



Chrysanthemum Breeding

Origin and History

- ♣ Chrysanthemum is native to **Europe and Asia**
- ♣ It originated in **China**.
- ♣ Species involved in the development are *C. sinense*, *C. indicum*, *C. japonicum*, *C. ornatum*.

In China

- ♣ The earliest mention of chrysanthemum was recorded by Confucius.

In Japan

- ♣ Chrysanthemum was proclaimed as the **National Flower** by emperor Uda in the year 910 AD
- ♣ At present cherry blossom is the National Flower and **chrysanthemum the symbol of Royalty in Japan.**

In Europe

- ♠ In 1690, Rheede described a Holland – grown type from India called Gool – doodi.
- ♠ In France, it primarily remained as cemetery flower.
- ♠ In England, the emphasis was on exhibitions
- ♠ National Chrysanthemum Society of England lists more than 5000 cultivars.

In USA

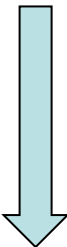
- ♠ The first chrysanthemum known to the USA was 'Dark Purple' imported by a scientist John Stevens in 1798.
- ♠ The National Chrysanthemum Society of America was founded in 1890, consisting exclusively of commercial growers at New York.

In India

- ◇ In North India, chrysanthemum is primarily grown for landscape gardening either in the ground or in pots.
- ◇ In Southern part of the country, it is mostly grown as loose flowers for garland, hair decoration by women and offerings to god.

Classification: According to National Chrysanthemum Society (NCS) of America

- ◇ The species of the genus *Chrysanthemum* are annual, perennial herbs, sometimes partly woody.
- ◇ The genus *Chrysanthemum* belongs to the family Compositae / Asteraceae.

Division – A (Classes: 1-9)	Division – B (Classes: 9-11)	Division –C (Classes: 12-13)
Characters: Ray florets: Flattened to concave or convex 	Characters: Ray florets: Regular/tubular, coiled/straight with distal portion open/flattened/spoon like Disc: Apparent/may not appear	Characters: Ray florets: Flattened/tubular Disc: May/not be obvious
Section I : Disc: Prominent, circular and many disc florets	Section II : Disc: Not apparent/may be concealed/entirely absent	



Section I: Class 1 - 3

Class 1. Single

- Ray florets in a single row at right angles to the stem.
- Disc is flat to slightly rounded and may be of contrasting colors, e.g., Potomac.



Class 2. Semi-double

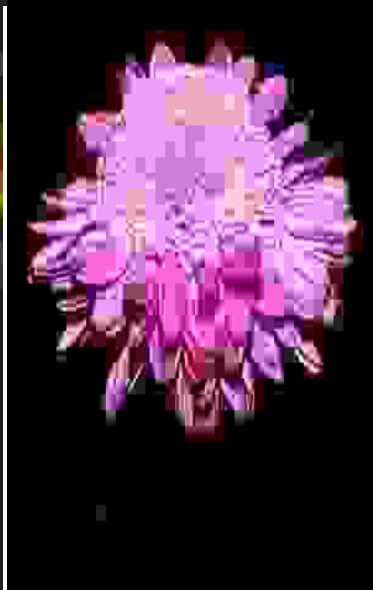


- Ray florets: More than one row at right angles to the stem but may curve downward at the tips.
- Disc as in class 1.

Class 3. Anemone



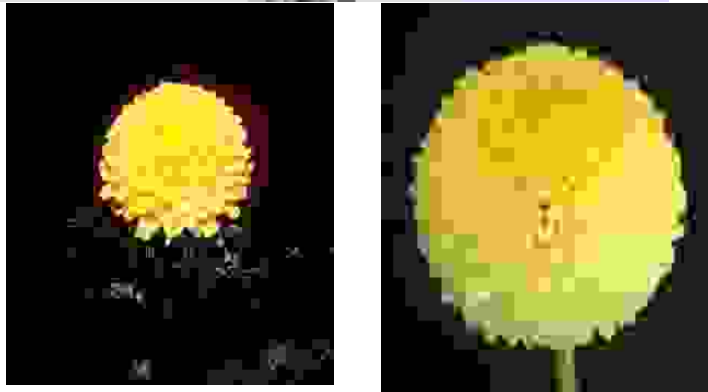
- Ray florets: Variable, from flattened, broad and equal in length to reflexing, pointed at tip and unequal in length.
- Disc florets: Numerous tube-like and elongated so as to form a prominent disc which may range from flat to hemispherical in form.



Section II: Class 4 - 8

Class 4. Pompon

- Bloom globular, some what flat in young stage or small button type. Ray florets broad, incurved, smooth and firm with good substance.



Class 5. Incurve



Incurve



Regular Incurve



Irregular Incurve

- Breadth and depth should be equal to produce a globular bloom.
- Ray florets narrow to broad, smooth and incurve in a regular to an irregular manner without producing an open center
- Ex: Snow Ball, Mountaineer, Nob Hill.



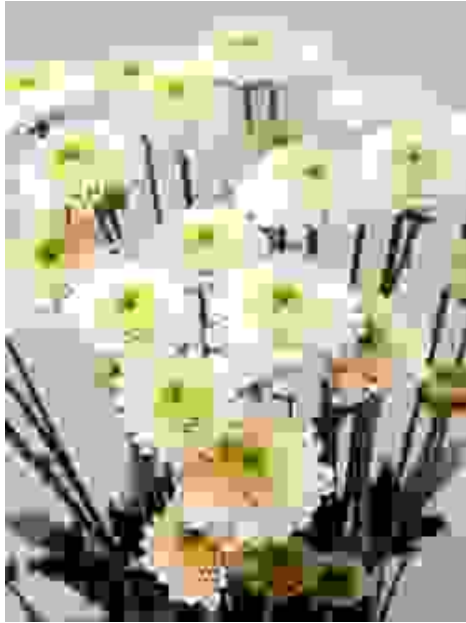
Intermediate Incurve

Class 6. Reflexing incurve



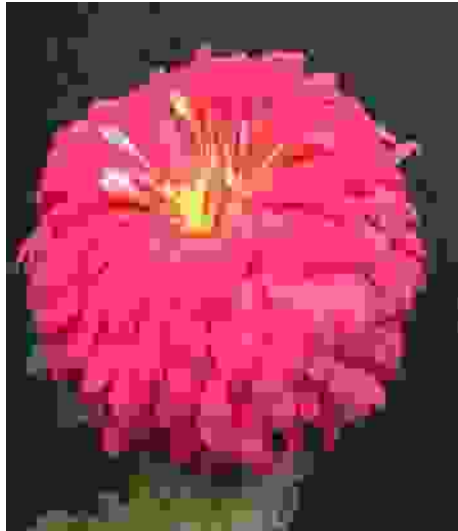
- Ray florets: usually broad and smooth. Breadth and depth nearly equal to form a globular bloom, sometimes flattened, may be less compact than incurve.
- All mature florets not completely incurving and not all completely reflexed.
- The lower florets sometimes reflexing to give a skirted effect,
- e.g., Dream Castle, Indianapolis.

Class 7. Decorative



- Ray florets from short and broad to narrow, long and pointed, they generally reflex, although upper florets may tend to incurve.
- Blooms more flattened than globular,
- e.g., Otome Pink, Princess Anne.

Class 8. Reflex



- Bloom globular with equal depth and breadth and a full center, or somewhat flattened. Ray florets narrow to broad, gracefully overlapping in either a regular or in an irregular manner and reflexed.
- e.g., Coronation Pink.

Class 9. Spoon



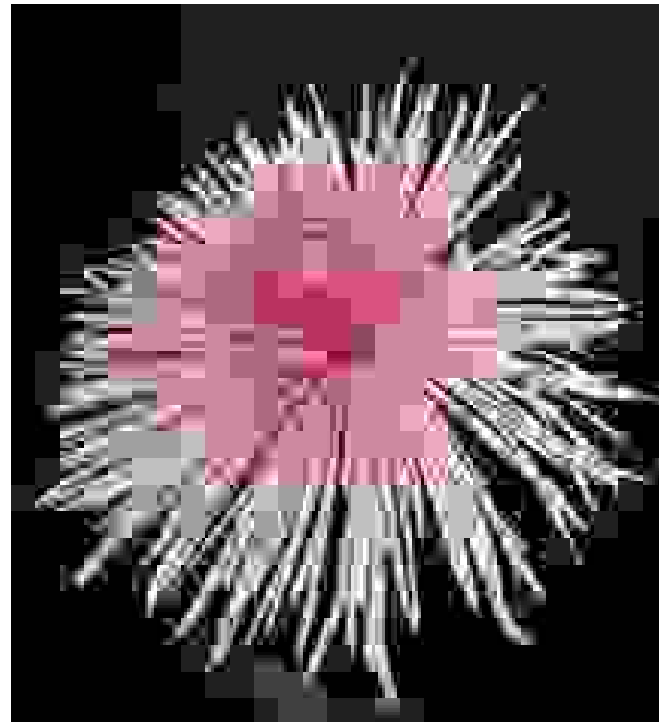
- Ray: Regular, tubular, straight, distal portion open, flattened and spoon like.
- Disc: Not apparent



Class 10. Quill



- Ray: Tubular, straight, not coiled(closed tip), pointed or open and spatulate
- Disc: Not visible



Class 11. Spider



- Ray: Long and tubular, distal portion closed/open and spatulate and have hooks and coils
- Disc: Not visible

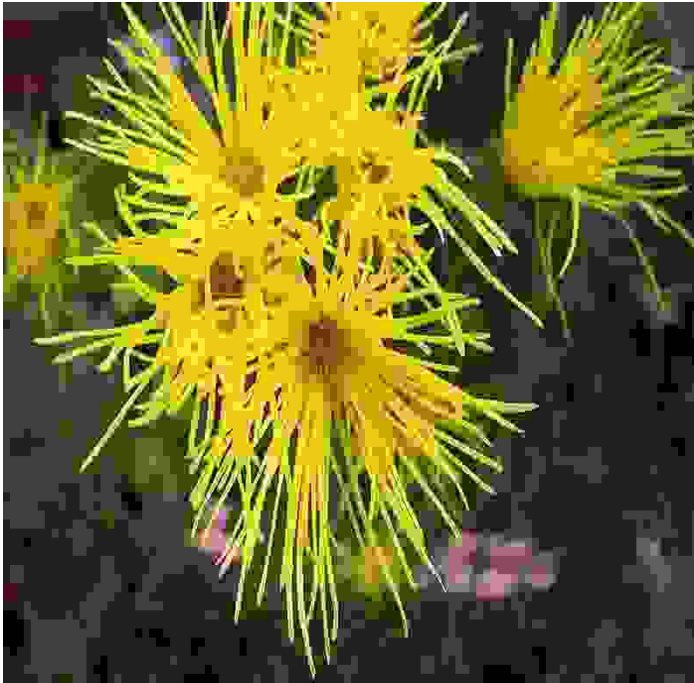


Class 12. Lancinated



- Ray: Lancinated/feathered at tip
- Disc: May/not visible
- Ex: Jack Straw

Class 13. Brush/Thistle like



- Ray: Fine tubular grown almost parallel to the stem in a brush like
- Disc: Concealed
- Ex: Saga and White Ise



Classification

Based on the size, shape of flower, arrangements of florets and purpose used, the chrysanthemums are classified into several groups.

I. Small flowered types.

II. Large flowered types

III. Classification based on plant growth

IV. Based on usage.

I. Small Flowered

- **Singles** – The petals are arranged in one or not more than five rows with prominent central disc.
- **Anemones** – Prominent centrally raised hemispherical cushiony disc florets surrounded by short rounded or flat or twisted or quilled ray florets. Ex. Golden sands, White sands.
- **Korean single** – Small flowers with a prominent central disc, ray florets are flat, number of whorls or ray florets are five and less than five. Ex: Cardinal, Gul-e-Sahir, Chairman.
- **Korean double** – The number of whorls of ray florets are more than five and the central disc is open. Ex: Flirt, Man Bhawan.
- **Spoon** – The outer ray florets are tubular with a spatula or spoon like opening at the tips. Ex: Anokha.
- **Decorative** – Fully double flowers with flat petals and central disc is generally absent or not seen, ray florets are longer. Ex: Arctic, Elegance, Blue chip, Dolly.
- **Quilled** – Small flowers, ray florets are tubular. Ex: Golden crystal, Snow crystal.
- **Button** – Very compact, small flowers, produce numerous flowers. Ex: Golden dust.
- **Pompon** – The flowers small, freely opened, compact, hemispherical or ball shape, the central disc is concealed or absent, florets neatly arranged. Ex: Apsara, Jayanthi, Lameo, Dandy, Eve.

II. Large flowered types

- **Incurved regular** – The outer ray florets curve upwards and inwards towards the disc florets to form a globular shape. Ex: Snow ball, Sonar Bangla, Chandrama.
- **Incurve irregular** – The outer ray florets incurve loosely and irregularly and do not form a ball as in case of regular.
- **Refluxed** – The outer ray florets curved outwards and downward away from the centre so that only their upper surface is seen. Ex: Cresta, City Beauty, Golden Rule, Day dream, Peach blossom, Sweet Heart.
- **Intermediate** – The inner florets incurved and outer florets are refluxed, they are intermediate in shape to incurved and refluxed. Ex: John Reid, Lady Hope town.
- **Spider** – The outer ray florets are large, elongated, tubular and curved to form a hook or coil like structure at the tip of the petals. Ex: Rupasi Bangla, Mahatma Ganthi.
- **Quill** – The outer ray florets are elongated, straight and tubular like a quill with tips open but not flattened.
- **Exhibition** - The outer florets are refluxed and inner florets incurved, the ray florets are generally twisted, irregularly overlapped each other and looks attractive.
- **Ball type** – Ray florets are straight and radiated in all directions to give a complete ball shape.

III. Classification based on plant growth

- **Standards** – plants with single flower, other buds are removed if arise from the laterals and produce big flower.
- **Spray** – The main apex bud is removed and lateral buds are allowed.
- **Pot mums** – Small flowered mums with 6-9” height are beautiful in decorating the places.

IV. Based on usage.

1. Cut flowers –
 - i) Disbudded inflorescence
 - ii) Spray inflorescence
2. Loose flowers
3. Potted/bed plants

Species and cultivars

- Some important species of chrysanthemum are:
- $n=9$ ($2n=18$ to 198)

Species	Characters
<i>Chrysanthemum boreale</i>	Abura – Giku
<i>C. carinatum</i>	Tricolour chrysanthemum
<i>C. coronarium</i>	Garland chrysanthemum/annual chrysanthemum
<i>C. cinerariifolium</i>	Used for making insecticide- pyrethrum
<i>C. coccinium</i>	Pointed daisy
<i>C. frutescens</i>	Marguerite/Paris daisy
<i>C. indicum</i>	Ancestral species for modern chrysanthemum
<i>C. japonicum</i>	Grown in Pacific coastal region of Japan
<i>C. maximum</i>	Shasta daisy Flower: white and yellow
<i>C. morifolium</i>	Florist chrysanthemum- evolved by interspecific crosses

Species	Characters
<i>C. rubellum</i>	Hardy species
<i>C. satsumense</i>	Satsuma-nogiku - Ancestral species for florist chrysanthemum
<i>C. sibiricum</i>	Parent of Korean hybrid
<i>C. sinense</i>	Ancestral species for florist chrysanthemum Flower- White
<i>C. ornatum</i>	Ancestral species for florist chrysanthemum

Genetics and Floral Biology

- Basic chromosome No. $n = 9$
- Nazeer and Khoshoo (1982) – Surveyed the chromosome no. in India
- $2n = 18, 36, 45, 51, 72, 75, 90$ and 198
- Most of Chinese cvs. – Hexaploids and Aneuploids ($2n = 54$ or $2n = 54 \pm 1$)
- Self incompatibility reaction – Sporophytic – having more than one locus with 2 alleles
- Ray florets: Pistillate
- Disc florets : Hermaphrodite

Colour genes:

Flower colour is determined by the presence or absence of carotenoids, anthocyanins, flavanols and other glucoside's in the plant.

- 'A' gene : Production of anthocyanin
- 'I' gene: Inhibits carotene production
- 'A' and 'I' gene absence : Enhances Xanthophyll production (Yellow colour)
- 'A' gene absence : White colour
- 'A' and 'I' combination : Pink, Carmine, bluish red flowers
- 'A' with out 'I' gene: Bronze and brownish red flowers

Flower type:

- Singleness is partially dominant over doubleness type of flower

Breeding

- *Chrysanthemum* – Compositae
- Second largest family among flowering plants comprising about 20,000 species, largest being *Orchidaceae*.
- The individual flowers are called florets and are of two types.
- The outer ones are called **ray florets** and are **unisexual with only female parts** while the **inner ones are called disc florets-hermaphrodite**
- *C. morifolium* is a hybrid species.
- Several elemental species namely *C. sinerise*, *C. indicum*, *C. japonicum*, *C. ornatum*, *C. satsumense* and *C. boreale* are believed to have contributed towards its development.

BREEDING METHODS

- The origin of each of the chrysanthemum cultivar grown in India can be traced to either of the **three modes of varietal upgrading viz.,**
 1. Introduction
 2. Selection
 3. Hybridization
 4. Mutation.
 5. Breeding for Pest and Disease resistance
- The main agencies responsible for varietal improvement are
 - individual enthusiasts,
 - nurserymen,
 - Chrysanthemum Society of India or
 - breeders working in research institutes and agricultural universities.

Breeding objectives

The objective of breeding has been different at different places.

- Breeding for high yielding cultivars for garland purpose or pot culture or cut flower type or exhibition types
- Cultivar for low temperature requirement or no vernalization requirement for year round cultivation.
- Pollen free cultivar are desirable (as pollen induces allergy)
- Free from suckering and easy rooting
- Uniform response to environment
- Resistant to pest and diseases

Institutes working on Chrysanthemum

- NBRI, Lucknow
- IIHR, Bangalore
- PAU, Ludhiana
- BCKV, Kalyani
- TNAU, Coimbatore
- IARI, New-Delhi
- UHS, Bagalkot --- Released Var. Dundi

Methods: 1. Introduction of Plant Material

- In the absence of any documentary evidence it is difficult to say as to when, wherefrom and by whom chrysanthemum was first introduced in India.
- 1690 by H. Van Rheede, of an Indian variety of chrysanthemum called *Gool-Doodi*, introduced from this country to **Holland**
- Chrysanthemum was in cultivation in **North India in 17th** century (*Guldaudi* being **Hindi** name for chrysanthemum still in vogue in North India).

Examples: Introduction

Sl. No.	Country	Introduced Cvs.
1	Australia	J.S. Lloyd, Louisa Pockette, Willium Turner and T.W. Pockette
2	France	Gloria Deo, St. Andre Reffaud, and Sancho
3	Japan	Ajina Purple, Kenroku Kangiku, Kiku Biori, Taiho Tozan, Tokyo, Shin Mei Getsu, Senkyo Emaki and Otome Zakura
4	New Zealand	Gusman Red, Icicles, Jane Sharpe, Orange Fair Lady; and Nancy Ferneaux.
5	United Kingdom	'Ifred Wilson, Alfred Simpson, Balcombe Perfection, Beatrice May, May Shoesmith, Maurice White, Leviathan, Pink Cloud, Princess Anne and Woolman Century.
6	United States	Casa Grande, Mountaineer, Nob Hill, Snow Ball, Potomac and Peacock.
7	Hungary	<i>D. corymbosum</i> , <i>D. frutescens</i> , <i>D. caucasium</i> , <i>D. segetum</i> , <i>D. coccineum</i> , <i>D. vulgare</i> , <i>C. maximum</i> , <i>D. lucanthemum</i> , <i>D. cinerariefolium</i>

2. Introduction of Plant Material

- Selections were made from the Open pollinated seedling selection.

Sl. No	Variety	Institute	Parentage	Characters
1	Rakhi	IIHR	Lord Doonex	Anemone type Flowers: Yellow with red strips
2	Appu	NBRI	Original dwarf	No pinch and no stake type Flowers: Purple colour
3	Apsara	NBRI	Nanako	Pompon type Flowers: Rosy flush on white flower
4	Apurva Singar	NBRI	Double Korean	No pinch and no stake type Flowers: Mauve colour and pot culture
5	Arun Kiran	NBRI	Original dwarf	No pinch and no stake type Flowers: Red colour and supper dwarf
6	Arun Singar	NBRI	Original dwarf	No pinch and no stake type Flowers: Red colour
7	Birbal Sahni	NBRI	Nanako	Pompon type Flowers: White flower and cut flowers

8	Diana	NBRI	-	Anemone type, dwarf type Flowers: Red color
9	Guldasta	NBRI	-	No pinch and no stake type, anemone type, Flowers: Bronze colour
10	Hemanth Singar	NBRI	-	No pinch and no stake type, Korean type, Flowers: Purple colour
11	Haldi Ghatti	NBRI	Original dwarf	No pinch and no stake type, Korean type, Out of season flowering with purple colour
12	Apurva	NBRI	-	No pinch and no stake type, pot culture Flowers: Pink colour
13	Jayanti	NBRI	Nanako	Yellow flowers suitable for garland, cut flower and pot culture purpose
14	Jubilee	NBRI	Nanako	Pompon type and cut flowers Flowers: Orange red flowers
15	Kundan	NBRI	Jayanti	Yellow seedling of `` with brighter blooms suitable both for garland and cut flowers.
16	Maghi	NBRI	-	Pink pompon blooms in January at Lucknow
17	Mother Teresa	NBRI	-	Cineraria type, No pinch and no stake type, Flower colour: White

18	Peet Singar	NBRI	-	Anemone type, No pinch and no stake type, Flower colour: Sulphur
19	Shanti	NBRI	-	Decorative type, Flower colour: White
20	Sharad Singar	NBRI	Original dwarf	Out of season blooming, No pinch and no stake type, Flower colour: Yellow with bronze stripes
21	Suhag Singar	NBRI	-	No pinch and no stake type, Double Korean type, Flower colour: White
22	Chandrak ant	IIHR	-	Decorative type, Flower colour: White
23	Pankaj	IIHR	-	Decorative type, Flower colour: Pink
24	Co-1	TNAU	-	Early type, Flower colour: Yellow
25	Co-2	TNAU	-	High yield, Flower colour: Purple
26	Mdu-1	TNAU	-	Early type, Flower colour: Sulphur Yellow
27	IHR-Se1-5	IIHR	-	Flowers: Pink color, high yield, loose flower
28	IIHR-Se1 6	IIHR	-	Flowers: White blooms, high yield, loose flower
29	Sadbhawana	NBRI	-	Double Korean type, Dwarf and bushy, Profuse blooming

30	Kargil99	NBRI	-	Small flowered type, Flower colour: Purplish mauve (florets), Yellow (disc)
31	Y2K	NBRI	-	Small flowered, anemone type, Flower colour: White
32	Mini Queen	NBRI	Little Darling	Pompon type, Flower colour: Dark terracotta
33	Rangoli	NBRI	Diana	Double Korean type, Flower colour: Dark red
34	NBRI Little Pink	NBRI	Little Darling	Decorative type, Flower colour: Purple
35	NBRI Little Kusum	NBRI	Little Darling	Pompon type, Flower colour: Bronze
36	NBRI Little Hemant	NBRI	Little Darling	Pompon type, Flower colour: Yellow
37	NBRI Little Orange	NBRI	Little Darling	Pompon type, tubular type, Flower colour: Yellow
38	NBRI Himanshu	NBRI	-	Anemone type, Flower colour: Creamy white
39	Pusa Aditya	IARI	Jaya	Spray type, Flower colour: Yellow

40	Pusa Chitraksha	IARI	Lal Pari	Spray type, Flower colour: Deep magenta
41	Pusa Sona	IARI	Sadbhawana	Spray type, Flower colour: Yellow
42	Gul-e-Sahir	PAU	-	Flower colour: Yellow, flowering: October
43	Shanti	PAU	-	Flower colour: White, garland
44	Basanti	PAU	-	Flower colour: Yellow, sport of Shanti
45	Baggi	PAU	-	Flower colour: White, cut flower

The Chandra Nursery, Rhenock, Sikkim

➤ Selection from Japanese seedlings released in 1957

Sl. No	Variety	Parentage	Character
1	Anokha	Japanese seedlings	White exhibition large
2	'Smt. Bhima	Japanese seedlings	Yellow spider type
3	'Chandra's Choice	Japanese seedlings	Yellow tubular with tips open and hooked
4	Rangmahal	Japanese seedlings	Rosy mauve, globular with silvery reverse

Bred by Prof. Atma Sahay, Allahabad

Sl. No	Variety	Parentage	Character
1	Mahatma Gandhi (1958)	-	A tubular variety with giant sized blooms

Bred by Mr. K.B. Srivastava, Modinagar

1	K.N. Modi (1978)	Captain Kettle	-
2	Satish Modi (1978)	Fofa	-

3. Hybridization

- Being cross pollinated crop (sporophytic self- incompatibility), new varieties arise mainly as seedlings obtained either **by natural or conscious cross-pollination.**

The hybridization technique is given below

- **Selection of parents:** Select male and female parents depending on characters desired to be combined.
- **Emasculation:** Clip/remove anthers of disc florets before dehiscence in **blooms of female parent** and cover them with wax-paper bag to prevent natural pollination.
- Trim long ray florets in female parent to expose stigma

- **Pollination:** Collect pollen from male parent in petri dish. Dust pollen on stigma of female parent after temporarily opening wax bags.
- **Bagging:** Tie the bags giving details of male and female parents.
- Remove the paper bags after all stigmas wilt.
- Collect the seeds when completely dry (1 month after pollination) and store in dry place. Most of the small flowered cultivars in India have been developed by natural or artificial pollination by seedling selection.

The desirable characters in cultivars

Parameters for good pot variety:

- Profuse branching,
- uniform spread of plant,
- dwarf-ness,
- compactness,
- simultaneous blooming to give carpet like appearance,
- attractive colour, good colour retention,
- strong framework to withstand bloom weight and healthy leaves

Parameters for good cut flower variety:

- Attractive colour,
- normal spray with high central bloom,
- long erect stem, quick growth from late struck cuttings,
- easy to root cuttings,
- uniform bloom opening with 5-6 blooms per spray, tough florets,
- long vase life and healthy leaves.

Parameters for good garland variety:

- Yellow or white colour of bloom,
- diameter of bloom about 5 cm, fluffy blooms,
- disc absent or not visible,
- good quality of recovery from pressure,
- high yield (15m. tons/h or 150 gm. per plant),
- good colour retention in the field,
- storage life more than 3 days,
- long blooming season,
- smooth bloom - periphery, profuse branching and sweet scented blooms are preferred

Hybrids developed by different Institutes

Sl. No	Hybrids	Institute	Parentage	Characters
1	Indira	IIHR	Lord Doonex x (Flirt x Valentine)	Double Korean type Flowers: Yellow
2	Red Gold	IIHR	Flirt x Valentine	Double Korean type Flowers: Golden Yellow
3	Chandrika	IIHR	Angela x G.P.I.	Decorative type Flowers: White
4	Kirti	IIHR	Angela x G.P.I.	Korean type Flowers: White
5	Nilima	IIHR	Flirt x Valentine	Decorative type Flowers: Purple
6	Ravikiran	IIHR	Flirt x Valentine	Stellate type Flowers: Grey red to Grey orange
7	Red Gold	IIHR	Flirt x Valentine	Korean type Flowers: Greyish orange to Golden Yellow
8	Yellow Star	IIHR	Flirt x Valentine-22	Decorative type Flowers: Yellow

Sl. No	Hybrids	Institute	Parentage	Characters
9	Punjab Gold	PAU	Flirt x Gul-e-Sahir	Flowers: Coppery red changes to Golden Yellow. Resistant <i>Septoria</i> leaf spot
10	Wains Pink Lady	PAU	Pink Arola x Charm	Flowers: Pink
11	Jannel	PAU	Green Pea x Keystone	Pompon type, Flowers: White Susceptible to leaf minor
12	NBRI Indiana	NBRI	Little Darling x Nanako	Pompon type, Flowers: Yellow
13	NBRI Kusum	NBRI	Haldighati x Sharad Kanti	Korean type, Flowers: Yellow (disc) and bright yellow (ray)
14	NBRI Little Darling	NBRI	White Charm x Jubilee	Pompon type Flowers: Yellow –Orange
15	NBRI Mini Jessi	NBRI	Cameo x Jessie	Cineraria type Flowers: Red purple
16	NBRI Kaul	NBRI	Lal Pari x Vijay	Korean type, Flowers: Yellow (disc) and purple (ray)

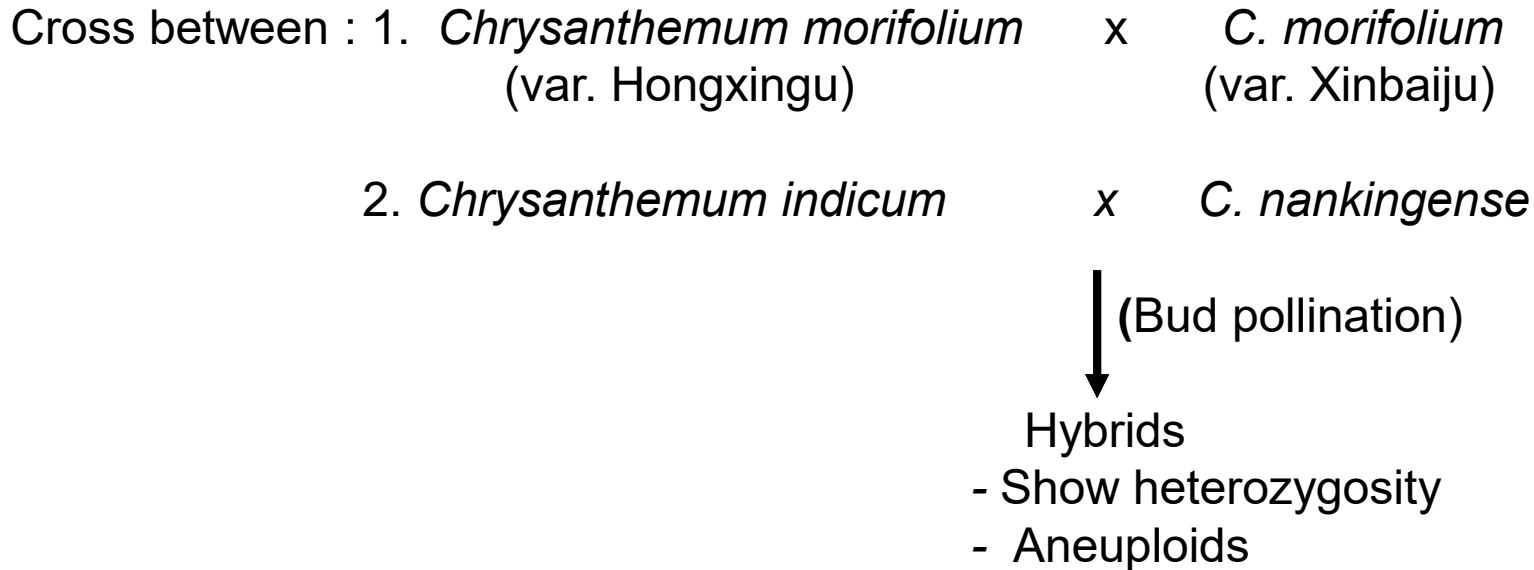
Sl. No	Hybrids	Institute	Parentage	Characters
17	NBRI Khoshoo	NBRI	Lal Pari x Vijay	Single Korean type Flowers: Grey red
18	Arka Swarna	IIHR	Nanako x Co-1	Pompon type Flowers: Yellow
19	Arka Ravi	IIHR	Mundial x Hybrid-87-17-1	Semi double type Flowers: Peach
20	Arka Ganga	IIHR	Flirt x Red Gold	Flowers: White with pink ting
21	Anmol	PAU	Panchoo x Rage	Anemone type Flowers: Bright yellow
22	Royal Purple	PAU	Bindiya x Rage	Anemone type Flowers: Purplish pink
23	Yellow Delight	PAU	White Bouquet x Gul-e-Sahir	Pompon type Flowers: Bright yellow
24	Winter Queen	PAU	White Bouquet x Flirt	Spoon type Flowers: Pink
25	Autumn Joy	PAU	White Bouquet x Flirt	Flowers: Pink

Bred by Mr. Barin Gupta, Pioneer Breeder of Jamshedpur

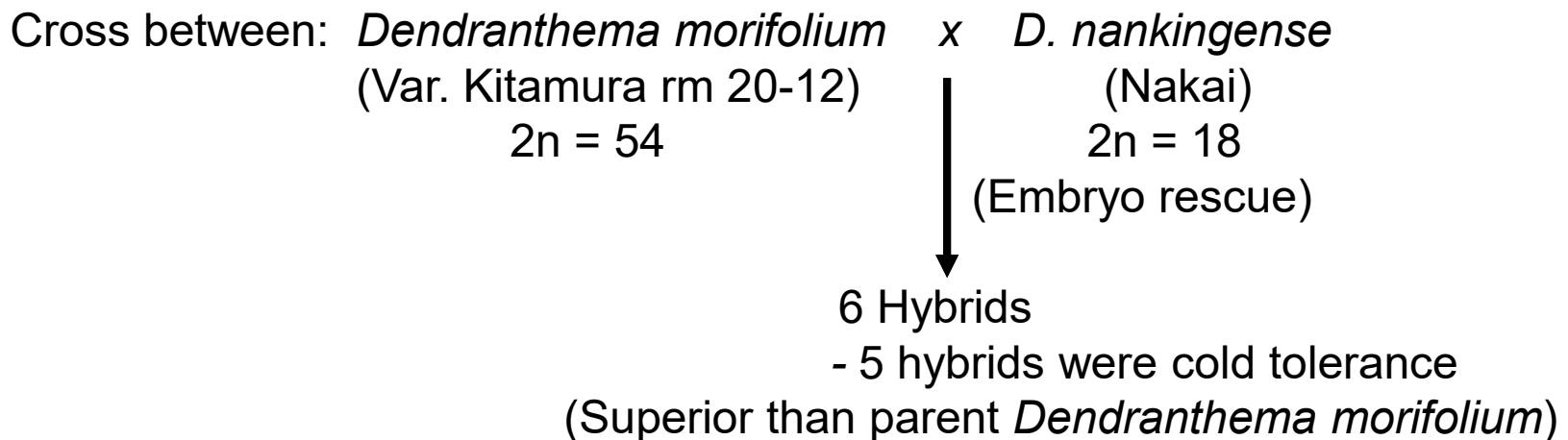
Sl. No	Hybrids	Parentage
1	Pride of Jamshedpur (1976)	Rajah x Alfred Simpson
2	Jamshedji (1976)	Alfred Simpson x Rajah
3	Steel City Beauty (1976)	White Cloud x Temptation
4	Red Carpet (1978)	Mrs. W.A. Reid x Kikubiori
5	Others: Jamshedpur Glory'(1987) R.R. Karnad Russi Modi Shri Ganga(all 1988)	

Interspecific Hybridization

Huang *et al.* (2011)



Cheng *et al.* (2010)



4. Mutation Breeding

a. Natural Mutation:

- Chrysanthemum some times mutate to give new cultivars – Sports, but the mutation frequency in nature is low.

Original cultivar	Sport	Character changed	Place of occurrence with year
Mahatma Gandhi	Kasturba Gandhi	Mauve to White	Allahabad in 1961
Snow Ball	Sonar Bangla	White to Yellow	Kalyani (W.B.) in 1970's
Pink Cloud	White Cloud	Pink to White	West Bengal in 1970's
Sharad Shobha	Sharada	White to Yellow	Lucknow in 1978
Casa Grandi	Queen of Tamluk	White to Yellow	Tamluk (W.B.) in 1985
S.S. Arnold	R. Venkataraman	White to Yellow	New Delhi (1991)
Pink Turner	William Turner	Pink to White	-
William Turner	J.S. Lloyd	White to Yellow	-
Pride of Madford	White ball	-	-
A-22	NBRI-Pushpangadan	-	-

b. Induced Mutation:

- Higher rate and frequency of mutation can be induced through induced mutation
- The most suitable dose of gamma rays for inducing mutation in chrysanthemum ranged between **1.5 and 2.5 krads** (Gupta and Jugran, 1978; Gupta and Shukla, 1971).
- NBRI, Lucknow released 40 mutants

Occurrence of Colour mutants in Chrysanthemum

- The mutants in chrysanthemum occur in a definite pattern and directions

Dowrick and E I Bayoumi, 1966		Carotenoids	
		Without	With
Anthocyanins	With	Pink	Bronze
	Without	White	Yellow

```
graph TD; Pink --> Bronze; Pink --> White; White --> Yellow; Bronze --> Yellow;
```

- This pattern mainly due to either the **loss of whole chromosome** or **single gene**
- The gamma rays dosage w.r.t. LD-50 is laying between **1.5 to 2.5 kR** for changes in colour and other characters.
- The rate of mutation was found to be highest in **Pink cultivars**
- But the **reverse pattern** is not true

Induced Mutants developed at NBRI, Lucknow

Name of parent	Name of mutant	Bloom color change Parent to mutant
Small flowered		
1. D-5	1. Agnishikha	Magnolia Purple to Red
	2. Alankar	Magnolia Purple to Orange
2. E-13	3. Lohit	Mauve to Reddish
	4. Kapish	Mauve to Brownish
	5. Anamika	Mauve to Light Red
	6. Basanti	Mauve to Yellow
3. Megami	7. Hemanti	Pink to Chinese Yellow
4. Flirt	8. Manbhavan	Red to Red and Yellow
5. Himani	9. Subarna	Red to Yellow
6. Ratna	10. Sheela	White to Yellow
7. Kalyani Mauve	11. Sonali	Red to Yellow
8. Sharad Mala	12. Navneet	Mauve to Creamy
9. Surekha	13. Sharad Har	White to Yellow
	14. Surekha Yellow	Ruby to Yellow

Large Flowered

10. Hope	15. Asha	Pink to Creamish
11. Undaunted	16. Kanak	Bright Mauve to Dark Brown
	17. Nirbhaya	Bright Mauve to Lighter Mauve
	18. Sawrnim	Bright Mauve to Light Brown
	19. Shafali	Bright Mauve to Reddish
12. Ashankit	20. Aruna	Bright Mauve to Dark Red
13. Paul	21. Basant	Terracotta to Yellow
14. Belur Math	22. Gairik	Pink to Salmon
15. Rose Day	23. Kansya	Rosy Pink to Bronze
16. Pink Casket	24. Pingal	Rosy Pink to Bronze
17. Kansya	25. Pitaka	Bronze to Yellow
18. Otome Zakura	26. Purnima	Pink to White
	27. Pitamber	Pink to Yellow
19. King Ford Smith	28. Rohit	Purple to Red
	29. Taruni	Purple to Azalia Pink
20. Mrs. H. Gubby	30. Shukla	Mauve to White
21. Fish Tail	31. Shveta	Mauve to White
22. Goldie	32. Tamra	Apricot to Copper Red
23. M-71	33. Kum Kum	Lilac to Garnet Red

Mutations with Change in Form

24. D-5	34. Shabnam	Tips simple to tips with whitish appendage
25. Undaunted	35. Ashankit	Tips simple to Tips fringed
	36. Kunchit	Irregular to incurve
	37. Jhalar	Irregular to flat, fringed florets
	38. Nirbhik	Irregular to flat, fringed florets
26. M-26	39. Tulika	Spoon to brush like anemone
	40. Cosmonaut	Korean to brush like anemone

IIHR, Bangalore

1. Flirt	1. Yellow Gold	Red to Yellow
----------	----------------	---------------

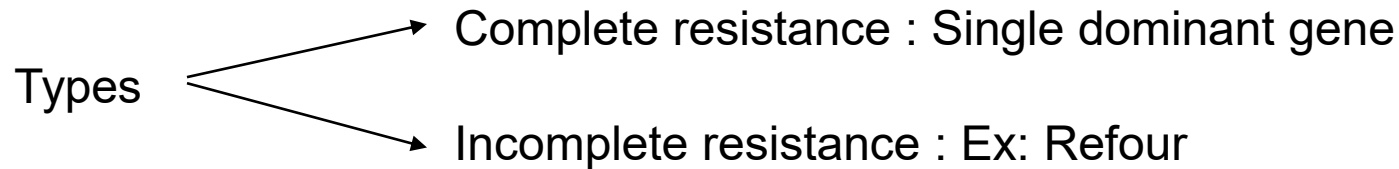
IARI, New Delhi

1. Ajay	1. Pusa Anmol	Pink to Yellow
2. Thai Chen Queen	2. Pusa Centenary	Pink to Brilliant Yellow
	3. Pusa Arunodya	Pink to Pink
	4. Pusa Kesari	Pink to Red

5. Breeding for Pest and Disease resistance

1. Disease Resistance

a. White Rust (*Puccinia horium*)



b. Septoria leaf spot: Ex: Punjab Gold – Resistance

2. Insect Resistance

a. Leaf minor (*Liriomyza trifolii*)

Ex: *C. pacifucum* , Cv. Penny Lone and White Spider – Resistant
Cv. Pink Pompon – Susceptible

b. Spider mite (*Tetranychus urticae*)

Cv. Angel Bell – Least infestation

c. Bud Borer (*Helicocarpa armigera*)

Resistant cvs (< 10% damage) : Angel Bell, Arka Swarna, Chandrika, Nilima, Snow Ball and Collection No.9

3. Resistant to Frost and Physiological disorder

a. Resistant Frost/winter hardiness:

Cv. Peach Centre Piece (Bud sport of Centre Piece)

F₁: Sesqui Centennial (Bandit x Sun Allune)

b. Pre mature budding

Ex: Line derived from Japanese cv. Chiyozaakura (Pink, single)

Thank you



Chrysanthemum (From IIHR)

Arka Swarna: A cross between 'Nanako x CO-1'. This hybrid bears Yellow pompon flowers. It is found superior in respect of plant height, number of flowers per plant, flower size, flower weight, flower yield per plant and flowering duration. This is suitable for both cut and loose flower purposes.

Arka Ravi: It is a cross between Mundial and Hybrid 87-17-1, flowers in 102 days which is earlier than local varieties. Flowers are semi-double type, each being in 6 cm diameter. It produces 130 flowers per plant. Flowers are attractive peach in colour. It has a vase life of 12 days. Flowers can be used for cut flower purpose.

Arka Ganga: Bears attractive double Korean white flowers with pink tinge. Flower yield is higher than Local White variety. Suitable for both loose and cut flower purposes.

Chandrakant: Flowers are decorative, white in colour, takes 124 days to flower. It is dwarf with a plant height of 39cm. On an average, flower diameter is 4.7 cm and weighs about 1.85 g. It is floriferous and produces 149 flowers with an yield of 272 g per plant, it produces about 2 times more yield than the local white variety, flowers are more attractive and can be used as loose flower.

Chandrika: A white flowered hybrid obtained by crossing Angela x GP1. It produces decorative flowers. It takes 92 days to flower. Number of flowers per plant is 130, which is 3.7 times more than the local white variety. It can also be used as cut flower. Its shelf life is 7 days and vase life 10.8 days. It can also be used in flower arrangement, bouquets, can also be used as loose flowers for Pooja and floral decoration.

'Indira' is a cross between an open pollinated seedling of 'Lord Donex' LD-14 (imperial purple) and a hybrid seedling of 'Flirt' x 'Valentine' F x V-1 (beet root purple). It flowers in three months. The flowers are double Koreans,, yellow at bud stage and butter cup yellow at picking stage, fading to aureolin. Each flower is 5 cm in diameter. Produces about 300 g flowers per plant under field conditions. It is a good multiplier and can be multiplied through cuttings. Ideal for cut flower purpose, religious offerings, wreaths, bedding and potting.

Kirti: It is a hybrid between Angela x G.P.1. It flowers early (88days). It bears white coloured double Korean type of flowers, which fade to a pink tinge. It is floriferous and produces 119 flowers per plant. It yields 168g of flowers per plant, which is 1.71 times more than the Local white. Its shelf life is 7.5 days. It is dwarf (34.5 cm), spreading (41.1 cm) and compact. Therefore suitable for bedding and potting purposes; besides, the flowers can also be used for floral decoration.

Nilima: Hybrid produced by cross cvs 'Flirt' x 'Valentine'. It takes 116 days to flower. It bears purple coloured decorative flowers whose diameter is 4.86 cm and average flower weighs 1.96 g. It is floriferous and bears 144 flowers per plant. On an average its flower yield is 281 g per plant. suitable for cut flower (spray type) purpose having vase life of 14 days. Flowers are compact and are good for loose flower purpose in floral decoration.

Pankaj: It flowers early and takes about 114 days to bloom. It bears pink, attractive flowers which are decorative type. Diameter of flower is 4.8 cm which weight 2.68 g. It is high yielding and; produces 140 flowers with an yield of 363 g per plant. Its attractive flowers on stiff stalk makes them suitable for cut flower purpose. Loose flowers can be used for floral decoration.

Rakhee: is an open pollinated seedling of 'Lord Done x' (Super yellow with purple stripes). It flowers in 3 months. The flowers are anemone primrose yellow with red stripes on ray florets, each of 5 cm diameter. Plants are bushy, compact with shiny leaves. Produces about 125 flowers in beds but around 100 flowers in pots. It is a good multiplier, is good for potting, veni and religious offerings.

Ravikiran: One of the hybrid produced by crossing cvs 'Flirt' x 'Valentine'. It takes 122 days to flower. This hybrid is an ovelty. It looks like a papery flower. The flower type is stellate. Its flower diameter is 6.12 cm and flower weighs 2.48 g. It produces 86 flowers per plant. Flower is grey-red and fading to grey-orange. It is suitable as cut flower and can be used in flower vases or in bouquets. It has a vase life of 12 days.

RedGold: is a cross between 'Flirt' (Current red) x 'Valentine'; (amethyst violet). It flowers in 4 months. Flowers are initially greyish-orange and fade to golden yellow, double Koreans, 5 cm diameter. Flowers profusely produced at an average of 400 g flowers per plant, can be used for cut flower purpose; good for bedding, potting, wreaths and for religious offerings.

Usha Kiran: An induced mutant of IIHR cv. Kirti, with more plant height and spread compared to Cv. Kirti. The floral traits were at par with the cv. Kirti, but the flower colour of mutant is yellow. Mutant is dwarf, compact and spreading and found suitable for bedding/ potting and loose flower purposes as it has a shelf life of 7 days as against 5 days in Kirti. The flowers are semi- double with prominent disc

Yellow Gold: This is a yellow flowered induced mutant of the red flowered variety 'Flirt' obtained by gamma irradiation. On an average, it takes 140 days to flower. It bears yellow coloured decorative flowers whose diameter is 5.26 cm and weighs 2.16 g. Petals has Brick Red coloured stripes. It produces 113 flowers per plant. Flower yield is 244 g per plant; good for loose flower **purpose but also suitable for cut flower (spray type) purpose with a vase life of 14 days.**

Yellow Star: It is a yellow flowered cultivar. Flowers are decorative, with average diameter of 4.33 cm. It takes 140 days to flower. It produces 150 flowers per plant. It is high yielding and produces 272 g flowers per plant, which is 1.3 times more than in the local yellow variety. Flowers can be used as cut flower, in flower arrangement and as loose flowers for garlands, floral decorations.