# Origin and Genetic Improvement of Indian Cauliflower

VISHNU SWARUP AND S. S. CHATTERJEE [1]

Among the cole crops, cauliflower (*Brassica oleracea* L. var. *botrytis* L. subvar. *cauliflora* DC.) follows cabbage in importance with regard to area and production in the world. However, in India cauliflower is more widely grown than cabbage. This crop grows at latitudes 11° N to 60° N with average temperature ranging from 5°–8°C to 25°–28°C. In its vegetative growth period it may stand temperatures as low as −10°C and as high as 40°C for a few days. The total area under cauliflower in the world is 164, 594 hectares. Italy and India have the largest areas, each covering about 25 percent of the total acreage (2, 3). In India, cauliflower is grown both in the hills and in the plains and from 11° N to 35° N. Some of the most important cauliflower growing states in India are Uttar Pradesh, Mysore, West Bengal, Punjab, and Bihar. It is also grown commonly in the northern Himalayas and in the Nilgiri Hills in the south. Cauliflower is harvested from late August or early September to late February or early March in the north Indian plains and from March to November in the hills.

Cauliflowers cultivated in the Indian plains can be broadly classed into four maturity groups depending upon time of curd availability: I, September to early November; II, mid-November to early December; III, mid-December to mid-January; and IV, mid-January to early March. Of these groups, the first three are typically Indian cauliflowers while the fourth is of Snowball, Erfurt, or Alpha types. Seeds of Indian cauliflowers can be produced in the northern plains, but Snowball and allied types do not set seed there.

In large cities of northern India like Delhi, cauliflower is available in the market almost all year except during 6 to 7 weeks in May and June. Curds from the crop grown around Delhi are available from early September until late February. During August as well as in early March, cauliflower in the Delhi market is from Ajmer and neighbouring areas of Rajasthan. Cauliflower sold in Delhi during July and August comes from the north Indian hills, particularly from Solan, Simla, and other neighbouring hills. Though area and production figures from different maturity groups are not available, the supply of curds in the market is, in general, limited during the early period, i.e., August to October. This is also supported by the high price (Rs.3 to Rs.5 per kg.) of cauliflower during this period compared to the later period, when it varies from Rs.0.25 to Rs.0.75 per kg. (Rs.1.00=$0.13 approx.).

## Origin of Cauliflower

Cauliflower is thought to have been domesticated in the Mediterranean region since the greatest range of variability in wild types of *Brassica oleracea* is found there (20, 30). According to Boswell (5) it originated in the island of Cyprus from where it moved to other areas like Syria, Turkey, Egypt, Italy, Spain and northwestern Europe. In cultivation for a little more than 2,500 years, it appeared about 15 centuries later than cabbage (5). In the middle of the 16th Century the first illustration

[1] Division of Vegetable Crops & Floriculture, Indian Agricultural Research Institute, New Delhi-12, India. Submitted for publication 14 June 1971.

and description of cauliflower were presented by the herbalist Dodoens (9). It was after this period that the crop became more commonly cultivated, particularly in the beginning of the 18th Century.

The cole crops, including cauliflower and cabbage, have descended from a common kale-like ancestor, the wild cabbage (*B. oleracea* L. var. *sylvestris* L.) still found in western and southern Europe and north Africa (1, 15, 20, 26, 36). According to Allard (1), cabbage, cauliflower, broccoli, brussels sprouts and other varieties of *Brassica oleracea* have been separated morphologically on the basis of a few gene differences. The varieties of *B. oleracea* have the same chromosome number ($n=9$), and there are almost no differences in chromosome morphology. Pachytene chromosome studies have shown that the species *B. oleracea* is a triple tetrasomic with the genomic formula A BB CC D EE F with 6 basic genomes and showing some secondary pairing (12, 33).

### European Cauliflowers

Before discussing the origin of Indian cauliflowers, it would be appropriate to describe the history of development of the European types. Systematic and extensive cultivation of cauliflower was first started in Italy where the "Originals" were developed. These original Italian types were taken to France, England, Germany and Netherlands where some important local types were developed from them, e.g., the "Northerns" in Yorkshire and Derbyshire, the "Cornish" in Cornwall, the "Angers" and "Roscoff" in Brittany (20), and the "Erfurt" or its allied "Snowball" in Germany (15) and in the Netherlands (31). These types were mainly for winter cultivation except "Erfurt," which was suitable for growing in summer. In England, commercial cultivation of cauliflower began in 1619 though Giles (26) reported that its cultivation there was not brought to any degree of perfection until about 1860; in France, cultivation was started in 1600 (5).

In England the cauliflower industry started in early 19th Century with the Cornish types commonly grown in western Cornwall (20, 23). Cornish cauliflowers were grown till 1920 or so when English housewives began preferring the white-curded "Roscoff" from France, which was shipped across the channel in small boats. The "Roscoff" was closely and jealously guarded and seeds were not available. However, in 1924 its seeds reached England and were mutiplied for distribution and for breeding (23). Later, the Cornish types were replaced by the "Roscoff" and other improved strains such as "Seale Hayne." The chief characteristics of these important cauliflower types are presented in Table I. It should be emphasized that these different types of cauliflowers, adapted to cold winter as well as summer conditions, were developed by man through simple selections from the original material brought from Italy, a region of mild Mediterranean climate.

### Indian Cauliflowers

Indian cauliflowers are characteristically different from the types grown in Europe. They are tolerant to high temperatures and to humid conditions. Indian cauliflowers are perhaps the earliest-maturing types known. According to Giles (15), Indian cauliflowers are dwarf selections of Erfurt or Snowball types. This view is also supported by Nieuwhof (30), who stated that selections from Erfurt-Alpha types have yielded early varieties that performed better in warmer regions, producing good curds at temperatures above 20°C. (Some of these varieties were Early Patna, Early Benaras, and Early Market.) Our studies have led us to

TABLE I

CHIEF CHARACTERISTICS OF DIFFERENT EUROPEAN CAULIFLOWER TYPES

| Cauliflower types | Origin | Probate date of cultivation | Characters |
|---|---|---|---|
| Originals or Italians | Mediterranean | 16th Century | Plants short; leaves erect, broad with round tips, bluish green; curds good, not protected. |
| Cornish | England | Early 19th Century | Plants vigorous, long stalked; leaves loosely arranged, broadly wavy, curds flat, irregular, loose, not protected, yellow, highly flavoured. |
| Northerns | England | 19th Century | Leaves petiolate, broad, very wavy, serrated; curds good, well protected. |
| Roscoff | France | 19th Century | Plants short; leaves long, erect, slightly wavy with pointed tip, midrib prominent, bluish green; curds white or creamy, hemispherical, well protected. |
| Angers | France | 19th Century | Leaves very wavy, serrated, greyish green; curds solid, white, well protected. |
| Erfurt & Snowball | Germany & Netherlands | 18th Century | Plants dwarf; leaves short, erect glaucous green; curds solid, well protected. |

question the origin of Indian cauliflowers from Erfurt or Snowball types only. The investigation was made from the historical, morphological, and genetic points of view. Our data may be useful in breeding work to improve the crop.

## History

Cauliflower was introduced to India in 1822 when Dr. Jemson, a botanist from Kew, took charge of the Company Bagh (United Provinces, Saharanpur in the northern plains) to carry out some horticultural experiments during the period of the East India Company. The Royal Agri-Horticultural Society, Calcutta (West Bengal), also introduced seeds of English vegetables including cauliflower, in 1824 from South Africa (4). The Company Bagh was transferred to Dr. Jemson by the then Mogul Ruler at Delhi, through a special "Farman" (order) issued to the Moghul Governor at Najibabad (U.P.). From Sutton & Sons, Reading, London, Dr. Jemson introduced seeds of several English vegetables such as cabbage, cauliflower, beets, tomatoes, etc. After the Indian Mutiny in 1857, on the proclamation of the British Rule in India, the Company Bagh was renamed as the Government Botanical Gardens, Saharanpur (24).

During the days of the East India Company, the seeds of vegetable crops were brought to India from England in small sailing boats, which carried dried botanical specimens and other raw materials like jute, cotton, etc. from India to England (24). The seeds were distributed to different parts of the country and performance reports obtained from them. For about a century (1822 to 1929), cauliflower underwent selection by local growers. The selections

FIG. 1. Plant type No. 1 (Flat and exposed).

were made for early maturity and for adaptability to hot humid weather. This is evidenced from the 1880 Progress Report of the Government Botanical Gardens, Saharanpur and Mussoorie, by J. F. Duthie (10), who was in charge of the gardens. He reported that adapted varieties selected by the local growers were good for early sowings, maturing in October to December, and could be followed by imported varieties. The first four Indian varieties listed by Sutton & Sons, India, in 1929 were Early and Main Crop Patna, and Early and Main Crop Benaras. Incidentally, this company did not establish its office in India until 1916; its catalogue mentioned the variety Snowball for the first time in 1920. Perhaps around 1860–1880 (19) the Company also supplied seeds to India from the Head Office in England by mail order.

TABLE II

DISTRIBUTION OF STALK LENGTHS IN DIFFERENT MATURITY GROUPS IN INDIAN CAULIFLOWERS

| Maturity groups | Percentage of plants having stalk lengths: | | |
|---|---|---|---|
| | up to 15 cm. | 16 to 20 cm. | 21 cm. & above |
| I (Sept. to Early Nov.) | 20.0 | 56.0 | 22.0 |
| II (Mid. Nov. to Early Dec.) | 32.2 | 67.8 | NIL |
| III (Mid. Dec. to Mid. Jan.) | 54.5 | 45.5 | NIL |

FIG. 2. Plant Type No. 2 (Semi-erect).

## Morphology

The morphological features studied by us included stalk length, plant type, leaf characters, date of curd maturity, and colour and flavour of curd.

As many as 200 varieties were collected from different sources within India, including many from the farmer's fields. Most of these varieties were not true breeding, and hence pure lines were obtained by inbreeding for two to four generations. In all, about 300 inbred lines were developed and studied in detail. These inbred lines were broadly classed in three of the four maturity groups mentioned earlier. In general, the stalks of plants of Groups I and II were longer than those of Group III (Table II). Four different plant types were observed in the inbred lines. In Plant Type 1 the curd was completely exposed while Plant Type 4

represented the completely erect habit with covered curd; Plant Types 2 and 3 were intermediates, the former being closer to 1, the latter to 4 (Fig. 1 to 4). Of these, Plant Type 3 is considered the best as it has long erect leaves with or without the self-blanching habit and has medium-sized curd. The curd of Type 4 is very small and not of marketable size, perhaps because the erect leaves do not provide enough space for the development of the curd. This type is not considered worthwhile for selection. (Incidentally, the plant commonly observed in the late Snowball strains belongs to Type 3—it produces medium-sized, solid and white attractive curds due to its self-blanching habit). In maturity groups I and II among the inbred lines, Plant Type 2 was most frequent; in maturity group III, Plant Type 3 was predominant but there were several in-

FIG. 3. Plant Type No. 3 (Erect).

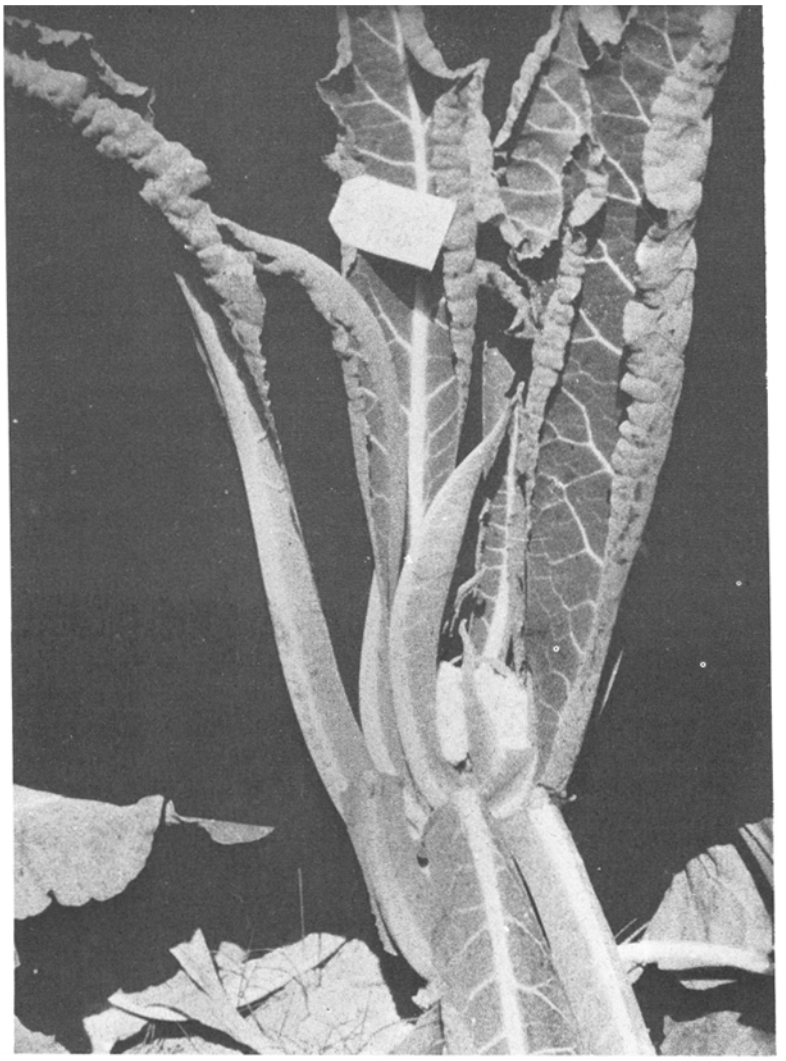

FIG. 4. Plant Type No. 4 (Very erect).

TABLE III

DISTRIBUTION OF PLANT TYPES, IN DIFFERENT MATURITY GROUPS IN INDIAN CAULIFLOWERS

| Maturity groups | Plant type, in percent | | | |
|---|---|---|---|---|
| | No. 1 | No. 2 | No. 3 | No. 4 |
| I (Sept. to Early Nov.) | 26.5 | 53.2 | 19.1 | 1.2 |
| II (Mid. Nov. to Early Dec.) | 14.5 | 53.3 | 29.0 | 3.2 |
| III (Mid. Dec. to Mid. Jan.) | NIL | 10.0 | 68.0 | 22.0 |

FIG. 5. Left, Inbred line 330-5-23-# and Right, Variety Early Cornish (M/s Hurst, U.K.).

breds of Plant Type 4 also. Plant Type 4 was observed in very few inbred lines in Groups I and II (Table III).

Leaf characteristics of Indian cauliflowers are quite different from Snowball or Erfurt Types but are closer to Cornish, and some were also similar to Roscoff, Italians, and Northerns. The inbred lines developed from the same variety differed much in respect to leaf and curd characteristics. Of the 162 inbreds of Group I, 153 were like Cornish (Fig. 5), while 9 belonged to other Types (6 Roscoff, 2 Northerns, and one Italian). Groups I and II produced comparatively loose, uneven, yellow to creamy curds having a strong flavour—characteristics typical of the Cornish. However, the main season inbred maturing in December and January produced comparatively more compact and somewhat whiter curds not so strongly flavoured. The chief morphological characteristics of both Indian and Cor-

TABLE IV

CHIEF MORPHOLOGICAL CHARACTERISTICS OF INDIAN AND CORNISH CAULIFLOWERS

| Characters | Indian | Cornish |
|---|---|---|
| Plant Type | 1 and 2 (Exposed) | 2 (Exposed) |
| Stalk length | Medium long to long | Long |
| Curd: Shape | Flat and Uneven | Flat and Uneven |
| Colour | Yellow to Cream | Yellow |
| Compactness | Less compact | Less compact |
| Flavour | Strong | Strong |

TABLE V

SELF INCOMPATIBILITY STATUS OF INDIAN CAULIFLOWERS

| Maturity group | Percentage of Plants | |
|---|---|---|
| | Compatible (Fertility Index 0.5 to 1.0) | Incompatible (Fertility Index 1.0 & above) |
| I (Sept. to Early Nov.) | NIL | 100 |
| II (Mid. Nov. to Early Dec.) | 1 | 99 |
| III (Mid. Dec. to Mid. Jan.) | 9 | 91 |

nish cauliflowers are presented in Table IV.

## Genetics

The genetical investigations included self-incompatibility status, heterosis and genetic diversity, and resistance to black rot [*Xanthomonas campestris* (Pam.) Dows.].

**Self-incompatibility.** The self-incompatibility of the inbred lines, judged by the "Fertility Index" as suggested by Watts (37), varied greatly in different inbreds of the three maturity groups. Group I was found to be highly self-compatible while in Group II and III 1% to 9% of the plants were self-compatible (Table V). In contrast, the Erfurt or Snowball group is highly self-compatible (8, 22, 29, 37).

**Heterosis and genetic diversity.** Considerable genetic diversity was observed in the different groups studied. This was revealed in the diallel analyses of the intra- and inter-group crosses. Appreciable heterosis was observed in most of the characters studied, particularly in maturity and curd weight (Table VI). It was better manifested in intra- and inter-groups I and II than in Group III in which genetic diversity among lines was low. However, in case of Snowballs or Erfurts, heterosis is almost negligible except in curd weight (35, 38, 39). Haigh (17, 18) even suggested that heterosis is almost absent in cauliflower. This may perhaps be due to low genetic diversity in Snowball types. In contrast, our genetical studies have shown that morphological variations of Indian cauliflowers are related to the

TABLE VI

HETEROSIS IN INTRA- AND INTER-GROUP DIALLEL ANALYSES OF INDIAN AND SNOWBALL CAULIFLOWERS

| Maturity group Heterosis | I | | II | | III | | I×II | | IV (Snowball) † | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Maturity | Curd wt. | Maturity | Curd wt. | Maturity | Curd wt. | Maturity | Curd wt. | Maturity | Curd wt. |
| Heterosis % (Over means) | 3.25 | 37.05 | 2.11 | 37.08 | 2.72 | 18.11 | 5.37 | 58.75 | 2.66 | 14.69 |
| Heterotic Crosses * (Percentage) | 14.3 | 10.1 | 32.14 | 57.14 | 7.15 | 14.29 | 42.42 | 30.30 | 42.86 | 7.14 |
| Range of Heterosis | 0.06 to 7.23 | 0.36 to 78.09 | 0.06 to 5.91 | 1.17 to 55.21 | 0.21 to 5.33 | 4.62 to 60.25 | 0 to 10.50 | 0.36 to 174.68 | 0–5.52 | 0–28.91 |
| Parents | 8 | 8 | 8 | 8 | 8 | 8 | 12 | 12 | 9 | 9 |
| $F_1$ Hybrids | 28 | 28 | 28 | 28 | 28 | 28 | 66 | 66 | 14 | 14 |

* Significant over better parent.
† Swarup & Pal (35).

genetic diversity observed in the material.

**Resistance to black rot.** A very interesting observation was made that the genes for resistance to black rot disease were not present in any of the varieties of Erfurt or Snowball types but were present in some of the varieties of Indian types. However, some of the Indian types were as highly susceptible as the Snowball types. Of the 150 varieties and 50 inbreds developed from the Indian types and screened for reaction to this disease, only 10 (one of which was inbred) were found to have resistance to this disease; all of these (except the inbred line) belonged to maturity Group I. The resistance was found to be dominant and polygenic.

## Conclusion

From the results of our studies, we conclude that Indian cauliflowers are a separate group from European types. It appears that they have originated by simple selection and later perhaps by recombination as a result of natural crossing between different types. This view is based on the fact that there are several inbreds with very close morphological affinity to different European types like Cornish, Roscoff, Italian, Northerns, Angers, and Snowball or Erfurt though not exactly the same. Typical Indian cauliflowers belong to maturity Groups I and II since their vegetative growth and curding are completed in high temperature and humid conditions. In contrast, Group III compares favourably well with the late Snowball or Erfurt types in regard to climatic requirements. From these observations it appears that the parental varieties contributing most to the Indian types tolerant to high temperature and rainfall conditions are the Cornish, which is the predominant type in Groups I and II but almost absent in Group III. This is further substantiated by the fact that the introduction of cauliflower to India in 1822 from England coincided with the establishment of the Cornish cauliflower industry in England. Morphological and other characteristics, e.g., long stalk, open habit, exposed, yellow, uneven curds which loosen up easily and strong flavour, are some attributes common to both Cornish and Indian cauliflowers, particularly early types maturing in September to November. However, Indian cauliflowers did not develop only from Cornish but also from some other types like Roscoffs, Italians, and Northerns as evidenced from characteristics of leaves and curds. In the late maturing Indian types (Group III), however, plants having the erect habit of Plant Types 3 and 4 are more frequent than in the earlier groups, in which Plant Types 1 and 2 are more common. This suggests that perhaps the late maturing varieties, particularly those becoming ready between late December to early January, are more similar to Erfurts and Italians.

The observations on self-incompatibility also support the view that Indian types are genetically different from the Erfurt because, in the former, self-incompatibility is predominant, while, in the latter, self-compatibility is more common. However, in maturity Group III of the Indian varieties closer to Erfurts and Italians, some self-compatibility was recorded as expected. This indicates that the Indian types, particularly Groups I and II, have been developed from winter types and not from summer types of Erfurt or Snowball. Cornish, Roscoff and Northerns are classified as winter types and have been reported to be highly self-incompatible while the Italians or autumn cauliflowers are intermediate (37).

The greater genetic diversity in Indian types has perhaps resulted from the natural crossing taking place between the different varieties of separate

maturity groups because the selection was done by the growers without any scientific basis and the selections were even made prior to Mendelian times. This is conclusively proven by the presence of appreciable amount of heterosis in almost all economic characters in these Indian types. On the other hand the Erfurt or Snowball did not show pronounced heterosis, mainly due to the fact that these types did not have much genetic diversity. The different types like Cornish, Northerns, Roscoff, Angers and Erfurts originated from the Italians independently in different regions, and seeds of these were not available for growing in any other region for quite a long time because they were jealously guarded. For example Roscoff moved out of France to England only in 1924 and Angers in the late 19th Century; the case of Erfurts or Snowball was similar. These types, therefore, remained genetically isolated for a century or more and were thus able to maintain their characteristic features. As stated earlier the Cornish type almost disappeared after the introduction of Roscoff to England in 1924. Similarly some of the other types like Roscoff and Northerns have also been replaced by other improved strains, e.g., 'Seale Hayne' strains in England. It is likely that the Cornish type—perhaps the first to be introduced to India and contributor of many genes to the Indian varieties—has gone out of cultivation, resulting in the loss of many possibly useful genes. When the Cornish types were brought from typical temperate conditions to the tropical environment of India, they adapted well to higher temperature and humid conditions. Simple selection from these types gave rise to an entirely different type, both genetically and morphologically, from temperate types of cauliflower. This view can further be corroborated from the fact that Snowballs or Erfurts, when planted with Indian types, do not stand the hot weather and rainfall of the early season; if any curd is formed in the surviving plant later, it becomes deformed and fails to set seeds in the plains. This is possibly the reason why maturity groups I and II did not give rise to any line having closer affinity to Erfurt or Snowball while it was possible to recover lines closer to them in maturity Group III.

Our studies have shown conclusively that the genes for resistance to black rot are present only in Group I (except one inbred line in Group II), while all the varieties tested in the Erfurt or Snowball groups were susceptible. This also supports the view that the Indian hot weather types have not originated from Erfurt or Snowball types as suggested by Giles (15) or Nieuwhof (30).

Finally, it is interesting to note that cauliflower, after its origin in Cyprus, became established around the Mediterranean, particularly in Italy. Its further development and improvement were achieved in northern and northwestern Europe and its cultivation was extended to 60°N. The selection and development of Indian cauliflower types made it possible to extend the growing areas to the tropics and subtropics. Besides, certain favourable genes such as tolerance to high temperature and rainfall, which was unknown in the European types, have been successfully utilized in other tropical and subtropical regions for developing improved varieties such as Pua Kea in Hawaii (13, 14), Campinus in Brazil (6), Improved Japanese and D-96 in Israel (11), and Extra Early in Taiwan. The Indian varieties released by Sutton & Sons were also found to be promising in other tropical areas, including Ceylon, West Indies, the Philippines, and Florida (28, 32, 34, 40). Thus the crop is presently cultivated from 11°N to 60°N. Such flexibility in the adaptation of this crop is attributable to the inherent character of the ancestral parent *B.*

*oleracea* L. var. *sylvestris* L, which is found growing well in various regions varying from temperate to tropical.

The character for wider adaptability to fluctuating conditions of climate has not been exploited in cabbage to the same extent as in cauliflower. However, reports suggest that in some varieties of cabbage, head formation and seed set can take place under comparatively higher temperatures than those required for most varieties (7, 21, 25, 27). It is believed that genes for adaptability to warmer temperatures can be utilized in breeding varieties for these conditions. These would make it possible to extend the cultivation of cabbage to warmer regions as has already been achieved in cauliflower with the help of genes from Indian types.

### Acknowledgments

The authors are grateful for the keen interest in this study shown by Dr. M. S. Swaminathan, Director, IARI; Dr. S. K. Mukherjee, Ex-Head, Division of Horticulture; and Dr. B. Choudhury, Head, Division of Vegetable Crops & Floriculture. Grateful thanks are also acknowledged for help rendered by Shri Kashiram, Ex-Economic Botanist, Govt. of U.P., in spite of his failing health; Dr. A. Prasad, Director, Horticultural Research Institute, Saharanpur (U.P.) for providing facilities for consultation of old Annual Reports of the Government Botanical Gardens; and Shri J. Hodges, Managing Director, Sutton & Sons, India Ltd., for providing some facts on his Company.

### Literature Cited

1. Allard, R. W. 1960. Principles of Plant Breeding. John Wiley & Sons Inc., New York.
2. Anonymous. 1965. Land utilization statistics-issued by the Dep. of Economics and Statistics. Min. of Food & Agriculture, Govt. of India.
3. ———. 1969. Production Consumption and foreign trade of fruits & vegetables-cauliflower (Organisation for Economic Cooperation and Development. 1969).
4. ———. 1970. 150th anniversary Souvenir, Royal Agri-Horticultural Society, Calcutta.
5. Boswell, V. R. 1949. Our vegetable travellers. Nat. Geog. Mag. **96**: 170–177.
6. Camargo, L. S. 1956. New lines of cabbage and cauliflower for the state of Sao Paulo. Bragantia **14**: 315–328.
7. Chatterjee, S. S. & S. K. Mukherjee. 1957. Studies on vegetables in West Bengal, II. Seed production of cabbage. (*B. oleracea* var. *capitata*). Indian J. Hort. **14**: 151–162.
8. ——— & ———. 1965. Selection and maintenance of cauliflower. Indian J. Hort. **22**: 60–68.
9. Dodoens. 1544. Cited by Giles (1941).
10. Duthie, J. F. 1880. Report on the progress and condition of the Govt. Botanical Garden at Saharanpur and Mussoorie, year 1880.
11. Feldner, H. 1956. (New varieties of cauliflower developed locally.) Bull. Independent Biol. Lab. Kefar Malal, Israel, 1956: 12(2): 13–14. (Pl. Breed. Abstr. **31**: 3063. 1961).
12. Gerhard, R. 1960. Beiträge zur Analyse des Brassica Genoms. Chromosoma **11**: 205.
13. Gilbert, J. C. 1953. Improved hot weather cauliflower types. Circ. Hawaii Agr. Exp. Sta. **40**: 7.
14. ———. 1955. Pua Kea-cauliflower for low elevations. Hawaii Fm. Sci. **4**(2): 5–8.
15. Giles, W. F. 1941. Cauliflower and broccoli—what they are and where they came from. J. Roy. Hort. Soc. **66**: 265–277.
16. ———. 1944. Our vegetables: Whence they came. J. Roy. Hort. Soc. **69**: 132–138, 167–174.
17. Haigh, J. C. 1960. Cauliflower and brussels sprouts. 9th Ann. Rep. National Vegetable Research Station Vellesbourne, Warwick, 1958, (Pl. Breed. Abstr. **30**: 836. 1960).
18. ———. 1962. Cauliflower. Ann. Rep. Glass House Crops Res. Institute, Little Hampton, Sussex, 1961. (Pl. Breed. Abstr. **33**: 3754. 1963).
19. Hodges, J. 1970. Personal communication to Dr. B. Choudhuri, Head, Division of Vegetable Crops & Floriculture, I.A.R.I., New Delhi-12.
20. Horne, F. R. 1954. Winter cauliflower:

History and breeding in the South-West. Sci. Hort. **11**: 128–139.

21. Ito, H. & T. Saito. 1961. Time and temperature factors for the flower formation in cabbage. Tohuku J. Agr. Res. **12**: 297–316.
22. Jensma, J. R. 1957. Cultivation and breeding of cauliflower. Meded. Inst. Vered. Tuinbouwgew. **96**: 61.
23. Johnstone, K. 1963. Cornish cauliflower. Agriculture **70**: 216–219.
24. Kashiram. 1970. Personal communication to Mr. Hodges, Managing Director, Sutton & Sons, India Ltd. Calcutta; and personal contact by the authors.
25. Kuroki, T. 1970. It is paying to grow cabbage and cucumber in summer. Indian Fm. Digest **3**(8): 41–42.
26. Magruder, R. 1937. Improvements in the leafy cruciferous vegetables. USDA Year Book 1937: 289–299.
27. Miller, J. C. 1955. Some technic used in the breeding of vegetable crops in the United States. Report, 14th Int. Hort. Cong., Vol. I: 460–467.
28. Mortensen, E. & E. T. Bullard. 1968. Hand book of tropical and sub-tropical horticulture. Department of State, Agency for International Development, Washington, D.C.
29. Nieuwhof, M. 1963. Pollination and contamination of *Brassica oleracea* L. Euphytica **12**: 17–26.
30. ———. 1969. Cole crops: Botany, cultivation and utilization. World crops Books, Leonard Hill (Books) Ltd., London.
31. ———. 1970. Personal communication.
32. Paul, W. R. C. 1933. A note on the cultivation of the cauliflower in the low country districts of Ceylon. Trop Agriculturist **81**: 91–94.
33. Robbelen, G. 1960. Contribution to the analysis of *Brassica* genome. Chromosoma **11**: 205.
34. Rodrigo, P. A., P. S. Urbanes, & P. S. Hernais. 1935. A progress report on the acclimatization of cauliflower. Philippine J. Agr. **6**: 115–127.
35. Swarup, V. & A. B. Pal. 1966. Gene effects and heterosis in cauliflower. I. Indian J. Genet. **26**: 269–281.
36. Vilmorin, R. L. de. 1956. Masters Memorial lecture, 1956: The improvement of strains of vegetables. J. Roy. Hort. Soc. **81**: 338–346; 386–395.
37. Watts, L. E. 1963. Investigations into the breeding system of cauliflower I: Studies on self-incompatibility. Euphytica **12**: 323–340.
38. ———. 1964. Studies of maturity in $F_1$ and $F_2$ generations of cauliflower from crosses between summer, autumn and winter types. J. Hort. Sci. **39**: 84–91.
39. ———. 1965. Investigations into the breeding systems of cauliflower II. Adaptation of the system to inbreeding. Euphytica **14**: 67–77.
40. Wood, R. C. & H. M. Jones. 1936. Cauliflower cultivation in the tropics. Tropical Agriculture **13**: 218–220.