

CHRYSANTHEMUM (*Chrysanthemum moniliformin*) (2n=36)

Florist's chrysanthemum (*Chrysanthemum morifolium*, Ramat) ranks second among commercial flowers in the world. In India it occupies third position, with jasmine and rose standing first and second. It is grown in wide range of environment, suitable for various purposes e.g. pot culture, field culture, for garland making or cut flowers or simply bedding purpose, long post harvest life, predictable response to environment and amenability to different attractive training methods or styles. However, the most important of all factors is the immense number and diversity of shape, size and colour displayed by its cultivars. Breeding has played a pivotal role in augmenting this diversity during the long history of its evolution.

Origin: China

Distribution: China, Japan, France, USA, Australia, Europe, and Asia. In India all the states.

Species of chrysanthemum

Genus *Chrysanthemum* belongs to the family Compositeae which is second largest family among flowering plants comprising about 20, 000 species, largest being *Orchidaceae*.

Chrysanthemum morifolium

C. sinense

C. indicum

C. japonicum

C. arnatum

C. satsumense

C. boreale

Indigenous species

C. indicum – Native to India, Florist chrysanthemum

Wild species

C. stilliszkai, *C. rkhtsria*, *C. atkinsoni* and *C. leucanthemum* as wild species in the Indo-Tibetan border

Introduced species / Exotic species

C. caronanium (Garland chrysanthemum)

C. carinatum (Tricolour chrysanthemum)

C. rubellum (for hardiness)

C. sagetum (Corn marigold (or) pot plant)

C. boreale (Evolution of florif, chrysanthemum)

C. cinerarifolium (Used as insecticide)

C. coccineum (Perennial, seed propagated)

C. manifoldum (Florist chrysanthemum)

Breeding objectives

Cultivars with low temperature requirement

Rapid growth habit with small to medium size of leaves to enable close planting.

Pollen – free cultivars have been reported to be desirable as pollen spoils the appearance and also induces allergy reactions during handling.

Uniform response to environment,

Long storage life

Compact and dwarf

Easy to root cutting

Cultivars with no vernalisation requirement are preferred for year around production.

Breeding Methods:

Introduction: Scrutiny of names of cultivars grown in this part of the country show their Australian, English, French, Japanese or American origin in addition to those originating within the country. In South India on the other hand only a few yellow or white small coloured cultivars are grown for use as loose flowers which are probably of Indian origin. Introduction of exhibition types seems to have started in East India, particularly in Calcutta and Sikkim during British period. Most introductions till two decades back were done by resourceful individuals or nurserymen in these two places or through some embassies in New Delhi.

Names of some well known cultivars grown in India have been given below along with the name of country wherefrom they were introduced into this country or where it originated:

Country from which introduced / or originated	Name of cultivar
Australia	'J.S. Lloyd', 'Louisa Pockette', 'William Turner' and 'T.W. Pockette'
France	'Gloria Deo', 'S.L. Andre Raffaud', and 'Sancho'
Japan	'Ajina Purple', 'Kenroku Kangiku', 'Kiku Biori', 'Taiho Tozan', 'Tokyo', 'Shin Mei Getsu', 'Senkyo Emaki' and 'Otome Zakura'.
New Zealand	'Gusman Red', 'Lcicles', 'Jane Sharpe', 'Orange Fair Lady', and 'Nancy Ferneaux'.
United Kingdom	'Alfred Wilson', 'Alfred Simpson', 'Balcombe Perfection', 'Beatrice May', 'May Shoesmith', 'Maurice White', 'Leviathan', 'Pink Cloud', 'Princess Anne' and 'Woolman Centruy'.
United States	'Cassa Grande', 'Mountaineer', 'Nob Hill', 'Snow Ball, Potomac' and 'Peacock'.

The realization of this fact led to introduction of 80 cultivars from Japan in 1972 at National Botanic Gardens, Lucknow (Kher, 1977). These introduced cultivars formed the basis for filling the gaps mentioned above by hybridization or mutation breeding at the institute.

2. Selection:

Most of the outstanding spray and loose flower type cultivars evolved in India, namely Birbal Sahni, Apsara, Kundou, Jaya, Shard Singer, Co1, Co2. The drawback of this method include unknown parentage, need for raising a very large number of seedling population. Failure of the improved double long and tabular ray florets to set seeds etc. Single plant selection method is followed.

3. Hybridization

The aim of hybridization is improvement which assumes different meanings depending-upon the purpose for which a new cultivar is intended. A cultivar suitable for pot - culture may not be fit for growing as cut-flower. Similarly, a cultivar may be suitable for cut-flower purpose but not for garland making. The desirable characters in cultivars intended for pot-culture, cut-flower and garland purpose have been enumerated for the benefit of breeders at the 5th workshop of the All India Coordinated Floriculture improvement project held in New Delhi in 1983 (Report of AICFIP, 1982-83), as given below.

Parameters for good pot variety: Profuse branching, uniform spread of plant, dwarfness, compactness, simultaneous blooming to give carpet like appearance, attractive colour retention, storage 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 stem cuttings, easy to root cuttings, uniform bloom opening with 5-6 blooms per 32.ray, tough florets, long vase life and healthy leaves.

Parameters for good garland variety: Yellow or white colour of bloom, diameter of bloom about 5cms, fluffy blooms, disc absent or not visible, good quality of recovery from pressure, high yield (15 m. tons/h or 150 gms. 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.

4. Mutation breeding:

Pioneering work on induction of somatic mutation in chrysanthemum by using a Co 60 radioactive gamma irradiation source has been done at N.B.R.I., Lucknow, resulting in the development of about 40 mutant cultivars strikingly different from their parents. The main advantage of this method lies in changing one or few characters of an otherwise outstanding cultivar without altering the remaining, and often unique, part of the genotype.

Examples:

Basanti, Pusa centenary, pusa anmol, usha kiran

Sports

A good number of outstanding chrysanthemum cultivars in the world have arisen a natural mutants commonly called sports. examples:

S. No.	Original cultivar	Sport
1.	Mahatma Gandhi	Kasturba Gandhi
2.	Snow Ball	Sonar Banla Bangla
3.	Sharad Shobha	sharada



MARI GOLD (*Tagetes erecta* L). (2n = 24)

Introduction

Marigold (*Tagetes erecta* L., Asteraceae) is grown as an ornamental crop for loose flowers and as a landscape plant, as well as source of pigment for poultry feed. Flowers are sold in the market as loose or after making into garlands. Other than loose flowers, it can also be used as cut flowers. Marigold especially is used for beautification and also in landscape plans due to its variable height and colour of flowers. It is highly suitable as a bedding plant, in a herbaceous border and is also ideal for newly planted shrubbery to provide colour and fill spaces. French marigold is ideal for rockeries, edging, hanging baskets and window boxes.

Origin: Mexico

Distribution: USA, Europe India etc. In India Maharashtra, West Bengal, Karnataka, Tamil Nadu and Andhra Pradesh.

Species, Types and Cultivars

Species: There are about 33 species of the genus *Tagetes*. The characters of important species (Bailey, 1963) are given below:

***Tagetes erecta* (African marigold):** The plant is hardy, annual about 90 cm tall, erect and branched. Leaves are pinnately divided and leaflets are lanceolate and serrated. Flowers are single to fully double and large sized with globular heads. The florets are either 2-lipped or quilled. Flower colour varies from lemon yellow to yellow, golden yellow or orange.

***Tagetes patula* (French marigold):** A hardy annual, about 30 cm tall, forming a bushy plant. Foliage is dark green with reddish stem. Leaves are pinnately divided and leaflets are linear lanceolate and serrated. Flowers are small, either single or double, borne on proportionately long peduncles. The flower colour varies from yellow to mahogany-red.

***Tagetes tenuifolia* (Syn. *Tagetes signata*):** It is an annual with a branching habit. Leaves are pinnately divided into 12 oblong, linear, sharply serrated segments. Flowers have 5 rays, yellow, roundish and obovate. *Tagetes signata* cv. *Pumila* is a dwarf, brushy and grows less than 30 cm. Flowers are bright yellow and small but numerous.

***Tagetes lucida* (Sweet scented marigold):** The plants of this species are tender, perennial. Leaves are sessile, small and lanceolate. Flowers usually are 2-3 rayed, produced in dense, terminal corymbs. The flowers have much more agreeable odour than other species.

***Tagetes lacra*:** It was discovered in California. The plant grows upto 120-150 cm in height and flowers profusely. Flowers are yellow in colour.

***Tagetes lemmonii*:** It is a shrubby plant, grows up to 60-70 cm. Leaves are slender, opposite; leaflets about 2-3 cm long. Flowers are showy and 2-3 cm in diameter.

The other species grown in gardens are *Tagetes minuta*, *Tagetes pusilla* and *Tagetes corymbosa*. In India, however, the cultivation of *Tagetes erecta* and *Tagetes patula* dominates.

B reeding objective:

- Compact and dwarf growth habit
- Uniform response to environment
- More flower yield.
- Free from diseases and pests

Breeding Methods:

1. Introduction :

A wide array of germplasm was collected At N.B.R.I., Lucknow and Punjab Agricultural University, Ludhiana from exotic sources. In African marigold, 5 varieties, namely Alaska, Doubloon, Fire Glow, Golden Jubilee and Yellow Fluffy were recommended for loose – flower production, whereas eight varieties viz., Gerardine, Golden Climax Giant, Orange Fluffy, Orange Mums, Sovereign, Sun Giants, Super Chief Double and Yellow Climax were found suitable for cut flower purpose at N.B.R.I. Lucknow, PAU, Ludhiana recommended 2 varieties like Giant Double African Orange and Climax of African marigold and 3 varieties Rusty Red, Butter Scotch and Red Brocade of French marigold for loose flower production and 3 varieties, namely, Valencia, Sussana and Tetraploid for bedding purpose.

Selection: A large number of varieties of African marigold were collected at IARI, New Delhi. Since, most of the varieties were in heterozygous condition, single plant selections were made in the basis of desirable attributes. As a result of these efforts, few promising selections have been developed, which are in pre-release stage.

Hybridization: Hybridization between distantly related types is the most effective and commonly employed tool to induce variation so as to improve the existing cultivars and evolve new, high yielding and better quality of genotypes. Different principles of breeding have successfully been used in marigold, which resulted in new cultivars and present day F₁ hybrids.

Inter-Varietal Hybridization: In well-planned breeding studies, Singh and Swamp (1972) observed appreciable heterosis. Attempts were made to develop F₁ hybrids in marigold because F₁ hybrids are considerably uniform and capable of producing large blooms with high yield potential. In addition, they are characterized by their semi-tall nature with excellent large full double flowers. For the last 20 years, F₁ hybrid seeds of *Tagetes erecta* are available. Climax was the first F₁ hybrid to be released. A number of other F₂ hybrids are also available in the market.

Inter-Specific Hybridization: The inter-specific hybridization between *Tagetes erecta* x *Tagetes tenuifolia* and *Tagetes erecta* x *Tagetes jaliscensis* has been done by Towner (1961, 1962). Recently, inter-specific hybridization between *Tagetes erecta* x *Tagetes patula* has been carried out which finally led to evolution of Red and Gold hybrids. These hybrids are dwarf-like French marigolds but produce bigger flowers like that of African marigolds in large number.

Pedigree Breeding: A large number of single crosses were made involving genetically diverse inbred lines / open pollinated varieties. Selections started from F₂ generation onwards till they attained homozygosity. As a result of these studies, a few very promising improved lines have been developed, which are in pre-release stage.

Polyploidy: Studies on the nature and the limit of polyploidy in marigolds were carried out at N.B.R.I., Lucknow. Interspecific crosses between *T. erecta* (2n=24) and *T. patula* (2n=48) were attempted and interspecific triploid hybrids (2n=36) were produced. It was inferred that hexaploidy may not be successful in marigold as the highest ploidy level in about 50% of the species of the genus *Tagetes* is tetraploidy.

Male sterility: Male sterility in marigold is of two kinds: (1) apetalous, and (2) double-flowered. Apetalous sterility is preferred to full double flowers because the latter type is prone to break down and it gives rise to a few disc florets at later stages which may be due to either age of plants or environmental factors. However, apetalous flowers are less attractive to pollinating insects. Male sterility is governed by a recessive gene and is incorporated into the seed parent. It is maintained by crossing the heterozygous plants with the sterile ones.

African marigold (hybrid seed production)

In African marigold, genic male sterility system is being used for F₁ hybrid seed production. There are two types of male sterility in marigold, that is, apetalous form (with no stamens) and true double form (produces no anthers in the disc florets). Apetalous type of male sterility has greater liability and is being used for the production of F₁ hybrid seeds on a commercial scale in the U.S.A., U.K., Holland, France, etc. The apetalous type of male sterility is controlled by recessive alleles. Thus, a male sterile plant has a genetic constitution of *ms ms* (homozygous recessive), while male fertile plants may be of *Ms Ms* or *Ms ms* genotypes. The heterozygote *ms ms* will segregate to give 1 *Ms Ms*:2 *Ms Ms ms*:1 *ms ms*, the usual ratio for a single gene, but both homozygous *Ms Ms* and *ms ms* will, of course, breed true (except that the latter will produce no pollen to allow to breed further).

Therefore, for use as a parent in F₁ hybrid production, the male sterile line is perpetuated by back-crosses of double recessive (*ms ms*) male sterile by heterozygous male fertile (*Ms ms*) maintainer. In the subsequent generations, 50 per cent of the progeny will be male fertile *Ms ms*,

while the other 50 per cent will be male sterile $ms\ ms$. Male sterility phenomenon can be incorporated into standard varieties through five or six generations of back-crossing.

For the actual production of F_1 hybrid seed in the field, the back cross generation is inter-planted with the other parental lines (which is a normal male fertile inbred) and heterozygous male fertiles occurring in back-cross generation should be removed as soon as identification is possible, thus leaving male sterile plants only. The male sterile plants can be identified in the early stage by the shape of sunflower buds as these plants have pitcher type of flower buds, whereas the male fertile plants have normal flower buds.

To summarise, the mechanisms of using genetic male sterility for F_1 hybrid seed production under open field conditions require (1) a normal fully fertile inbred line and (2) an inbred line which is maintained by crossing together known heterozygous ($Ms\ ms$) and male sterile ($ms\ ms$) plants. Seeds should always be harvested from $ms\ ms$ plants. The cross of $ms\ ms \times Ms\ ms$ should be repeated in every generation, as it will segregate in 1 fertile : 1 Sterile ratio. A ratio of male sterile to pollinating fertile line is dependent on the size of hybrid block, but a ratio of 3 male sterile line : 1 male fertile has proved to be the optimum.

