75	0.75	0.76	0.78	0.79	0.80	0.81	0.77
	Y	9.13	9.36	9.38	9.50	9.75	9.85	10.00	10.12	9.63
Total production		38.92	40.03	40.02	41.96	43.19	44.20	47.32	48.51	48.27

Source : FAO Production Yearbook 1980-1987.

bles is given in Table 1.

India sharing only about 12% of the world output is the second largest producer of vegetables in the world, next only to China (Singh, 1986 and Chadha, 1988). However, productivity per unit area is one of the lowest in the world. The comparative productivity of some important vegetables is given in Table 2.

Singh (1986) has projected India's present requirement of vegetables to be about 70 million tons. However, at the present leval of population of about 800 million our annual requirement of vegetables at the rate of 250 g per capita per day should amount to the order of 73 million tons. From our present production availability of vegetables is only 125 g per capita per day. It calls for massive research and development efforts to achieve required production level and bridge the wide gap. However, progressive trends in production witnessed during the last decade give enough hope.

Sengupta (1986) reported that the value added per hectare by vegetables is of the order of Rs. 5829compared to Rs. 9418by fruits, Rs. 2219by rice and Rs. 1629by wheat.

Exports of vegetables from India

According to Sengupta (1986) India's exports of fruits and vegetables in their fresh and processed form increased from Rs. 674 million in 1980-81 to Rs. 1086 millon in 1983-84 and Rs. 1492 million in 1984-85 registering an average growth of 22% during the 5 year

Table 2 Productivity of some vegetables (t/ha)

Crop	Developed countries	Developing countries	World average	India		
				Experimental yield*	Farm Yield 1981	Farm Yield 1987
Cabbage	25.17	17.28	21.34	20-50	6.00	6.13
Cauliflower	16.90	10.15	13.29	20-35	7.33	7.56
Onion	17.24	9.94	12.27	20-50	9.96	9.96
Peas	6.24	3.17	5.25	7-11	2.90	2.98
Tomato	27.46	15.61	20.99	15-65	9.15	9.63

Source : FAO yearbook 1982 and 1987.
* All India Coordinated Vegetable Improvement Project Data.

Table 3 Export of fresh vegetables and their seeds from India

Year	Fresh vegetables*		Vegetable seeds**	
	Quantity (million tons)	Value (Rs. million)	Quantity (tons)	Value (Rs. million)
1980-81	0.21	324.6	1.79	0.137
1981-82	0.20	379.5	0.47	0.029
1982-83	0.21	413.6	0.12	0.016
1983-84	0.21	530.0	0.53	0.043
1984-85	0.31	698.5	0.41	0.047

Source : * Sengupta, 1986.
** National Seeds Corporation.

period. The exports of fresh vegetables from India are presented in Table 3.

Compared to the world trade of US$ 23.5 billion, in 1983 India's share of the international trade in vegetables and fruits was only 0.45% during the same year, despite the above growth rate of 22%. The share of vegetables in these exports has been of the order of about 90% by quantity and about 75% by value. The foreign exchange earnings per hectare from vegetable crops were US$ 2,674 (including onion) to 7,907 (excluding onion) compared to US$ 9,266 from fruits and US$ 249 to 299 from wheat and rice respectively (Kaul, 1987).

Future needs

The National Commission on Agriculture (1976) projected the total production of vegetables at 84.00 million tons from an area of about 5.00 million hectares at an average yield of 20 tons per hectare, as depicted in Table 4.

Table 4 Targets of production set by NCA for 2000 A.D.

S. No.	Crop	Area m. ha	Production m. tons	Yield/ha in tons
1.	Onion	0.16	3.20	20.00
2.	Chillies (dry)	0.73	0.91	1.24
3.	Other Vegetables	4.00	80.00	20.00
	Total	4.89	84.11	17.20

Source : NCA Report (1976) Part-VI.

However, at the present rate of population growth in India we are expected to feed about 1000 million mouths by 2000 A.D. The minimum requirement of vegetables to feed this large population at the rate of 250 g/capita/day will be over 91 million tons. As such we have to practically double the present day production of vegetables during the next decade.

Constraints on vegetable production in India

According to the project document of Technology Mission on Vegetables (1988) the major constraint on vegetable production in the country is the low priority given to vegetable crops in the national planning. Non-availability of reliable statistics on area and production makes their economic appreciation inadequate and consequently impairs the prospective planning for research and development. Inadequate availability of quality seed of improved varieties leads to low productivity per unit area. Inadequate extension support and lack of efficient post-harvest and marketing infrastructure and absence of price support, in addition to lack of high-yielding, widely adaptable varieties and hybrids resistant to some specific diseases, insectpests and abiotic factors in some vegetable crops are other serious problems. Hardly 25% of the new technology developed has reached the grower. Integrated disease and pest management systems and vegetable-based cropping systems have not been developed to the desired extent which has also kept the productivity of these crops at a very low level. Intermittent situations of glut and scarcity due to inadequate post-harvest technology support have resulted in very low returns to growers, thereby discouraging them from producing vegetables consistently as a major venture.

Research infrastructure

Singh (1979) reported that research on vegetable crops in India was initiated by Indian Council of Agricultural Research (ICAR) soon after independence during 1947-48 with the sanctioning of a nucleus plant introduction scheme at the Indian Agricultural Research Institute, New Delhi. Simultaneously, the ICAR also started *ad hoc* schemes in different states like Punjab, Uttar Pradesh, West Bengal, Maharashtra, Himachal Pradesh, Jammu and Kashmir and Tamil Nadu. The Government of India established a vegetable Breeding Station at Katrain in Kulu Valley in Himachal Pradesh in 1949, which was transferred to the Indian Agricultural Research Institute in 1955. This research station has been carrying 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 the Indian Agricultural Research Institute in 1956-57, and establishment of Indian Institute of Horticultural Research in 1968 with a full-fledged Division of Vegetable Crops. A separate Division of Vegetable Crops and Floriculture was started at IARI, New Delhi in 1970, which was divided in 1982 to separate the work of Floriculture and enable the Division of Vegetable Crops to work exclusively on different vegetables. Establishment of 26 Agricultural Universities located in various States from 1960 onwards, gave further impetus to vegetable research in their Departments of Horticulture/Vegetable Crops (Randhawa, 1979). During the Fourth Five Year Plan an All India Coordinated Vegetable Improvement Project was started by the ICAR during 1970-71 to provide a national grid for multilocation testing of the technologies developed by various research institutes and agricultural universities (Singh, 1979). This project was upgraded as a Project Directorate of Vegetable Research in the VII Plan (strategies in Horticulture during the VIII Plan, 1989).

Research accomplishments

Singh (1979) highlighted the achievements of vegetable research during the first three

decades starting from 1947-48. Gill *et al.*(1988) documented the research accomplishments under the All India Coordinated Research Programme from 1970-71 onwards, whereas Chadha and Ram Phal (1989) reviewed the entire progress of research on vegetables to date as follows.

1 Crop improvement

1) New varieties released

The evaluation of indigenous and exotic germplasm introductions, and their hybridization resulted in the selection of over 30 good varieties of several vegetables during the fifties. 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 along with some others, still continue to be the main vegetable varieties due to their high yield potential and consumer's preferences for their taste. As a result of multi-disciplinary, multi-location testing of the new research materials during the last two decades 95 improved varieties in 15 vegetable crops have been recommended for cultivation in the country.

2) F_1 hybrids

Heterosis breeding in vegetable crops in India has been a recent development and progress in developing and popularizing hybrid varieties has been very slow and insignificant. Attavar (1988) reported that the first F_1 hybrids of tomato (Karnataka Hybrid) and capsicum (Bharath) were released for commercial cultivation in 1973 by a private seed company, the Indo-American Hybrid Seeds followed by 18 other hybrids in 9 vegetable crops. Of the 17 F_1 hybrids in 8 vegetable crops developed so far by public research institutions, 'Arka Navneet' and 'Azad Hybrid' in brinjal, 'Punjab Hybrid' in muskmelon, 'Arka Jyoti' in watermelon and 'Pusa Meghdoot' and 'Pusa Ranjari' in bottle gourd have been recommended for commercial cultivation. F_1 hybrid 'Pusa Sanjog' in cucumber, 'Pusa Alanker' in squash, 'Pant Hybrid-1', 'Pant Hybrid-2', 'Hybrid-10' and 'Hybrid-11' in tomato and 'KT-1' and 'KT-2' in capsicum have already established their superiority under multilocation testing. A synthetic cauliflower variety 'Pusa Synthetic' has already been released. However the F_1 hybrids developed have not been fully exploited due to inadequate facilities for their seed production. With the available technical personnel, cheap labour and suitable climatic conditions there is great potentiality for expansion of the hybrid seed industry in the country both for domestic use and export purpose.

3) Disease and pest-resistant varieties

'Pusa Sawani' a variety of okra resistant to yellow-vein-mosaic is the first example of successful breeding for disease resistance in vegetable crops in India, It replaced almost all earlier okra varieties in cultivation and become the leading variety throughout the country. Chilli variety 'Pusa Jwala' was also bred for resistance to virus diseases. Tomato 'Pusa-120' is the first tomato variety released to be resistant to root-knot nematodes in the country. Other disease and pest-resistant varieties developed and recommended during recent years are the brinjal variety 'Pusa Purple Cluster' tolerant to little leaf and bacterial wilt, 'Pant Samrat' resistant to phomopsis blight, bacterial wilt, shoot and fruit borer and jassids and 'Pant Rituraj' with field resistance to bacterial wilt, cabbage varieties 'Pusa Drumhead' resistant to black leg and 'Selection-8' resistant to black rot, cauliflower 'Snowball K-1' resistant to black rot, and 'Pusa Shubhra' resistant to riceyness and black rot, cowpea 'Pusa Komal' resistant to bacterial blight, muskmelon 'Arka Rajhans' resistant to powdery mildew, okra 'Selection-2' resistant to yellow vein mosaic, onion N-2-4-1' resistant to Alternaria blight and thrips, garden pea 'PM-2' resistant to powdery mildew, tomato 'Pant Bahar' resistant to Verticillium wilt and Fusarium wilt and watermelon 'Arka Manik' resistant to downy mildew, powdery mildew and anthracnose.

2 Agrotechniques

A large number of agronomical practices have been developed to grow almost all vegetable crops under varied agro-climatic conditions. Similarly several control measures for protecting these crops from the attack of various diseases and insectpests have been divised. Under the all India Coordinated Research Project alone 28 agronomical recommendations relating to spacing, nutritional requirement, irrigation and weed control in 8 vegetable crops namely brinjal, cauliflower, cabbage, onion, tomato, radish and muskmelon have been made. For chemical control of diseases and insectpests in 11 vegetable crops namely brinjal, bottle gourd, okra, chillies, onion, peas, muskmelon, watermelon, tomato, cauliflower and turnip, 48 measures against major diseases and insectpests have been standardized. Technology has been developed and improved for the production of vegetable seeds in general and that for temperate vegetables in the hilly region of the country in particular.

Impact of vegetable research and development

Development of a large number of improved varieties with wider adaptability and standardization of their production technologies for various agro-climatic conditions have made it possible to produce vegetables in wider areas and have improved the prospects of their supply tremendously. Garden pea variety 'Arkel' has revolutionized the production of early peas in all pea-growing areas. Cauliflower variety 'Pusa Synthetic' has been adapted to the warm climatic conditions of Tamil Nadu and has made it possible to grow cauliflower commercially in this non-traditional area for the crop. Watermelon variety 'Sugar Baby' has spread fast throughout northern and eastern India including the Sundarbans and has benefitted both the growers with better remuneration and the consumers with superior quality. Similarly the watermelon variety 'Arka Manik' has made a dent in the southern and southwestern parts of the country. Okra variety 'Pusa Sawani' bred for resistance to yellow vein mosaic virus made it possible to grow profitable crops in yellow vein mosaic virus-prone areas/seasons and replaced all other local varieties from cultivation all over the country, whereas the tomato variety, 'Pusa-120' has made it possible to achieve high yields of quality produce in root-knot nematode infested soils. Identification of variety N-53 and development of technology for kharif onion have enabled to get two crops of onion annually in northern India where it was only a winter/spring crop. With appropriate choice of suitable varieties for specific seasons now we can grow radish round the year. Similarly with the release of the cold tolerant variety 'Pusa Sheetal' we can now grow tomatoes all the year round. Development and improvement of technology for quality seed production of temperate vegetable crops in general and cauliflower and cabbage in particular have reduced almost all the imports of seed for these crops from European countries except for the seeds of some new hybrids/varieties.

Seed production

The quality of seed of vegetables in general and temperate vegetables in particular produced indigenously now is not only comparable but even superior to that of the imported seeds which has led the country to become self-reliant in seed production of these crops both qualitatively and quantitatively. However, we have lagged behind our requirement of improved vegetable seeds, since adequate efforts have not been made for the multiplication of foundation and certified seeds. Therefore, the vegetable growers have not been able to reap the full benefits of research achievements. The establishment of the National Seeds Corporation in 1963 helped to promote the vegetable seed production but not to the desired extent (Attavar, 1988). The present situation of demand and supply of vegetable seeds in India is presented in Table 5.

Since the availability of seeds of superior quality is the most important single input for production of vegetable crops, tremendous attention is being paid on strengthening

Table 5 Demand and supply of vegetable seeds in India

(Tons)

Category of seed	Immediate			2,000 A.D
	Demand	Supply/ Production	Shortfall	Demand
Breeders'seed	36.00	10.00	26.00	52.00
Certified seed	27,000.00	2,650.00	24,350.00	40,000.00

Source : Swarup *et al.*, 1989.

research on seed production technology of these crops. Therefore, the efforts for production of breeders' seed of these crops are being intensified. Accordingly, production of breeders' seed of vegetables has been included in the National Seed project for the Seventh Plan which is operating in eleven centers in the country. About 10,000 kg of breeders' seed is being produced annually, which forms the base of multiplication of superior quality foundation and certified seeds. Although we are short of our requirements of quality seed, some quantity of vegetable seeds is being regularly exported from India. This includes both organized exports by the public institutions like National Seeds Corporation and unorganized exports by private agencies. Whereas it is not possible to account for the unorganized exports, the organized exports of vegetable seeds through the National Seeds Corporation are depicted in Table 3.

Future thrusts

Despite a large number of improved varieties and hybrids developed, the productivity of vegetable crops requires improvement. According to the strategies for Horticulture in the VIII Plan, work needs to be intensified on developing varieties with wide adaptability and resistance to several important diseases and insectpests in tomato, brinjal, okra, chillies, onion, cole crops, peas and beans, etc. There is acute dearth of real good hybrids in crops like cauliflower, cabbage, tomato and onion and taking up heterosis breeding in these crops is the immediate need. Export-oriented research has to be carried out on vegetables like onion, chillies, okra, peas and tomato due to their potential for export. Breeding for nutritional and processing qualities in vegetables like tomato, onion, peas and garlic (dehydration) should be implemented urgently. Other aspects requiring attention are research on growing vegetables in protected environments, use of biotechnology for incorporation of resistance to diseases, insectpests and abiotic stresses, studies on insecticidal residues and research on off-season vegetable production and on under-exploited vegetables. Research on seed production has not received the desired attention. Development of vegetable-based cropping systems and integrated disease and insect-pest management would receive concerted efforts.

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Discussion

Imai, H. (Japan) : ICAR has produced a large number of good varieties of cauliflower, especially F_1 hybrids. However, the multiplication and distribution of F_1 seeds to local farmers are difficult compared to those of open-pollinated seed. How can you supply F_1 seeds continuously to the local farmers ?

Answer : We use self-incompatible lines for the production of hybrid seeds. Actually, our seed production industry is insufficiently developed to meet the full requirement of even open-pollinated vegatable varieties. The situation is even more critical in the case of F_1 hybrids. This is the reason why only 4 F_1 hybrids out of 20 developed in 8 vegetables have entered commercial production. No seed production organization has so for taken up F_1 seed production. Only research institutions which have developed these hybrids are producing hybrid seed in limited quantities and supplying them to interested growers in very small amounts. N.S.C. is making arrangements to take up F_1 seed production.

Yamamoto, M. (Japan) : 1. How do you identify the black rot resistance genes for cauliflower and how do you evaluate black rot resistance ? 2. Which type of cabbage do you grow in your country ?

Answer: 1. Resistance genes are located by screening a large number of germplasm collections and identifying the resistant lines. The resistance to the disease is evaluated by screening the materials artificially in the field (sick soil) and in the laboratory. Hybridization is carried out with commercial varieties of acceptable quality with eventual backcrossing. 2. The green-headed, round, compact, small to medium-sized cabbage is preferred in our country and not the drum-headed, purple red and very large-sized ones.