

Temperate Vegetables: Germplasm Resources, their Utilization and Achievements in India

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Temperate vegetable crops need chilling temperature (4-7°C) for about two months for changing their vegetative phase into reproductive phase. The different pockets in the Hindukush Himalayas namely Humid Western and Eastern Himalayan Region comprising Jammu and Kashmir, Himachal Pradesh, Uttaranchal and North-East states have congenial climate for seed production of temperate vegetable crops. The history of germplasm introduction in respect of temperate vegetables and their breeding dates back prior to second world war when seeds of all the temperate vegetable crops were imported from abroad mainly from England by seed companies such as M/s Suttons & Sons. Later Imperial Government of India established a research station at Quetta (Baluchistan) in 1942-43 which went to Pakistan after independence. Subsequently, Government of India set up a Central Vegetable Breeding Sub-station at Katrain in Kullu Valley in Himachal Pradesh in 1949 that was transferred to IARI in 1955 in order to strengthen the improvement work on temperate vegetable crops. From historical facts, it is evident that most of the temperate/European vegetable crops were introduced into India by the Portuguese during 18th century followed by English in 19th century. Jenson from Kew introduced cauliflower varieties as early as in 1822 and grew it in botanical garden at Saharanpur. After independence several organizations like NHRDF, DARL, VPKAS, GBPUA&T etc. were established and different programmes namely AICRP were implemented at different times to give further fillip to breeding of temperate vegetable crops. In recent times, under open general license (OGL) the private seed companies have introduced lot of seed material and started their own R&D programmes. India has also collaborated with AVRDC, Taiwan, China, USSR and SAVERNET (South Asian Vegetable Research Network) countries for testing of vegetable entries. Some of the research projects on temperate vegetable crops were funded by NATP (National Agriculture Technology Project). A detailed account on utilization of vegetable crops has been highlighted with special reference to cole crops and root crops. Cauliflower being the most important cole crop received maximum attention and lot of varieties of late cauliflower (Group IV), namely, Pusa Snowball 1, 2, Pusa Snowball K-1 were developed using exotic lines. In cabbage majority of ruling varieties are through introductions e.g. Golden Acre, Pride of India etc. Pusa Mukta, a black rot resistant variety was developed by crossing two exotic lines (EC 24855 x EC 10109). Hybrid KGMR-1, the first from the public sector was identified for release during 2005 under the AICRP (VC). Many tropical cabbage hybrids such as KK cross, Golden cross were introduced and tropical cabbage lines DTC 50-7-4, 513, 528 etc. were developed. CMS system has also been transferred successfully to various cabbage lines from EC 173419 at Katrain. In root crops also the improved cultivars are developed either through introductions followed by selection or by hybridization with exotic lines as one of the parents. The sources of pests and diseases resistance in cole crops are mainly exotic lines through introduction. The vast genetic resources of temperate vegetable crops have opened up the prospects of breeding using introductions made from different countries.

Key words: Temperate vegetables, Introductions, Genetic resources, Varietal improvement

A large number of vegetable crops are grown in India, perhaps more than any other country of the world. On the basis of seed production, these vegetable crops can be classified into two groups, first group includes those vegetables, the seeds of which can be produced in the plains and lower hills of Indian sub-continent (tropical, sub tropical or Asiatic group). The second group includes temperate vegetable crops requiring chilling temperature (4-7°C) for about 2 months for changing their vegetative phase into reproductive phase. However, the period of chilling requirement differs according to the kind of crops and also varieties. The temperate vegetables occupying a significant position generally include cole

crops (cabbage, late cauliflower, knol-khol, kale, collard, brussels sprouts, broccoli etc.), root crops (beet, temperate varieties of carrot, radish and turnip) and some other crops. These are also commonly known as European or biennial vegetables.

The different pockets in the Hindukush Himalaya are suitable for seed production of temperate vegetables. In India, Humid Western Himalayan Region consists of states like Jammu and Kashmir, Himachal Pradesh, Uttaranchal and Humid Eastern Himalayan Region with Sikkim, Meghalaya, Manipur, Nagaland, Mizoram, Tripura and Arunachal Pradesh. Likewise Pakistan Himalayan Region of Baluchistan, whole of Nepal and Bhutan are suitable for this purpose.

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Germplasm Introductions in South Asia

Temperate vegetable breeding in India has a short history of about 5 decades plus. Earlier to Second World War (1939-45), the seeds of all temperate vegetable crops were being imported from abroad mainly by England based seed company M/S Sutton's and Sons. Later they established their office in India in 1916. During the war, there were difficulties in the import of seeds and therefore, the then Imperial Government in India established a research station at Quetta (Baluchistan) in 1942-43. After the partition of India in 1947, the Quetta centre went to Pakistan and the Government of India on the recommendations of an Expert's committee set up a Central Vegetable Breeding Sub-Station at Katrain in Kullu valley (H.P.) in May 1949. The main objectives were production and distribution of quality seeds of temperate vegetables, and to give advice to the growers on these aspects.

The historical facts reveal that most of the European/temperate vegetables were introduced into India by the Portuguese during 18th Century and little later by the English during 18th and 19th Centuries. Dr. Jenson, a botanist from 'KEW' introduced cauliflower varieties in 1822 and grew it in Botanical Garden, Saharanpur, which is the basis for bringing out Indian cauliflower varieties. The first four Indian varieties listed by Sutton and Sons in 1929 were Early and Main Crop, Patna, and Early and Main Crop, Banaras. The Royal Agri-Horticultural Society, Calcutta introduced seeds of English vegetables from South Africa during 1824. English rulers also brought seeds of European vegetables to India during their regimes.

In view to intensify the improvement work on temperate vegetables, the Katrain Station was transferred to the Indian Agricultural Research Institute, New Delhi in 1955 with its changed name as Vegetable Research Station and now as IARI, Regional Station Katrain (Kullu Valley) H.P. Soon after the transfer of the station to IARI, breeding work was taken up under the leadership of Dr. Harbhajan Singh (1955-1957) who also contributed greatly to the standardization of seed production technology. In 1958, the late cauliflower seed was produced for the first time in India. Indigenous production of temperate vegetable seeds is a unique example of import substitution leading to the development of viable vegetable seed industry in Himachal Pradesh. Government of India launched National Seed Project in 1976-77 with the financial aid from the World Bank under which the Katrain and Solan centres were strengthened for

temperate vegetable seed production and processing. Besides Kullu and Kashmir Valley, seed production work was also carried out in Kalpa Valley (H.P.), Kalimpong (Darjeeling), Saproon Valley (H.P.) and Nilgiri Hills (T.N.) during 1950 and 1960 but this was not in organized manner (Seshadri and Chatterjee, 1996).

Vegetable research further received a boost with the establishment of the Division of Horticulture at IARI, New Delhi in 1956-57 and subsequently by the Division of Vegetable Crops and Floriculture which came into existence in 1970 and Division of Vegetable Crops in 1982, and Katrain Centre was strengthened. The National Seed Corporation was established in 1963 to produce foundation and certified seeds and took seed production of temperate vegetables in Kashmir and Kullu valleys. The organizations like National Horticultural Research and Development Foundation (NHRDF) founded in 1977 by NAFED has been doing seed Production in Kullu valley. Under ICAR, All India Coordinated Vegetable Improvement Project came in to being in 1970-71 and gave further fillip to temperate vegetable research having main centres at Katrain, Srinagar and Solan and voluntary centres at Vivekanand Parvatiya Krishi Anusandhan Research Sansthan (VPKAS), Almora; Defence Agricultural Research Laboratory (DARL), Pithoragarh; and Govind Ballabh Pant University of Agriculture & Technology (GBPUA&T), Ranichauri. The VPKAS, Almora (after transfer to ICAR in 1974); ICAR Complex for NEH region, Shillong; National Bureau of Plant Genetic Resources, Regional Station, Shimla were established in 1976; Central Institute of Temperate Horticulture, Srinagar created in 1996 have been doing research on temperate vegetables. Food and Agricultural Sciences Defence Research and Development organisation (DRDO- Ministry of Defence) also established its Research and Production Centres at many places like Pithoragarh, Auli, Leh, Tejpur etc. The main centres involved in research are G.B. Pant University of Agriculture and Technology, Pantnagar (1960); Mahatma Phule Krishi Vidyapeeth, Pune (in 1969); Tamil Nadu Agricultural University, Coimbatore (in 1971); Bidhan Chandra Krishi Vishwa Vidyala, Heringhastta (in 1974); Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwa-vidyalaya, Palampur (in 1978); Sher-e- Kashmir University of Agricultural Sciences and Technology, Srinagar (in 1982) and Dr. Y.S. Parmar University of Horticulture and Forestry, Solan (in 1985).

The private seed companies have been developing their own Research & Development (R&D) programmes.

Many of them are getting temperate vegetable seeds in Open General Licence (OGL) from abroad and are distributing among users. Similarly Non-governmental Organizations (NGOs) have their involvement. National Horticulture Board, Gurgaon has been financing to the different government organizations and NGOs to create facilities for R&D. The visionary National Agricultural Technology Project (NATP), the largest project ever funded by the World Bank also included programmes on temperate vegetable research.

India has collaborative programmes with Asian Vegetable Research and Developmental Corporation (AVRDC), China and USSR. There is a South Asian Vegetable Research Network (SAVERNET) of the countries like India, Pakistan, Bangladesh, Sri Lanka, Nepal and Bhutan, which deals with the testing of elite vegetable entries. Testing of varieties as per the criteria of distinctness, uniformity and stability (DUS) under Union for Protection of Plant Varieties (UPOV) guidelines has also been undertaken in some of the temperate vegetable crops.

Utilization and Impact Improvement in Varieties

A lot of improvement work has been done, though all of these crops are introduced ones:

Cauliflower: Earlier cauliflower was considered as a purely temperate crop but in recent years due to the development of early types (Group I, II, and III), it is possible to produce seeds of these Indian cauliflowers in northern plains. Among cauliflowers, the late

cauliflower (Group IV), which is commonly known as summer cauliflower in Europe is not a strictly temperate type but requires mild temperature at the time of its seed settings has been dealt with.

The farmers continued to grow EC12013 (Snowball-16 from Holland) for many years. This was replaced by Pusa Snowball-1 (EC12013 x EC12012), Pusa Snowball K-1 (selection from exotic material). Another variety Pusa Snowball-2 (EC12012) could not become popular because of shy seed bearing. A few others like Indian Snowball, Dania, and Dania Kalimpong need a mention as late cauliflower. Kala Patta is being grown near Chandigarh. Of Kt 9 (Sel 12 x PSBK-1) and Kt 25 (EC103576 x PSBK-1) tested under All India Coordinated trials, Kt 25 was identified for release in the AICRP workshop 2002. The other varieties identified by AICVIP are given in Table 1.

Though number of hybrids are marketed by Private seed companies, it is heartening to note that no hybrid has been released by the public sector in the snowball group but efforts are being made at Katrain centre to develop S.I and CMS lines. Some of the hybrids like Himani, Guardian (Indo-American), Candid Charm, White Flesh, Cashmere (Sakata), Serrano (Sandoz), Early Himlata, Early Himanagiri (Century), Nath Ujwala, Nath Shweta (Nath), Namdhari 84 (Namdhari), Pusa Hybrid-2, Pusa Kartik Sankar (IARI) of course belong to variable groups.

Cabbage: Many varieties like Golden Acre, Pride of India, Copenhagen Market, September, Pusa Drum Head, Late Large Drum Head etc. are either introductions or

Table 1. Cauliflower Varieties identified for release by All India Coordinated Vegetable Improvement Programme (AICVIP)

Variety	Maturity group	Developing centre	Year of identification
Early Kunwari	Early group	PAU, Ludhiana	1975
327-14-8-3	September	IARI, New Delhi	1975
Pusa Deepti (351-4-1)	October	IARI	1975
Improved Japanese	November	IARI	1975
Pusa Synthetic (Synthetic-1)	December	IARI	1975
Pusa Snowball-2 (EC 12012)	January	IARI, Katrain	1975
Pusa Snowball-1	January	IARI, Katrain	1975
Pusa Snowball K-1	January	IARI, Katrain	1979
Pant Gobhi (114-5-1)	October	GBPUA & T	1981
Pusa Subhra (Line 6-1-2-1)	December	IARI	1985
Pusa Early Synthetic	Early group	IARI	1990
Pant subhra (235-S)	November	GBPUA & T	1990
Pusa Hybrids-2	November	IARI	1992
Pusa Snowball K-25	January	IARI, Katrain	2002
Pusa Kartik Sankar (DCH-541)	October	IARI, New Delhi	2003

Source: Kalloo, 2000

PAU – Punjab Agricultural University, IARI – Indian Agricultural Research Institute, GBPUA&T – Govind Ballabh Pant University of Agriculture & Technology.

selections from IARI Katrain. Pusa Mukta (EC 24855 x EC 10109) has been developed by hybridization and released from IARI, Katrain. Among red cabbage, Kinner Red from exotic material has been recommended by University of Horticulture and Forestry (UHF), Solan.

Cabbage is the one among cole crops where F_1 hybrids have become very popular. Hybrid KGMR-1, the first from the public sector, has been indentified for release during 2005 under the AICVIP from the IARI, Regional Station, Katrain. Other hybrids like H 44 (F_1 hybrid by using S.I.), H 64 (F_1 hybrid by CMS system) and BRH-5 (Sel-8 x AC 204, hybrid with a marker) were found promising only for hills. The requirement of F_1 hybrid seed is very high (>150 q) and being taken care of through OGL by the private seed merchants, and National and State Seed Corporations. Some of hybrids/synthetics have been identified through AICVIP i.e. Pusa Synthetic (from IARI Katrain in 1992), Sri Ganesh Gol (from MAHYCO in 1992), Nath-401 (from Nath Seeds in 1993), BSS-32 in the name of Swarna (from Bejo Sheetal in 1995), Nath 501 (from Nath Seeds in 1997), and Quisto (from Novartis Seeds in 1998). The other hybrids (Bahar, Pragati and Unnati from Pro Agro; Kalyani, Kranti and Hari Rani Gol from Mahyco; Hero, Mitra and Aditya from Sungrow; Yamuma, Ganga and Kaveri from IAHS; Masrgan, Meenaxi and Kuwaxi from Century; Vishesh and Uttam from Hindustan Lever; H-30, H-50, H-10 and H-20 from National Seeds Corporation (NSC); Gloria, Runa and Ratan from Dechan-Feldt; Rare Ball from Kaneko; Green Challenger from Hungnong are brought under cultivation directly without testing under AICVIP.

Similarly, many tropical cabbage hybrids were introduced e.g. Golden Cross, KK Cross, OS Cross, Resistlaka, Green Cornet, Autumn Queen, Green Ball (Takii); Green Boy, Green Express, Herculis, Stone Head, Regalia (Sakata). Japanese seed companies have also undertaken seed multiplication of their S.I. lines in South Asian Countries. Another significant achievement in cabbage breeding is the development of tropical lines e.g. DTC-50-7-4, 513, 528 (released as Pusa Ageti) etc. at the IARI, New Delhi. Cytoplasmic male sterility system (CMS), has been transferred successfully from EC173419 to all the cole crops at IARI Katrain but this source was associated with some undesirable traits and now an improved source of CMS obtained from IARI, New Delhi is being transferred to promising varieties/lines of cabbage.

Knol-khol: White Vienna, Purple Vienna, Kyote No. 3 and King of North are the introduced promising varieties.

Brussels sprout: The recommended varieties are Hild's Ideal and Rubine. The imported hybrids are Jade Cross, Doreman, Alkazar, Meron, Poster, Fortress, Predora, Rovoka, Somora, Ladosa etc.

Broccoli: The recommended varieties are Pusa Broccoli KTS-1 (selection from EC005559) from IARI Katrain, Palam Samridhi from HPKV, Palampur, Italian Green and Green Head from UHF, Solan. All are green sprouting broccoli and have been developed from the introduced exotic material. A cauliflower x broccoli hybrid (EC 243384 from Taiwan) produced greenish cauliflower heads with taste and flavour of broccoli (Gautam *et al.*, 2000). Many hybrids like Southern Comet, Premium Crop, Clipper, Laser (early), Corsair, Excalibur Cruiser, Emerald Carona (mid season), Late Carona, Stiff, Kayak, Green Surf (late) are being imported for cultivation in India.

Kale and collard: Kale is under cultivation in J&K. The variety Westo has been recommended from IARI Katrain.

Chinese cabbage: The Chinese cabbage as such could not be popularized, however, heat tolerant and black rot resistant line (EC345978) introduced from Taiwan is promising. Three genotypes have been developed at IARI Katrain from the crosses Petsai x Sarson, Wong Bok (Sutton's) x Sarson and Wong Bok (Sutton's) x Turnip to replace local mustard being used as *saag*.

Radish: The improved cultivars in European types have been recommended after introduction and selection e.g. Japanese White, White Icicle, Rapid Red White Tipped (all from IARI, Katrain), Chinese Pink (from NSC), Scarlet Globe, Scarlet Long etc. and by hybridization e.g. Pusa Himani by crossing Black x Japanese White, Sel 9 by crossing White Icicle x EC9005 (both from IARI, Katrain). No hybrid has been evolved in radish in India.

Turnip: The improved cultivars by selection or introduction have been developed. These are Snow Ball, Golden Ball, Purple Top White Globe, L-1 (Purple Top White Globe x 4-White), Pusa Swarnima (Golden Ball x Japanese White) and Pusa Chandrima (Snow Ball x Japanese White) have been developed by hybridization.

There is no variety available in foliage type; however, one line (Pusa Saag) has been developed by crossing

Chinese cabbage cv. Wong Bok (Sutton's) x Turnip cv. Golden Ball. There is no hybrid developed yet in turnip.

Carrot: The temperate carrots are orange coloured with pleasant flavour and have good root quality specially texture and high carotene content. They are preferred over Asiatic for candying, canning and drying. Among frozen vegetables for export, the prospect of carrot is bright. Many exotic cultivars Chantenay, Denverse, Nantes, Early Horn, Zeno and Early Gem Imperator are grown. Carotene 'A' rich collection obtained from USA (EC187207), early maturing hybrid (EC288579-82 from Denmark), male sterile and restorer lines (EC274883-86 from Netherlands) could not be utilized. Kuroda has been an imported variety to put under cultivation.

Efforts have been made to combine successfully the high yielding capacity of Asiatic types into temperate types having good qualities. Consequently, the improved cultivar, Pusa Yamdagini (EC9981 x Nantes) at IARI Katrain has been developed by hybridization. Carrot No.-1 a hybrid from Mahyco has been identified by AICVIP. To breed F_1 hybrids, the male sterile lines of Nantes (39 x N) and Pusa Yamdagini (28x PY) have been developed at Katrain.

Garden beet: All the cultivars belong to temperate type. Most of the cultivars in India are exotic. Two varieties, Crimson Globe and Detroit Dark Red have been recommended by IARI Katrain.

A variety of palak, Pusa Harit, has been evolved by crossing sugar beet (EC13001) and Local palak, yielding very high for green foliage.

Lettuce: Lettuce accessions (EC329320-22) could not be utilized. Among the different types, only crisp head (cv. Great Lakes), and Leaf Lettuce (cv. Chinese Yellow) are under cultivation in India.

Breeding for disease resistance

Black Rot: In cauliflower, Sn 445, MGS 2-3, Puakea, EC162587 and RBS-1 possess resistance to black rot. Sel-12 evolved through inter-varietal hybridization between Sn 445 and EC12012, has been identified as a source of resistance. Kt-9 (Sel-12 x PSB-1) is also showing field resistance.

In cabbages, Greenland Hammer, EC10109 and Spitzkool have been identified. Pusa Mukta (EC24855 x EC10109) has been identified by AICVIP as resistant

cultivar. BRH-5 (Pusa Mukta x AC 204) is another combination showing resistance.

Sclerotinia rot: Heading broccoli EC103576, EC131592, Janavon, Early Winter Adam's White Head, EC177283 and Kn-81 possess resistance to sclerotinia rot. Kt-25 identified as Pusa Snowball K-25 cauliflower, which has been developed as resistant variety by crossing broccoli EC103576 and Pusa Snowball-1. In carrot, line NV-1 has shown resistance to sclerotinia rot.

Other diseases: MR-1, an introduction from USA, in cabbage carries multiple resistance to soft rot, wire stem, black rot and sclerotinia rot. AC 238, Spitzkool and EC93559 have been found resistant against cabbage yellows. BR-2, MGS 2-3, 3-5-1-1, CC-12, EWAWH in cauliflower and Spitzkool in cabbage possess resistance to downy mildew. MGS 2-3, Puakea, 1-6-1-4, 6-1-2-1 and Pusa Subhra in cauliflower have resistance against black spot disease. Selection-1301 has high degree of tolerance to diseases like sclerotinia rot, downy mildew and black rot coupled with desirable horticultural traits.

Breeding for pest resistance

In cabbage, cultivars Large Blood Red and Red Pickling (all red types) were identified to possess preferential resistance against caterpillars of cabbage butterfly (*Pieris brassicae*) and susceptible to aphid (*Brevicoryne brassicae*). The white cabbage varieties All Season and Round Sure Head showed resistance to these pests as *vice-versa*. Cabbage IRCH-4 to 6 and KK Cross have shown tolerance to aphids.

A good number of collections have been made on temperate vegetables at the IARI, Regional Station, Katrain since its inception till date. Some of the promising collections/introductions are given in Table 2.

The major countries from where the temperate vegetables have been introduced are Russia, Canada, USA, Australia, Brazil, France, U.K., Netherlands, Germany, Italy, Poland, Hungary, Denmark, Turkey, Yugoslavia, Egypt, Zambia, Israel, Korea, Japan, Taiwan etc. Table 3.

Immediate needs

- Import of parental lines of desirable F_1 hybrids: In cross-pollinated crops (cole and root crops), the parental lines of F_1 hybrids may be introduced. The seed production of F_1 hybrids and maintenance of those lines may be taken up to reduce or cease the import of commercial F_1 seeds under OGL.

Table 2. Promising collection / introductions in temperate vegetable crops

S. No.	Crop	Total no. of collections	Promising collections / introductions
1.	Cabbage	1050	Golden acre, Pride of India, Early Drum Head, Copenhagen Market, Late Drum Head, Spitzkool, MR 1, AC204, AC208, AC238, EC240613, EC173419 (CMS), EC490162, EC490165, EC490174, EC490176, EC490185, EC490191 and EC490200
2.	Cauliflower	724	Snowball No.16, Janavon, EC103576, EC162587, EC12012, Puakea
3.	Capsicum	660	
4.	Carrot	334	Yolo Wonder, HC-201, Vindale, California Wonder
5.	Brussels sprout	35	Nantes, Chantenay
6.	Knol-khol	39	Hild's Ideal, Rubine
7.	Radish	308	White Vienna, Purple Vienna
8.	Turnip	114	White Icicle, Japanese White
9.	Spinach	90	Purple Top White Globe, Snow Ball, Golden Ball
10.	Lettuce	217	Virginia Savoy
11.	Broccoli	97	Great Lakes, Chinese Yellow
12.	Beet	111	EC005559 Detroit Dark Red, Crimson Globe

Table 3. Major Introductions in temperate vegetable crops

Crop species and accessions	Source	Desirable traits
Cole crops		
Cabbage		
EC187228-187230	Canada	Club root resistant
EC287707-287708	Japan	Resistant to yellows and tolerant to black rot
Cauliflower		
EC205372-205373	USA	Smooth, medium maturity in 60-70 days, disease tolerant.
EC175800-175806	USA	Multi-disease resistant
Root crops		
Carrot		
EC178385	Italy	High carotene content
EC187207 Beta III	USA	Good flavour and eating quality, high carotene content
EC277678	USA	Blunt and short root type, good flavour high carotene content and resistant to Alternaria blight.
Radish		
EC170668 Summer Top ACC No. 107	Taiwan	Attractive shape and colour

Source: Rana, 1993

- New temperate vegetables may be introduced e.g. asparagus, celery, parsley, leek, globe artichoke, swish chard etc.
- Seed production techniques may be refined to produce seed indigenously and efficiently.
- The lines with the minimum post harvest losses should be introduced. The quality aspect should be given preference.
- High yielding and wider adaptable lines need to be introduced.
- Monogerm varieties of garden beet need to be introduced. Likewise high temperature resistant lines in cabbage and cauliflower; white colour retentivity

mainly due to curd coverage by newly borne leaves in cauliflower, bigger and non woody knobs in knol-khol; compact, medium sized sprouts with close internodes in Brussels sprout; more foliage in kale and Chinese cabbage; high carotene content, smooth, self core coloured roots in carrot; smooth and non pithy roots in radish; good taste and non puffy roots in turnip, good colour without distinct zones in beet; non bitter leaves in lettuce; the important characters with high yield and quality lines are to be introduced.

- For off-season supply from the hills to the plains, the introduction of temperate vegetables should be made for those accessions which may adapt for lower to higher temperature conditions adverse to the plains where their cultivation is done in winter months (higher to lower) for vegetables.
- Though not temperate, but the lines of long day onions and garlic with better quality may be imported and introduced for their multiplication under the so called natural glass house of Western Himalayas.

Important traits

- Marketable yield and its related components
- Growth characters including DUS traits
- Quality aspects including physical and chemical components
- Consumer's preferential characters (external and internal)
- Nutritional status and pesticidal residues including heavy metallic element status
- Resistance to biotic and abiotic stresses
- Maturity period, storability and staying period

- Seed production ability
- Transportability and exportability in relation to transport and supply system
- Varietal suitability for efficient cropping systems
- Characters suitable for adaptability in different regions or climates and for sustainable production
- Other specific characters of the vegetable concerned

Emerging scenario

- Rapidly shrinking genetic diversity must be stopped.
- Long term/medium term conservation and regeneration programmes should be initiated.
- Characterization, Evaluation and Documentation should be taken up.
- Zero or low energy storages should be constructed in the hills for germplasm/vegetables.

Future needs and scope

The next generation of research for vegetable crops may include:

- Genetic engineering- cellular and molecular biology- cell and tissue culture-genetic diversity.
- Greater resilience to environmental stresses-cold, droughts, heat problem soils, and air pollutants- to ensure dependability of production.
- Greater resistance to biological stresses including integrated pest management and disease resistant varieties.
- Biological transformations-nitrogen fixation, mycorrhizal root interactions, nitrification, denitrification, "bacterization", protein synthesis.
- Hormonal mechanisms-control of plant growth, flowering, fruiting, seed production, tuberization.
- Enhancement of photosynthesis, total metabolism and differentiation processes for improvement of yields and harvest index.
- Alternative integrated resource (land, water, energy, capital) sparing production systems.

- Quality of fresh and processed vegetables.

The need for genetic variability in all breeding programmes is evident. The germplasm on temperate vegetables may be procured from NBPGR, AVRDC, NVRS etc., however, all the introductions in India must be routed through NBPGR, New Delhi.

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