CHARACTERIZATION OF CHRYSANTHEMUM CULTIVARS BASED ON THEIR MORPHOLOGICAL TRAITS

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CHARACTERIZATION OF CHRYSANTHEMUM CULTIVARS BASED ON THEIR MORPHOLOGICAL TRAITS

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All praise is to Allah who restored to me my health and returned my soul and has allowed me to remember Him

Dedicated to

The people who were being a great support throughout the research work and all the flower loving people

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CERTIFICATE

This is to certify that thesis entitled ***"CHARACTERIZATION OF CHRYSANTHEMUM CULTIVARS BASED ON THEIR MORPHOLOGICAL TRAITS"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in HORTICULTURE****, embodies the result of a piece of authentic research work carried out by* ***DINA AKTER****, Registration No.* ***14-05968*** *under my supervision and guidance. No part of the thesis has been submitted to any any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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- Authoress

CHARACTERIZATION OF CHRYSANTHEMUM CULTIVARS BASED ON THEIR MORPHOLOGICAL TRAITS

ABSTRACT

A research work was accomplished at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka from October, 2019 to April, 2020 for observing different morphological characteristics of chrysanthemum cultivars. Twenty five cultivars (V_1-V_{25}) were used in this experiment following Randomized Complete Block Design with three replications. Data on growth and flowering attributes showed significant variation. Different morphological traits of chrysanthemum cultivars were recorded and categorized into 9 groups according to The National Chrysanthemum Society Classification, USA. All the cultivars (V_1-V_{25}) were also classified according to UPOV (International Union for the Protection of New Varieties of Plant) classification and all the cultivars were also sorted into a wide color range according to The Royal Horticultural Society (RHS) Color Chart. Among the cultivars, V_2 (White snowball), V_3 (Yellow snowball), V_4 (Purple snowball), V_{16} (White chrysanthemum) and V_{22} (Sunny yellow) had cut flower quality considering the characteristics of flower head size (7.3 to 15.7 cm), stalk length (13.4 to 20.5 cm), stalk diameter (3.5 to 6.5 mm) and visual color. Remaining cultivars like V_1 (Crimson tide), V_5 (Pink shasta daisy), V_6 (Dark pink daisy), V_7 (Rose pink), V_8 (Orange pompon), V_9 (Orange paper white), V_{10} (Orange mum), V_{11} (Scale mum), V_{12} (Red mammoth), V_{13} (Cream colored mum), V_{14} (Ruby red), V_{15} (Yellow spider mum), V_{17} (Marigold chrysanthemum), V_{18} (White anemone), V_{19} (Paper white), V_{20} (Yellow daisy), V_{21} (Red bronze), V_{23} (Magenta spray mum), V_{24} (Magenta spoon mum), V_{25} (Red-orange mum) were suitable for pot plant, filler in flower bouquet. In view of the overall performances, this findings show that some of the cultivars can be addition to our flower market and this study also give an insight for the breeder to pick up standard traits among the cultivars for further genetic improvement.

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ABBREVIATIONS AND ACCORONYMS

AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of Variance
BARI	=	Bangladesh Agricultural Research Institute
CV	=	Coefficient of Variance
DAT	=	Days after Transplanting
et al.	=	And others
FAO	=	Food and Agriculture Organization
LSD	=	Least Significance Difference
RCBD	=	Randomized Complete Block Design
RHS	=	Royal Horticultural Society
Res.	=	Research
SAU	=	Sher-e-Bangla Agricultural University
Sci.	=	Science
UCL	=	Universal Color Language
UPOV	=	International Union for the Protection of New varieties of Plant
UNDP	=	United Nations Development Programme
USA	=	United States of America
Viz.	=	Namely

CHAPTER I

INTRODUCTION

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INTRODUCTION

Chrysanthemum is called ‘Mums’ or ‘Chrysanths’ and in Bangla it is known as "Chandramallika". It is one of the most beautiful flowers and perhaps the oldest flowering plants, commercially grown in different parts of the world. The name ‘Chrysanthemum’ comes from the Greek words ‘Chryos’- Gold and ‘Anthos’- Flower. Chrysanthemum (*Chrysanthemum indicum*) belonging to Asteraceae family is one of the most popular and commercial cut flowers that grown on longer scale in the world (Anjum *et al*., 2007). It has been used as a cut flower for its versatile beauty and economy and they often remains in good condition for two to three weeks depending on cultivars (Tewari and Shankar, 1994). Chrysanthemum is ranked as the second most economic important cut flower in the world after rose (Kafiand Ghahsareh, 2009). Some of the cultivars have good cut flower quality also as the vase life is almost twelve days. Besides, chrysanthemum has been considered as a number one among the major pot flower. The species is widely cultivated for the production of cut flowers and used in gardening, potted plants, and ornamental landscaping. In addition to its great economic and ornamental value, chrysanthemum holds special cultural significance (Chen *et al.* 2019).

It is the national flower of Japan but originated in China. It has been admired as a bloom of much significance in different cultures, particularly in their native homeland, China. The genus *Chrysanthemum* consists of more than 40 species distributed mainly in East Asia. The flowering potted chrysanthemum is a complex hybrid composed of crosses among several annual and perennial species native to China. For the past quarter century, until the mid-1980s there were 150 to 200 known species of chrysanthemums.

Chrysanthemum is a partly woody erect perennial herb or sub shrub up to 1m in height with alternate thick leaves and fibrous root. The inflorescence consists of many flower heads; each flower head has numerous florets - the disc florets and ray florets. The marginal ray florets are naturally male sterile and exhibit various colors which are specific to each cultivar, while the central disc florets are hermaphroditic with drab yellow or green colors. It is a short day plant requiring 12 hours or less than that for flowering.

It is a popular showy flower around the world because of its wide range of coloration, shapes and sizes. The chrysanthemum flowers range from dazzling white to deep bronze and the hardy plants are highlighted with full, dark green leaves. The success in cultivation of this plant is principally due to the great

diversity of cultivars with innumerable colorations and flower forms as well as different sizes and ways of rotating cultivars, always offering something new to consumers. There are 40 wild species and thousands of varieties of chrysanthemums. The number of varieties in the world is reported to be above 2000 (Joshi *et al.,* 2010). The varieties can differ in size, colors and number of flowers per stem. Chrysanthemums are classified into 13 classes on the basis of flower size and shape according to US National Chrysanthemum Society keeping with the international classification system to recognize varieties easily.

There are many varieties of chrysanthemums available in Bangladesh also. Here, chrysanthemum is quite popular as a garden flower and used in flower bouquet and decoration purpose in different functions during winter season. Those are among the best keeping flowers for home use and are most adaptable to design work like 'Ikebana'. As a landscape plant, chrysanthemum makes a beautiful fall display for home garden too.

The increasing market demand for chrysanthemum forcing scientists and breeders to develop new cultivars with novel appearances and improved stress tolerance and quality attributes. There are chrysanthemums that are specifically hybridized for cut flowers. Garden mums are generally bred to be cold hardy, compact. Therefore, for the improvement of new chrysanthemum varieties with elite traits, such as inflorescence, flower and leaf characteristics, and disease resistance need to know their genetic potentials (Yalcin-Mendi *et al*., 2006).

For widely commercial cultivation, quality flower production is important in chrysanthemum (Kher, 1988). Good quality flower production depends upon various factors such as genotype, environment, spacing, disbudding, pinching, substrate, use of growth regulator etc. (Jayathi and Gowda, 1988; Dutt *et al.,* 2002 and Moond and Rakesh, 2006).

Genetic resources are very crucial for all plant-breeding programs. Breeding programs have especially focused on important characteristics of ornamental value including flower color, size, form, production quality and reaction to the environment (Broertjes *et al*., 1980). In recent years, transgenic molecular breeding has been extensively employed by introducing foreign genes into chrysanthemum using *Agrobacterium*-mediated transformation and biolistic transformation and has led to considerable progress in horticultural character improvement. Furthermore, chrysanthemums have a lengthy association with various world cultures. As a result, flower breeders have created numerous genotypes during the millennia of breeding this crop, which has enabled its

establishment in the top ten cuts, potted flowering and garden crops across the world. Some basic knowledge on the relationships between the evolution and genomics of chrysanthemum traits, which are especially important for selecting donor and recipient plants in modern chrysanthemum breeding programs (Hwang, Y. *et al.*, 2020)

The environmental conditions of Bangladesh is quite favorable for growing chrysanthemum. Flower production as well as market demand is quite visible during winter season. However, generally flowers are not being cultivated realizing the prominence of different cultivars by the growers yet. Therefore, chrysanthemum growers remain lag behind in the race with other cut flowers in the market. Besides, only limited number of research have been done on chrysanthemum in Bangladesh. There is a high chance to bring forth mum flowers commercially in our flower industry. Different cultivars may be used in different aspects for the customers of flower. At the same time, gardeners also can get variations in flower color, forms and planting habit.

Hopefully this research work will give an appraisal about the phenotypic traits of different cultivars of Chrysanthemums. Growers will get acquainted with some important facts from the findings of this research of chrysanthemum cultivars and can grow chrysanthemums according to their purpose (garden decoration, pot culture, loose flowers and cut flower). This research will also be a great genetic resource for the breeders that can be used for further genetic improvement of chrysanthemums. Hence, this experiment was undertaken with the following objectives:

Objectives

1. To characterize chrysanthemum cultivars based on their morphological traits
2. To study the growth and flowering performances of chrysanthemum cultivars
3. To evaluate the potential cultivars for cut flower as well as pot flower

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Flowers have a pious place in the minds of human beings all over the world and they are linked with human civilization and social affinity. Demand for different flowers along with urbanization is increasing in horticulture sector. Floriculture has become a fast emerging and highly competitive industry now. Floriculture includes foliage, potted plants, ornament plants. Rose, gerbera, gladiolus, tuberose, chrysanthemum, marigold, orchid are the most demanding cut flowers in our country now. Chrysanthemum has made a good place already in floriculture sector due to its diversity in color, blooming pattern and impressive vase life.

Morphological characterization related

Anzum *et al*. (2007) executed an experiment by planting small and large sized suckers (with a difference of at least 5 cm in height) of chrysanthemum on four different planting dates i.e. 18th February, 18th April, 17th June and 16th August to study their effect on blooming and flower quality. Small sized suckers resulted in longer blooming period and more number of flowers per plant. The earliest planting (18th February) took more time to initiate flowers with prolonged blooming period, greater number of flowers with extended vase-life. On the other hand, the late planting gave the flowers with increased diameter and maximum fresh and dry weights per flower.

Ara *et al.* (2012-2013) evaluated 30 chrysanthemum cultivars at BARI to improve the quality of chrysanthemum. Plant height ranged from 36-70 cm, maximum flower number per plant was 70 whereas the minimum was 20 and the maximum flower diameter was found 7.8 cm.

Celem *et al*. (1991) recorded flowering and morphological characteristics of standard and pompon types of chrysanthemum. Standard types were divided into 3 main groups and pompom types into 2 groups on the basis of their adaptability to the environmental conditions of Central Anatolia for cut flower production.

Fukai *et al.* (1998) found the morphological and physiological characteristics of seven *Dendranthema* species native to Japan namely, *D. boreale, D. indicum*

(*Chrysanthemum indicum*), *D. japonicum, D. ornatum, D. occidentali-japonense var. ashizuriense, D. pacificum* and *D. yoshinaganthum.* Data were recorded on branching characteristics, flowering date, flower size and color. Every species showed unique leaf and flower morphology with considerable intra and inter specific variation.

Kim *et al.* (2014) studied genetic diversity of Korean *Chrysanthemum* species through multivariate analysis. Fifteen taxa of *Chrysanthemum* species were classified into three groups (Group I, II and Ill) through PCA (Principle component analysis) and cluster analysis based on the general plant growth and flowering characteristics. Group I was identified as desirable species of garden plants because of the white or pink flowers with a relatively large size (flower head diameter of 43.5-67.6 mm), good plant height (19.3-64.6 cm), and long flowering period (24-39 days).

Sushma Patil *et al*. (2017) conducted an experiment to evaluate the adaptability and performance of different Chrysanthemum varieties under ecological conditions of sub humid zone of Rajasthan. Significant differences were recorded in maximum characters studied. 'White Star' was found to be superior with respect to maximum fresh flower weight (18.14 g), largest flower diameter (11.92 cm), highest stalk diameter (0.38 cm) and longest stalk length (28.52 cm). Thai Chen Queen recorded highest vase life (18.00 days), in-situ life (21.67 days) and ray florets per flower (286.67). The highest number of flowers per plant (47.67) was recorded in Pusa Chitraksha.

Hoang *et al.* (2020) conducted a research to evaluate the morphological characteristics and chromosome analysis using florescence *in situ* hybridization (FISH) technique in four wild chrysanthemum species for better understanding of the relationships among species and their evolutionary adaptations to the environment. There were some similarities in leaf and flower characteristics; but there was high overall variation among the investigated species based on our analysis. Flower diameters ranged from 1.57 ± 0.07 cm (A102) to 3.10 ± 0.10 cm (A7). Also, the RGB values of the white flowers of species A7 were higher than those of the yellow flowers of species A5, A102, and B6. The longest leaf length was observed in species A5 (8.14 ± 0.10 cm), which was dark in color on the upper leaf side, whereas A102 exhibited the shortest leaf length (5.67 ± 0.28 cm) and width (3.20 ± 0.20 cm). FISH karyotype analysis showed that one pair of 5S and three pair of 18S rDNA were observed in all

investigated species. The number and distribution pattern of rDNA showed similar arrangement in A5, A102 and B6. One pair of 18S rDNA signals was detected on the terminal region of the short arm chromosomes 3, 7, and 8, respectively. One pair of 5S rDNA signal was located in the interstitial region of chromosome 4. For the A7 species, 5S rDNA were detected in the long arm of chromosome 7 and one pair of 18S rDNA were found in the short arm of chromosomes 2, 5, and 6. According to the results, that study provided basic knowledge on the relationships between the evolution and genomics of chrysanthemum traits, which were especially important for selecting donor and recipient plants in modern chrysanthemum breeding programs.

Kim *et al.* (2014) evaluated genetic relationship among Korean native *Chrysanthemum* species through the morphological study of 15 taxa of *Chrysanthemum* species Principal Component Analysis (PCA) and cluster analysis were conducted for the grouping based on the morphological data. Fifteen taxa of *Chrysanthemum* species were classified into three groups through PCA and cluster analysis based on the general plant growth and flowering characteristics. Groups I and II included non-bushy type and big size flower plants, while Group III included bushy type and small size flower plants. Group I had nine *C. zawadskii* subspecies: *acutilobum*, *acutilobum* var. *tenuisectum*, *acutilobum* var. *alpinum*, *lucidum*, *coreanum*, *naktongense*, *yezoense*, *latilobum* and *latilobum* var. *leiophyllum*. Group I was found to be desirable species as garden plants because of the white or pink flowers with a relatively large size (flower head diameter of 43.5–67.6 mm), good plant height (19.3–64.6 cm), and long flowering period (24–39 d). *C. lineare* was the only species included in Group II with unique cone head shaped seeds and no petiole. Group III included five *C. indicum* species and related species: *C. indicum*, *C. indicum* var. *albescens*, *C. indicum* var. *acuta*, *C. boreale*, and *C. makinoi*. Group III had great potentials as edible medicinal resources e.g. chrysanthemum flower tea, which was abundant in number and had small sized flowers with white or yellow petals.

Singh *et al*. (2017) studied with twelve varieties of chrysanthemum collected from the National Botanical Research Institute, Lucknow and those were evaluated under irrigated condition at Main Experiment Station, NDUA&T, Kumarganj, Faizabad during winter season (2011-12). A wide range of variation in the performance of the varieties was observed for various characters. Highest plant height (50.20 cm) and maximum number of florets

per flower was observed in Suneel (339.67 cm). Genotype Dentiment showed maximum plant spread (34.74 cm), maximum number of flowers per plant (103.60 g), maximum flower diameter (10.40 cm) and highest weight of ten flowers (63.00 g). As for suitability of particular genotypes is concerned, maximum number of primary branches in Jaya (10.30) and maximum flower vase life (16 days) in Jayanti was observed. Among all the 12 genotypes, few genotypes like Dentiment produced maximum flower yield (652.68 g per plant) followed by Suneel (345.33 g per plant) and Jaya (271.35 g per plant) which were significantly superior than the remaining varieties. Thus, on the basis of flower yield per plant those three genotypes were thought to be chosen for commercial cultivation in Uttar Pradesh condition.

Neelam Thakur *et al*. (2008) executed an experiment to evaluate the performance of forty-nine chrysanthemum genotypes for desirable horticultural traits at ICAR-Indian Institute of Horticultural Research, Hesaraghatta Lake Post, Bengaluru from 2015-17. Significant variations were observed for various vegetative and flowering traits during both years. The results from the pooled data of two years showed that among the genotypes maximum plant height was recorded in Arka Chandrakant (69.59 cm), maximum flower diameter in Arka Ravikiran (9.00 cm) and maximum weight of 100 flowers in Marigold (925.04 g). The genotype Roopanjali produced maximum number of flowers per plant (1199.17). Pusa Anmol was recorded to be taken the minimum number of days to first flowering (60.48 days) while Roopanjali took the longest period to first flowering (201.56 days). The genotypes with superior vegetative and floral traits desirable for the different segments of the floriculture industry like loose flower, cut flower and pot plant trade can be utilized in further improvement of chrysanthemum.

Zečević Veselinka *et al.* (2008) conducted a research on ten winter wheat cultivars from different selection centers to analyze the genetic and phenotypic variability for plant height and spike length. The experiment was performed in randomized block design in five replications on the experimental field in two years. A total number of 50 plants have been analyzed in the full maturity stage. Average estimated values of plant height and spike length differed significantly among years and among cultivars. The highest average value for plant height established at Ljubičevka cultivar (89 cm), and the lowest average Plant height established at Zagrepčanka (64.0 cm). Higher values are established in the second year than in the first year of investigation (69.1cm, 63.9cm, respectively). The variation coefficient of plant height for all examined

cultivars and years varied from 2.7% to 6.1%. The highest average value for spike length showed Ljubičevka (9.8cm), and the lowest Slavonija (7.0cm). All investigated cultivars had higher average value of spike length in the second year (8.8cm) than in the first year (7.7cm). The variation coefficient of spike length for all examined cultivars and years varied from 5.3% (Jugoslavija) to 8.7% (Baranjka). The highest influence on plant height expression had genetic factors (66.16%), but lower impact belonged to environmental factors (26.75%) and only 3.31% belonged to genetic/environment interaction. Spike length expression also highly depended to genetic factors (52.60%), but on this trait expression the environmental factors had higher influence (40.26%) than on plant height.

Physiological characteristics

Quanxiu Wang *et al.* (2015) conducted a genome-wide association study (GWAS) using a diverse worldwide collection of 529 O. sativa accessions. A total of 46 significant association loci were identified. Three F2 mapping populations with parents selected from the association panel were tested for validation of GWAS signals. We clearly demonstrated that Grain number, plant height, and heading date7 (Ghd7) was a major locus for natural variation of chlorophyll content at the heading stage by combining evidence from near-isogenic lines and transgenic plants. The enhanced expression of Ghd7 decreased the chlorophyll content, mainly through down regulating the expression of genes involved in the biosynthesis of chlorophyll and chloroplast. In addition, Narrow leaf1 (NAL1) corresponded to one significant association region repeatedly detected over two years. They revealed a high degree of polymorphism in the 50 UTR and four non-synonymous SNPs in the coding region of NAL1, and observed diverse effects of the major haplo types. The loci or candidate genes identified would help to fine-tune and optimize the antenna size of canopies in rice breeding.

Danijela Pavlović (2013) found in a study that photosynthesis is the basic process during which light energy is absorbed and converted into organic matter, the importance of the plant pigment chlorophyll (*a* and *b* forms) as an intermediary in transformation of the absorbed solar energy and its activity in the process of photosynthesis and synthesis of organic substances in plants are crucial. Therefore, this paper provides an overview of methods for monitoring the optical activity of chlorophyll molecules and methods (non-destructive and destructive) for quantification of chlorophyll in plants. These methods are used to estimate the effects of different stress factors (abiotic, biotic and xenobiotic)

on the efficiency of photosynthesis and bio productivity, aiming to assess the impact that these limiting factors have on the yield of various cultivars. Also, those methods for analysis of chlorophyll optical activity and/or content were appropriate for assessing the reaction of weed species to different agricultural practices (mineral nutrition, treatment by herbicides etc.) and studies of different aspects of weed eco physiology and their influence on crop harvest.

M. Sandoval-Villa *et al.* (2008) conducted a study to characterize SPAD readings for five tomato cultivars and SPAD reading response to a combination of two NSS (1X and 4X Steiner solution strength daily applied 18 days after transplanting at 7 p.m.) and two concentrations of NH_4-N in solution (0 and 25%) in order to evaluate the potential of SPAD readings as a tomato yield predictor in greenhouse production systems. The SPAD readings were not uniform across tomato varieties tested, being consistently higher for 'Max' and lower for the other varieties. Initially, SPAD readings for tomato varieties used in this study were low at the vegetative stage, and increased up to 40 DAT, but subsequently decreased at 49 DAT, or the fruit set of the first and second clusters. After this time, SPAD readings showed no variation. Chlorophyll meter readings for 'Max' were higher in the top plant layers, but decreased in the top plant layer of the other tomato varieties. The SPAD readings were higher for plants supplied with 25% NH_4-N than those without NH_4-N in solution, but the use of a nighttime nutrient solution did not affect SPAD readings. None of the possible interactions among tomato variety, NH_4-N: NO_3-N ratio and NSS were consistently significant.

Flower quality characterization

Behra *et al*. (2002) collected fifty seven germplasm lines of chrysanthemum from different parts of the country and were assessed on observational rows during 1998-99 for their growth, flowering habit and yield at IARI, New Delhi. High yielding genotypes namely, DCS 23 (634.60 g/plant), DCS 15 (553.50 g/plant), and DCS 6 (545.73 g/plant) were found suitable for loose flower production. The larger and decorative types, DCS 29 (14.57 cm dia), DCS 27 (14.17 cm dia) and DCS 36 (13.67 cm dia) were reported to be suitable for garden display or exhibition purpose whereas the genotypes having medium size and more number of lowers, DCS 24 (685.47) and DCS 23 (342.83), were found ideal for pot culture.

H. Mehraj *et al.* (2015) evaluated the growth and flowering performance of 32 chrysanthemum cultivars. Plant height, number of branch per plant, leaf area, number of leaf per branch, chlorophyll content, days to flower bud initiation, days to first petal spread, days to final bloom, number of flower bud per plant, number of flower per branch, number of flower per plant, bud diameter at initiation stage, bud diameter at mature stage, flower head diameter, stalk length and flower durability in plant (days to 50% flower senescence) for different cultivars varied significantly. Number of flowers per plant ranged from 4.3 to 194.6, flower head diameters varied from 2.8 to 17.6 cm and stalk lengths were from 4.4 to 20.1 cm. Among the chrysanthemum cultivars V_{15} (BARI chrysanthenum1) was the maximum flower producing cultivar, while V_1 produced the largest flowers and flowers from the V_{21} had the longest shelf-life. These variations might help in classifying chrysanthemum, for pot cultivation and cut flower, based on their flowering quality which could be beneficial for growers.

Twenty genotypes of chrysanthemum collected from the IARI were evaluated under irrigated condition at Horticultural Research Centre (HRC) of Sardar Vallabhai Patel University of Agriculture and Technology, Meerut (India) research farm during 2016-17. A wide range of variation in the performance of the varieties was observed for various characters. The minimum days to flower bud initiation (43.53 days) and minimum days for flowering (69.53 days) was observed in the cultivar of Ajay while cultivar White Star produced larger size flower (9.97 cm). The maximum flowering duration (57.53 days) was observed with the cultivar of Haldighati and maximum plant height at flower bud initiation stage (28.27 cm) and plant height at full bloom (57.53 cm) was observed with the cultivar of Sunny. Cultivar of Basanthi produced maximum number of primary branches (7.93), plant spread (70.73 cm) and maximum number of flowers. On the basis of studies, Atul Prakash *et al.* (2018) recommended genotypes namely Ajay, Ajay orange, Sunny, Pusa Centenary, Basanthi and Yellow Charm for commercial production for western Uttar Pradesh.

An investigation was carried out by Seetharamu *et al.* (2018) at the Regional Horticultural Research and Extension Centre, University of Horticultural Science, GKVK, Bengaluru during October 2015 to June 2017 to study the comparative performance of eight varieties of dendrobium orchid Viz. Ear Sakul, Mono Red, Charming White, Bubble Gum, Sonia-17, Burana Jade, Big

White and Nopporn Pink under naturally ventilated polyhouse and 50 per shade house condition. Plants grown under polyhouse condition took early days to bud initiation (291.55 days), days to first floret opening (33.17 days) as compare to shade house condition. The floral characters like spike length (30.90 cm), rachis length (17.59 cm), number of florets per spike (5.83) and floret diameter (7.04 cm) were found highest under polyhouse condition. Spike yield per plant and per meter square (1.48 and 51.63 respectively) was observed highest under polyhouse and least was noticed in shade house condition. With respect to varieties, early initiation of bud and spike emergence to first floret opening was (214.37 days and 30.42 days respectively) was recorded in var. Big White. The floral qualities like spike length (37.54 cm) and rachis length (23.06 cm) was recorded in highest in var. Mono Red. Number of florets per spike (7.55) was the maximum in variety Bubble Gum and minimum in (3.70) was observed in variety Nopporn Pink. Floret diameter (8.40 cm) was found highest in variety Sonia-17. Spike girth (4.10 mm) and spike weight (22.98 g) was found superior in variety Mono Red. The number of spikes per plant and per meter square was found highest in variety Big White (1.77 and 61.83 respectively) and it was minimum in variety Burana Jade and Nopporn Pink (1.17 and 40.83 respectively). Relatively vase life was highest in variety Mono Red and Big White (40.00 days) but lowest was observed in variety Nopporn Pink (20.83 days).

Mahawer *et al.* (2010**)** carried out a research work with nine dahlia cultivars by planting 12 plants/ replication. Minimum number of days required for flower bud initiation (81.60 DAT) and bud break (22.40 DAI) was recorded in cv. Jyotsna and complete flower opening (6.30 DAB) was recorded in cv. Korean Yellow. The maximum flowering duration (90.73 days) and maximum freshness of flower (7.73 days) on plant under open field conditions were recorded in cv. NT Pompon. The maximum number of flower per plant (60.40), flower diameter (19.66 cm) and average weight of flower (62.69 g) was recorded in cv. NT Pompon, Korean Yellow and Blackout respectively. In cv. NT Pompon, minimum flower diameter (11.20 cm) and flower weight (17.77 g per flower) were recorded. The maximum flower weight per plant (1072.56 g) was recorded in cultivar NT Pompon. Based on floral characteristics and economic parameters, cv. NT Pompon was found best under Udaipur conditions.

Baskaran *et al*., (2010) conducted a study to evaluate the performance of ten chrysanthemum cultivars for better post harvest quality under open field condition at the University of Agricultural Science, Bangalore. Flowers were harvested at fully open stage or nearly so. The results showed that the maximum stalk girth (0.32 cm) was recorded in Cv. Cassa and the maximum flower diameter (8.14 cm) was recorded in cv. Ravikiran, Cultivar Cassa recorded the maximum flower weight (3.59 g). Maximum number of ray florets was recorded by cv. Nilima (253.2). The maximum length of ray florets was recorded in cv. Ravikiran (3.96 cm). Maximum fresh weight, final weight and water loss (88.33, 40.63 and 47.67g respectively) from the spray type flowers were recorded in cv. Arka Swarna. Longer vase life of 16 days was also recorded in cv. Arka Swarna. Based on the performance studies it was observed that Arka Swarna, Ravikiran, Red gold, Nilima and Arka Ravi had better post harvest quality and thought to be selected for cut flower production

Sushma patil (2017) conducted an experiment to evaluate the performance and adaptability of different Chrysanthemum varieties under ecological conditions of sub humid zone of Rajasthan. Significant differences were recorded in the maximum characters studied. 'White Star' was found to be superior with respect to maximum fresh flower weight (18.14 g), the largest flower diameter (11.92 cm), the highest stalk diameter (0.38 cm) and the longest stalk length (28.52 cm). Thai Chen Queen was recorded to have the highest vase life (18.00 days), *in-situ* life (21.67 days) and ray florets per flower (286.67). The highest number of flowers per plant (47.67) was recorded in Pusa Chitraksha.

Uddin *et al.*, (2015) conducted a study at rooftop net house, Department of Horticulture, Sher-e Bangla Agricultural University, Dhaka, under 2a Biotech Lab, in 2014 to find out the growth, flowering and morphological attributes of Nandini (*Eustoma grandifolium*) varieties. Eight varieties of Nandini (*Eustoma grandiflorum*) namely, V_1 Mickey rose; V_2 Pink rose (single); V_3 Pink picotee; V_4 Blue rim; V_5 Chandra; V_6 Pink rose (double); V_7 Blue bell and V_8 Royal violet were used in this experiment. The maximum plant height (58.9 cm), number of stem (7.4), stem length (45.7 cm), number of leaves (22.0), days to first flower (113.0), flower head diameter (7.1 cm), number of petal (11.3), number of flower/stem (7.2) was found in V_6. The maximum stem diameter, number of bud and flower/plant (5.0 mm, 20.3 and 20.1 respectively) were observed in V_5. The minimum plant height, number of stem and stem length

were observed in V_3 (40.1 cm, 2.9, and 24.3 cm respectively). The minimum stem diameter (1.7 mm), days to first flower (78.0), number of bud/plant (10) and flower/plant (7.3) was observed in V_7 whereas minimum number of leaves (4.7), flower length (3.4), flower head diameter (3.3) was observed in V_1, V_6 and V_5 respectively. Growth and yield characters showed significant variation among different varieties.

Tabassum *et al*. (2002) evaluated ten rose cultivars namely Alexendra, Double Delight, Day Dream, Englique, Freesia, Golden Time , Paradise, Regret Berg , Red Sex and Yankee Doodle. Tallest plant was found in Englique (139.83cm) and shortest in Double Delight (87.17cm). Maximum days required for bud sprouting was found in Englique (46.17) and minimum was in Golden Time (34.67). Maximum days required for flowering was found in Day Dream and Englique (54.67 days) and minimum was in Red Sex (41.83 days). Maximum numbers of shoot/plant were found in Paradise (12.50) and minimum in Freesia (4.17). Highest numbers of flowers/plant were found in Day Dream (41.00) and lowest in Double Delight (5.33). Maximum flower diameter was found both in Alexandra and Paradise (7.93) and minimum in Regret Berg (5.17). Maximum numbers of petals/flower were found in Yankee Doodle (59.20) and minimum in Regret Berg (18.97). Longest flower persistency was found in Golden Time (17.17) and shortest in Regret Berg (5.67). Maximum vase life was in Freesia (8.00 days) and minimum in Regret Berg (5.00 days).

Siddiqua (2018) conducted an experiment to evaluate the growth and flowering performance of spray chrysanthemum cultivars in a well ventilated polyhouse condition. Nine spray chrysanthemum cultivars were evaluated in the experiment. Star Pink was recorded to have maximum plant height (104.29 cm), flower diameter (6.77 cm). The maximum leaf area per plant (1533.68 cm^2), number of leaves per stem at harvest (138.25), weight of cut stem (263.39 g), number of flowers per plant (109.67) and number of flowers per square meter (1108.5) were observed in cv. Bronze Spoon. The minimum number of days (95.50) for first flower bud initiation and duration of flowering (45.75 days) were recorded by cv. Indiana. The minimum number of days for 50 per cent flowering and first flower harvest (133.50 and 128.50 days), prolonged vase life of (7.50 days) in distilled water were observed in cv. Red Stone.

Jamal Uddin *et al*. (2015) accomplished an experiment at 2a Rooftop garden, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to assess growth and flowering of gerbera cultivars. Sixteen hybrid gerbera cultivars were used on the experiment. Plant height, number of leaves, number of flowers/plant, flower head diameter, peduncle length, peduncle diameter, petal thickness, petal number and petal color (L*, a*, b*, C* and h_{ab}) showed significant variation among the cultivars. The maximum number of flower/plant (11.6), peduncle length (65.0 cm), peduncle diameter (12.3 mm) and flower head diameter (10.8 cm) was found from V_8 which was followed by V_7. Maximum petal thickness (0.69 mm) was found from V_7 followed by V_{13} (0.42 mm), V_8 (0.36 mm) and V_{14} (0.36 mm). Among the cultivars V_8 was the best among the cultivars concerning the yield which was followed by V_7.

Ahmad (2013) conducted an experiment with ten gerbera cultivars (‘Labinel’, ‘Lilla’, ‘Alp’, ‘Alberino’, ‘Bonnie’, ‘Avemaria’, ‘Mammut’, ‘Lexus’, ‘‘Terramixa ’ & ‘Sarolta’) were evaluated for their growth, yield and quality characteristics under protected conditions during 2011. Among the cultivars studied, there were highly significant variations observed for growth, yield and quality parameters. The longest stalk length (60.3 cm) was recorded by the cultivar ‘Alberino’ followed by ‘Lexus’ (59.0) and ‘Mammut’ (54.0 cm). The same cultivar also produced flowers with maximum diameter. With respect to vegetative parameters like number of leaves per plant and plant spread were also more in the same cultivar. The maximum number of flowers 135 per square meters was recorded in cv. ‘Avemaria’ (135) followed by ‘Alberino’ (125). The maximum vase life was recorded in cultivars ‘Alberino’ and ‘Lexus’ (6.6) followed by ‘Mammut’ (5.6) and ‘‘Sarolta’’ (5.6). Excellent quality flowers were observed in cultivar ‘Alberino’ (4.8) followed by ‘Lexus’ (4.4). Cultivar ‘Alberino’ and ‘Lexus’ were found superior with respect to growth, yield and vase life characteristics under protected.

Azimi *et al.* (2012) conducted an experiment on *Iris* one of the most important cut flowers in Iran and in the world. The aim of this research was to study the genetic diversity of 18 *Iris* species collected from different parts of Iran and to identify them according to morphological and molecular characteristics and breeding potential. In this study, 15 quantitative traits, 30 qualitative traits and 10 arbitrarily primed (RAPD) markers were applied to identify genetic differences among species. Principle component and cluster analyses were used as multivariate procedures to classify different species

based on molecular and morphological data. Cluster analysis based on quantitative traits classified all species into two main groups. The first group consisted of tall *Irises* and the second of dwarf *Irises* either with rhizomes or bulbs. Cluster analysis based on qualitative traits classified all *species* in to two main groups mostly according to flower color, bud color and scent. High genetic diversity was evident among species using RAPD markers. In total, 255 RAPD polymorphic bands were detected for 10 random primes. Numbers of polymorphic bands ranged from 19 for primer RAPD3 to 31 for primer RAPD2. PIC varied between 0.152 and 0.193. Cluster analysis based on molecular data revealed six different clusters. *I. Spuria* and hybrid irises (*I. germanica* and *I. imbricata*) were separated from other species and placed in different clusters. The highest similarity coefficient (0.307) was estimated between *I. meda* and *I. iberica* species and the lowest (0.025) was estimated between *I. aucheri* and *I. pseudacaucasica*. According to molecular and morphological data *I. spuria* was segregated from the others. No clear relationship was found for genetic diversity between species in relation to geographical distribution, using either morphological or molecular information.

Tomizzo *et al.*, (2018) executed an experiment to determine the cycle duration in days and the quantitative parameters, i.e. stem length, spike length and stem diameter of gladiolus floral stems as a function of the planting date and locations in the Rio Grande do Sul/Brazil. Field experiments were established between 2014-2015 in three locations (Frederico Westphalen, Itaqui and Santa Maria). The experimental design was a complete randomized block, with six gladiolus cultivars in three distinct planting dates at each location as treatments. The shift from vegetative to reproductive stage, the stem length, spike length and stem diameter were evaluated. When planted during late July and early August, cultivars of early cycle (‘Purple Flora’, ‘Rose Friendship’ and ‘White Friendship’) and intermediate cycle (‘Green Star’ and ‘Jester’), produced floral stems of gladiolus in the desired patterns besides as well as having a shorter growth cycle than late cultivars (‘Gold Field’), being recommended for commercial cultivation in Southern Brazil.

Twenty six gerbera varieties were evaluated for cut flower production under polyhouse and field conditions by G. Mahindiran *et al.* (2014). Data were recorded on maximum plant height (43.19 and 37.16 cm) and flower stalk

length (65.85 and 60.12 cm) both under polyhouse and field conditions, respectively. The flower size was found the maximum in Sunway (13.17 cm) under polyhouse conditions, while it was found the maximum in Dune (11.58 cm) under field conditions. Dune also registered the maximum vase-life for under polyhouse (10.43 days) and field (8.20 days) conditions. The maximum number of flowers per plant (58.14) was recorded in Dune under polyhouse and for Dana Ellen (42.34) under field conditions.

CHAPTER III

METHOD AND MATERIALS

CHAPTER III

METHOD AND MATERIALS

This chapter represents the regarding methodology used for executing the experiment. It shows the outline of the location of the experimental site, climatic condition, soil, materials required for the experiment, treatment and design of the experiment, production methodology, intercultural operations, data collection procedure and statistical analysis through the following headings.

3.1 Experimental site and duration

The experiment was executed at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period of October, 2019 to April, 2020. Location of the site was $23^0$74' N latitude and $90^0$35' E longitudes with an elevation of 8 meter from sea level (UNDP – FAO, 1988) in Agro-Ecological Zone of Madhupur Tract (AEZ No. 28).

3.2 Climatic conditions

The climate of the experimental site was subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season).

3.3 Characteristics of soil

The experimental soil belongs to the Madhupur Tract under AEZ No. 28 (UNDP-FAO, 1988). The selected land was medium high and the soil series was Tejgaon. The experiment field primarily had a P^H of 6.5.

3.4 Planting materials

Healthy and disease free 22-25 days old chrysanthemum cuttings were used in this experiment which all were collected from ‘Krishibid Upokaran Nursery’, Sher-e-Bangla Nagar, Dhaka.

3.5 Treatment of the experiment

The experiment was conducted based on morphological characterization of chrysanthemum plants and flowers. The single factor experiment included twenty five chrysanthemum cultivars (Plate 1) as treatment which were used in this research as follows-

V_1: Crimson Tide	V_2: White snowball	V_3: Yellow Snowball
V_4: Purple Snowball	V_5: Pink Shasta Daisy	V_6: Dark Pink Daisy
V_7: Rose Pink	V_8: Orange Pompon	V_9: Orange Funnel Mum
V_{10}: Orange Paper White	V_{11}: Scaly Mum	V_{12}: Red Mammoth
V_{13}: Cream Colored Mum	V_{14}: Ruby Red	V_{15}: Yellow Spider Mum
V_{16}:White Chrysanthemum	V_{17}: Marigold Mum	V_{18}: White Anemone
V_{19}: Paper White	V_{20}: Yellow Daisy	V_{21}: Red Bronze
V_{22}: Sunny Yellow	V_{23}: Magenta Spray Mum	V_{24}: Magenta Spoon Mum
V_{25}: Red-orange Bicolor Mum		

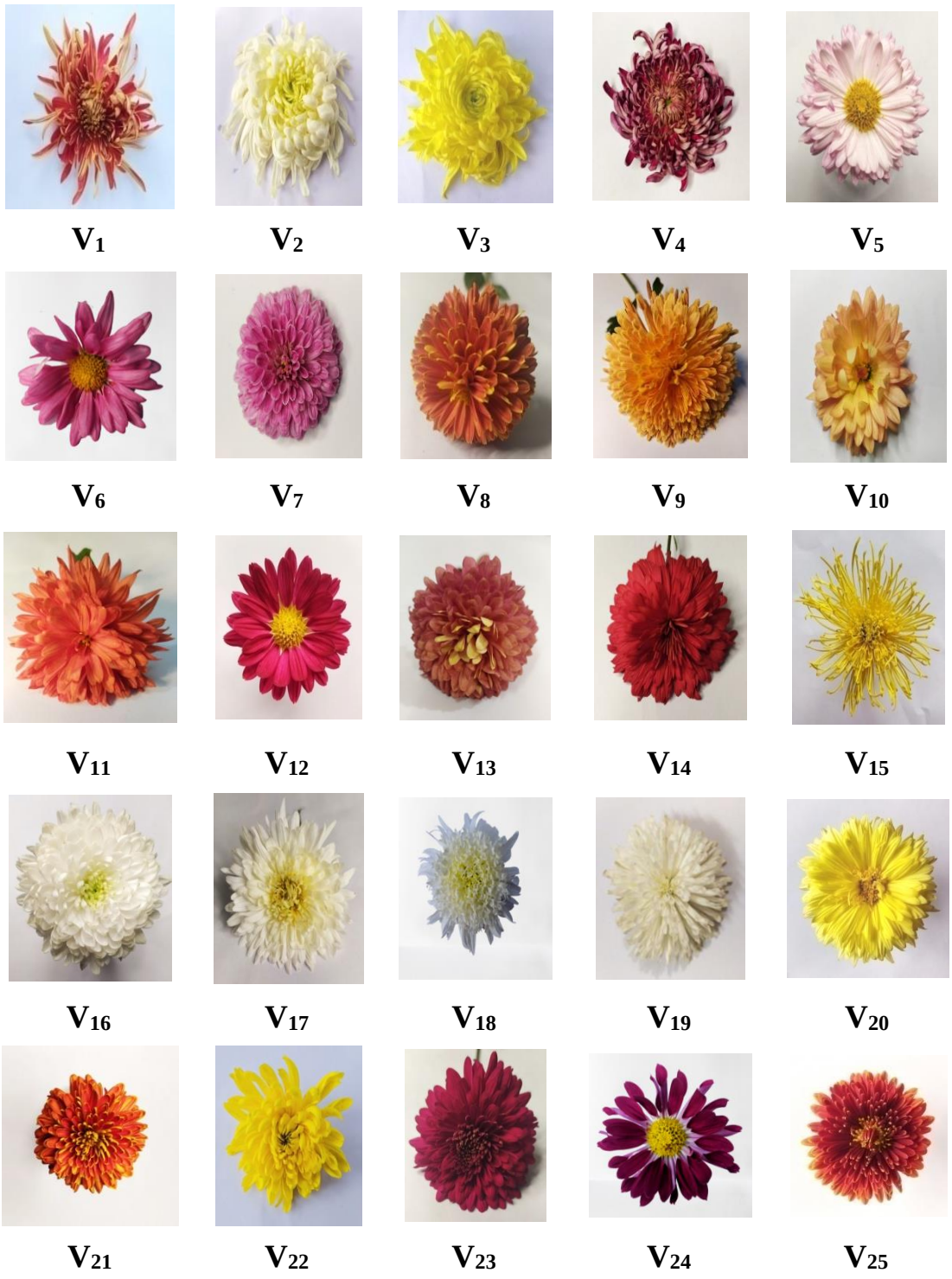


Plate 1: Pictorial presentation of 25 (V_1-V_{25}) flower head of chrysanthemum cultivars

V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

3.6 Design of experiment

This single factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. So, there were in total 75 plots (25×3).

3.7 Production technology

3.7.1 Land preparation

The land was first ploughed with the help of a power tiller and then it kept open to sun for seven days prior to further plowing. Thereafter it was prepared by plowing and cross plowing followed by laddering. The weeds and stubbles were completely removed from the field after each laddering. Simultaneously, the clods were broken and the soil was made into good tilth.

3.7.2 Application of manure and fertilizers

Mostly chrysanthemums are considered as heavy feeders. These plants imbibe considerable amount of nutrients from the soil. During the experiment whole amount of cowdung, half of urea, whole amount of TSP, MoP had been applied at the time of chrysanthemum transplanting. Rest of the urea was applied at 30-35 DAT and 50-60 DAT with three installments.

Table 1: BARI recommended dose of manure and fertilizers along with plot wise application dose

SL No.	Manure/ fertilizers	Recommended dose (/ha)
1	Cowdung	7 t
2	Urea	300 kg
3	TSP	150 kg
4	MoP	275 kg

3.7.3 Transplanting of cuttings

Cuttings were transplanted at 7 cm depth in each plot with sufficient care to avoid any injury of cuttings (Plate 2a). Total 75 plots were used in the experiment design and single plant was planted in each plot. So, three plants were used for three replications.

3.7.4 Plot size and spacing

The size of the each plot was 2 × 1.5 m. The cuttings were planted keeping 25 cm row to row distance and 25 cm plant to plant distance.

3.7.5 Tagging of plants

Plants were marked with tags according to 25 cultivars to collect data easily and correctly.

3.7.6 Intercultural operations

3.7.6.1 Weeding

Weeding was done in all plots as and when required to keep the plants free from unwanted plants by hand picking and hoeing.

3.7.6.2 Watering

Chrysanthemum requires a good amount of water to maintain optimum moisture for the growth. Water logging was avoided as it is considered as plant stress and causes yellow leaves and root rot sometimes. Frequency of watering depended upon the moisture status of soil (Plate 2b)

3.7.6.3 Disbudding

Disbudding was done by removing flower buds from the central and terminal portion of the branch at 35 DAT to maintain the flower number and a good size of the bloom (Plate 2d).

3.7.6.4 Pinching

Pinching was done at 20 DAT by removing the central portion of plant from apex to increase the branch number of the plants and for giving a bushy shape of the plants (Plate 2c).

3.7.6.5 Staking

Each plant was given support by staking those with sticks when started to stoop down because of the increasing height.

3.7.6.6 Fungicide and insecticide application

During the early growing stage powdery mildew and leaf spot were controlled by spraying Dithane M-45. Fungicide was sprayed two times at 15 days

interval. Crop was also affected by aphids during the early growing stage. Aphid was controlled by spraying neem oil at 15 days interval for three times.

3.8 Parameters studied

Three plants were selected from each plot for data collection. Data were collected on the basis of vegetative growth, physiological attributes, yield related attributes, and quality related attributes. Data were collected on following parameters:

1. Plant height (cm)
2. Number of primary branches / plant
3. Number of leaves / primary branch
4. SPAD value
5. Days to flower bud initiation
6. Number of buds/ plant
7. Days to first flowering
8. Number of flowers/ plant
9. Number of ray florets/ flower
10. Flower head diameter (cm)
11. Stalk diameter (mm)
12. Stalk length (cm)
13. Ray floret color measurement (CIELab)

3.9 Data collection

Plants were randomly selected from each unit of plot for the collection of data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect.

3.9.1 Plant height (cm)

Height of the plant referred to the length of the plant from ground level up to the tip of the longest leaf and it was measured with a meter scale at vegetative stage and mean value was calculated and expressed in cm (Plate 2e).

3.9.2 Number of primary branches/ plant

Number of primary branches produced in each plant was recorded by counting all the basal lateral primary branches of each plant at vegetative stage.

3.9.3 Number of leaves/ branch

Number of leaves per branch was recorded by counting the leaves of primary branch which were taken from three random plants of each plot at vegetative stage. It was measured in number.

3.9.4 Leaf characteristics

In this study, chrysanthemums cultivars were classified according to different shapes. Leaf shape was assessed as the flower blooming was initiated. The characters were assessed by visual observations which were usually based on the guidelines published by the Union for the Protection of Plant Varieties (UPOV).

3.9.5 SPAD value

SPAD value of chrysanthemum leaves was determined using an automatic SPAD (Soil Plant Analysis Development) meter (Minolta SPAD-502 meter). Three leaves of a plant at the optimum growth stage were taken for the SPAD value measurement at 60 DAT (Plate 2f).

3.9.6 Days to bud initiation

The days required for bud initiation were recorded from the date of planting of sapling to first bud initiation from three randomly selected plants of each plot.

3.9.7 Number of buds/ plant

Total buds number for each of the cultivars was counted from three randomly selected plant of each plot to assess the variability in bud number among the cultivars.

3.9.8 Days to final bloom

Days taken to final bloom were counted from bud initiation to when the flower were fully opened. Data were collected from three randomly selected plant of each plot.

3.9.9 Number of flowers/ plant

Flower number for 25 cultivars was counted from three randomly selected plants of each plot.

3.9.10 Number of ray florets/ flower

The ray florets number of each flower was counted after harvesting it fresh from the plant and characteristics of the florets were observed for characterization (Plate 3c).

3.9.11 Flower head diameter (cm)

The diameter of the flower head was measured with a centimeter scale after harvesting from the plant to evaluate the cut flower potentiality (Plate 3b).

3.9.12 Stalk diameter (mm)

Stem diameter was measured using Digital caliper-515 (DC-515) in millimeter (mm). Mean value was derived from the collected data (Plate 3a).

3.9.13 Stalk length (cm)

The total length from the base portion of the cut flower to the calyx of the flower was taken as stalk length and expressed in centimeter.

3.9.14 Ray floret color measurement (CIELab)

Ray floret color was measured using a handy-type tristimulus colorimeter, NR-3000 (NIPPON Denshoku), followed by L* (lightness), a*, and b* (two Cartesian co-ordinates), based on the CIElab scale with the standard CIE observer (100 visual field) and the CIE standard illuminant D65 (CIE, 1986; McGuire, 1992), (Plate 3e). Beams whose effective axes were at the angle of 45±20 from the normal of the specimen surface in illuminated petal. Metric chroma, C* and hue angle, h_{ab} (CIELab notation), were calculated according to the following equations: C* = (a*2 + b*2)0.5 and hab = tang-1 (b*/a*) (Gonnet, 1998). The individual ray florets were separated and were placed under the measurement port for the color measurement.

3.9.15 Classification of chrysanthemum cultivars

The bloom of chrysanthemum which appears as a single flower is actually hundreds of flowers called florets. Two kinds of florets are present in a single bloom disk floret in the center and small numerous ray florets in the perimeter; similar to other members of Asteraceae. Under the genus Chrysanthemum there are around 30 different species, which vary in size, shape and colors. These plants may have single-flowered stems (standards) or they can be pinched to form multiple-flowered stems (sprays).There are many flower forms including daisy, spider, quill, incurve (football), cushion, button and spoon. Besides the traditional yellow colored variety, there are also white, golden, orange, pink, red, purple and violet blooms. For ease of identification, the National Chrysanthemum Society divided bloom with varying forms into following 13 classes and in the present study these classes were considered for classification.

Class I: Irregular Incurve

Class 2: Reflex

Class 3: Regular Incurve

Class 4: Decorative

Class 5: Intermediate Incurve

Class 6: Pompon

Class 7: Single and Semi-Doubles

Class 8: Anemone

Class 9: Spoon

Class 10: Quill

Class 11: Spider

Class 12: Brush and Thistle

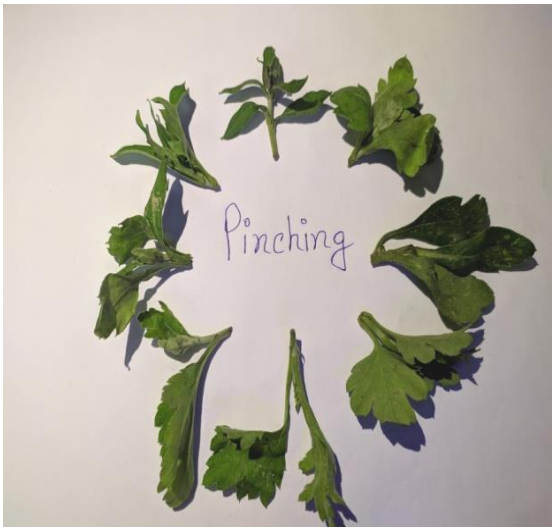
Class 13: Unclassified

3.7.16 Statistical analysis

Collected data were statistically analyzed using Statistix-10 scientific analysis software. Means for every cultivar were analyzed. Difference between cultivars was assessed by Least Significant Difference (LSD) test at 0.05% level of significance.

(a)

(b)



(c)

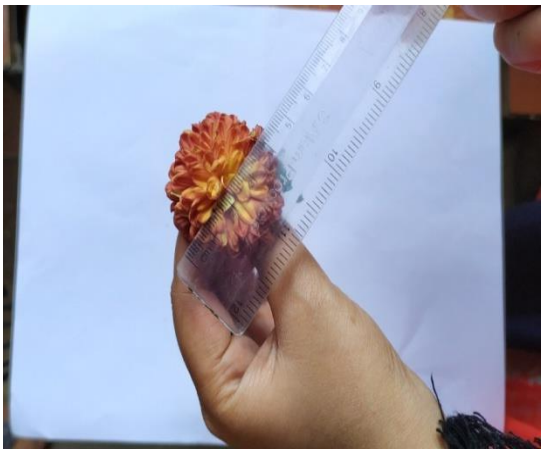
(d)

(e)

(f)

Plate 2: a) Transplanting of cuttings b) Watering in plants c) Intercultural operation: Pinching at 20 DAT d) Intercultural operation: Disbudding at 35 DAT e) Measurement of plant height by centimeter scale f) Measurement of SPAD value of mature leaves at 60 DAT

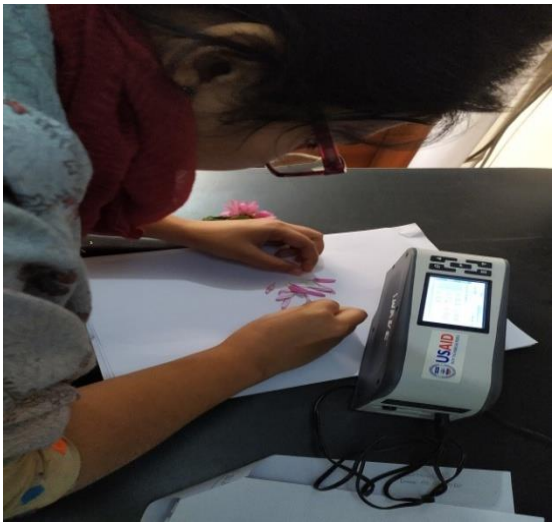
(a)



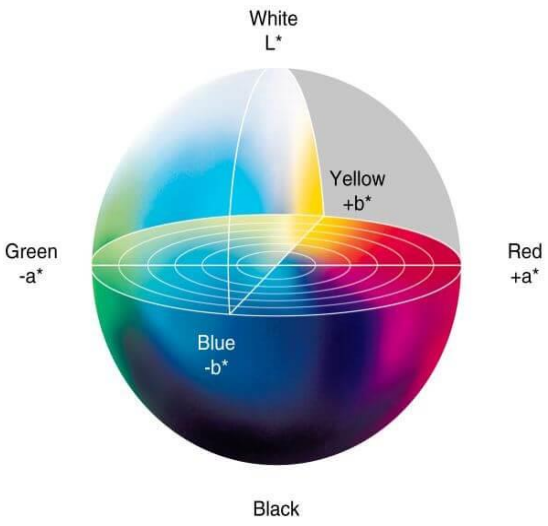
(b)

(c)

(d)



(e)



(f)

Plate 3: a) Stalk diameter measurement by Digital caliper-515 b) Flower diameter measurement by centimeter scale c) Counting ray floret number d) Color chart e) Ray floret color measurement with IWAVE WF32 precision colorimeter (Shenzhen Wave) f) CIELab color scale

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The research work was accomplished with the aim of evaluating the performance of 25 chrysanthemum cultivars in the field and hereafter characterizing the cultivars on the basis of phenotypic characteristics. The recorded characteristics of the cultivars showed distinction mainly because of their genetic constitution. The data recorded in this experiment were presented in this section with comprehensive discussion. Some data are presented in tables and some in figures for easier interpretation. Furthermore, appendices are attached at the end.

4.1 Plant height (cm)

The analysis of variance on plant height was found among chrysanthemum cultivars and height was affected by varieties (Appendix I). The range of plant height was from 65.4 to 26.2 cm (Figure 1). The tallest plant was found in V_3 (65.4 cm) whereas the shortest in V_8 (26.2 cm) among the chrysanthemum cultivars (Table 1). Ara *et al.* (2012-2013) recorded a range of 36-70 cm and Kim *et al*. (2014) found a range of 19.3 to 64.6 cm plant height and in 15 Taxa of Korean chrysanthemum species. Similar variation in plant height among varieties was also observed in marigold (Raghuvanshi *et al*, 1982) and in rose (Hussain and Khan, 2004). Genetic diversity of wheat genotypes influenced the differences in plant height according to Zečević *et al.*, (2008). The higher plant height could be attributed to increase photosynthetic capacity of the plants (Nxunialu and Wahome, 2010). According to Thakur and Kumar (2018) in chrysanthemum, taller plants are suitable for cut flower production, medium to short height with erect stem is good for open field cultivation or as garden flower and very short plants are good for pot plant or bedding plants. Plant height in chrysanthemum is strongly correlated with plant maturity, planting density, light quality and the most determining factor is the genotype.

4.2 Number of branches/ plant

Chrysanthemum cultivars showed significant variation for number of branches per plant (Appendix I). The data presented in the table 2 signify that the 25 cultivars showed noticeable difference for the number of branches per plant. The maximum number of branches was recorded in V_3 (22.3/ plant) while the minimum was in V_2 (13.7/ plant). Cultivar V_3 (Yellow snowball) performed best in the case number of branches per plant. Such kind of range (10.30-4.03) of primary branches number per plant among chrysanthemum genotypes was

recorded by Singh (2017**)**. Kumar (2014) also found similar kind of range in respect to number of primary branches/ plant among different chrysanthemum genotypes. He recorded maximum primary branches in cv. Flirt (8.46) whereas the minimum number of primary branches per plant was found in cv. Gaity (3.06). According to Thakur (2018) differences observed in production of branches among the chrysanthemum genotypes might be due to the inherent genetic factors of chrysanthemum cultivars. Zosiamliana *et al*. (2012) also found variation in branch number per plant of Chaina aster. In standard chrysanthemum, Schoellhorn *et al*. (1996) reported that branching is genotype-dependent, and according to Shin *et al*. (2003) branching is dominant over non-branching. The branching pattern of plants determines their aesthetic appeal and their commercial value. Branching profoundly influences the canopy architecture of a plant and is not surprisingly, a key factor of affecting crop yield. The architecture of chrysanthemum plants raised for cut flowers is strongly influenced by their ability to form branches.

4.3 Number of leaves/ primary branch

Leaves are the main functional units for photosynthesis, which greatly influence the vegetative growth and followed by flower yield. Leaf production of any crop decides the spread of plant also. Chrysanthemum cultivars showed significant variation for number of leaves per primary branch (Appendix I). The maximum number of leaves/ primary branch was observed in V_3 (22.3) but the minimum was in V_2 (13.7) cultivar (Table 2). The result referred that V_3 (Yellow snowball) produced maximum number of leaves per and V_5, V_{12}, V_{16} and V_{23} were statistically similar. This range of leaves number per branch was found close to the range referred by Uddin *et al.* (2015). This variation in number of leaves per branch might be determined by genotypic variation as well as environmental effects. Kumar (2019) recorded similar variation in leaf number per plant and he concluded that leaf number variation was mainly governed by genetic constitution of the plants.

4.4 SPAD value

Chlorophyll is a prime and an important element of photosynthesis and leaf greenness. Furthermore its content in plant leaves indicates their photosynthetic capacity as well as the presence of stress, leaf nutrient deficiencies and diseases. SPAD value varied significantly among chrysanthemum cultivars. The highest SPAD value was obtained in V_{16} (57.2) and the lowest was obtained from V_{25} (34.7) and V_{23} (33.7) respectively at mature stage of leaves (Table 1). This variation in SPAD value might be attributed due to genetic

differences. According to Soval-Villa (2016) the SPAD readings were not uniform across tomato varieties tested, being consistently higher for “Max” and “Min’’ for the other varieties. Some gene expression was involved in natural variation of chlorophyll content in rice according to Wang (2015).

4.5 Days to bud initiation

Notable variation in case of days taken for flower bud emergence (from days after transplantation of saplings) was found (visual observation) among 25 chrysanthemum cultivars. Early flower bud initiation was found in V_2 (21.7 days) while the late in V_{20} (53.7 days) (Table 2). This findings referred that V_2 (White Snowball) was early flower bud initiating cultivar. The variation for early or late bloom can be due to the varietal character (Behera *et al*., 2002) in chrysanthemum. Prakash *et al.* (2018) found that chrysanthemum cultivar Ajay initiated early bud (43.53 days) and the maximum days taken in the cultivar White Star (82.33 days). It was concluded that different genetic makeup was responsible for such kind of significant variation among different genotypes. Days taken to first flower bud initiation also varied in dahlia cultivars and according to Mahawer *et al* (2010) and the variation was due to genetic variability and prevailing environmental conditions.

Table 2: Performance of chrysanthemum cultivars related to plant height, number of branches/ plant, number of leaves/ primary branch and SPAD value

Cultivars	Plant height (cm)		Number of leaves/ primary branch		Number of branches/ plant		SPAD value	
V_1	55.3	e	18.3	c-e	14.9	c	52.2	bc
V_2	57.2	d	13.7	l	13.4	d	54.1	a-c
V_3	65.4	a	22.3	a	13.8	d	55.5	ab
V_4	60.8	bc	18.0	c-f	14.7	c	53.1	bc
V_5	26.2	q	15.7	h-k	15.2	c	33.9	jk
V_6	35.7	jk	17.0	d-i	8.7	j-l	36.6	g-j
V_7	36.8	j	16.7	e-i	10.5	g	36.1	h-k
V_8	44.5	g	17.7	c-g	10.8	fg	48.2	d
V_9	34.8	kl	19.3	bc	7.9	m	36.2	h-k
V_{10}	46.2	g	16.7	e-i	11.5	ef	43.5	e
V_{11}	52.9	f	18.0	c-f	17.8	a	40.1	e-g
V_{12}	33.4	lm	15.7	h-k	11.0	fg	32.7	k
V_{13}	41.0	h	17.0	d-i	11.8	e	51.4	cd
V_{14}	38.9	i	19.3	bc	11.9	e	35.3	i-k
V_{15}	34.1	k-m	18.7	b-d	12.1	e	40.9	ef
V_{16}	61.9	b	15.7	h-k	14.8	c	57.2	a
V_{17}	59.5	c	15.3	i-l	8.1	lm	55.8	ab
V_{18}	52.5	f	14.7	j-l	6.7	n	39.4	f-h
V_{19}	30.3	o	14.3	kl	9.1	i-k	38.9	f-i
V_{20}	42.0	h	17.3	d-h	10.3	gh	54.6	a-c
V_{21}	28.3	p	16.3	f-j	9.3	ij	36.3	h-k
V_{22}	53.9	ef	20.3	b	8.5	k-m	55.5	ab
V_{23}	31.1	no	15.7	h-k	9.8	hi	33.7	jk
V_{24}	37.3	ij	16.0	g-k	17.6	a	38.9	f-i
V_{25}	32.4	mn	15.3	i-l	16.7	b	34.7	jk
CV (%)	2.58		6.69		3.77		5.16	
Lsd (0.05)	1.85		1.87		0.74		3.71	

Here, [x]V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

[y]In a column means having similar letters are statistically identical and which are dissimilar in letter differ significantly at 0.05 level of probability

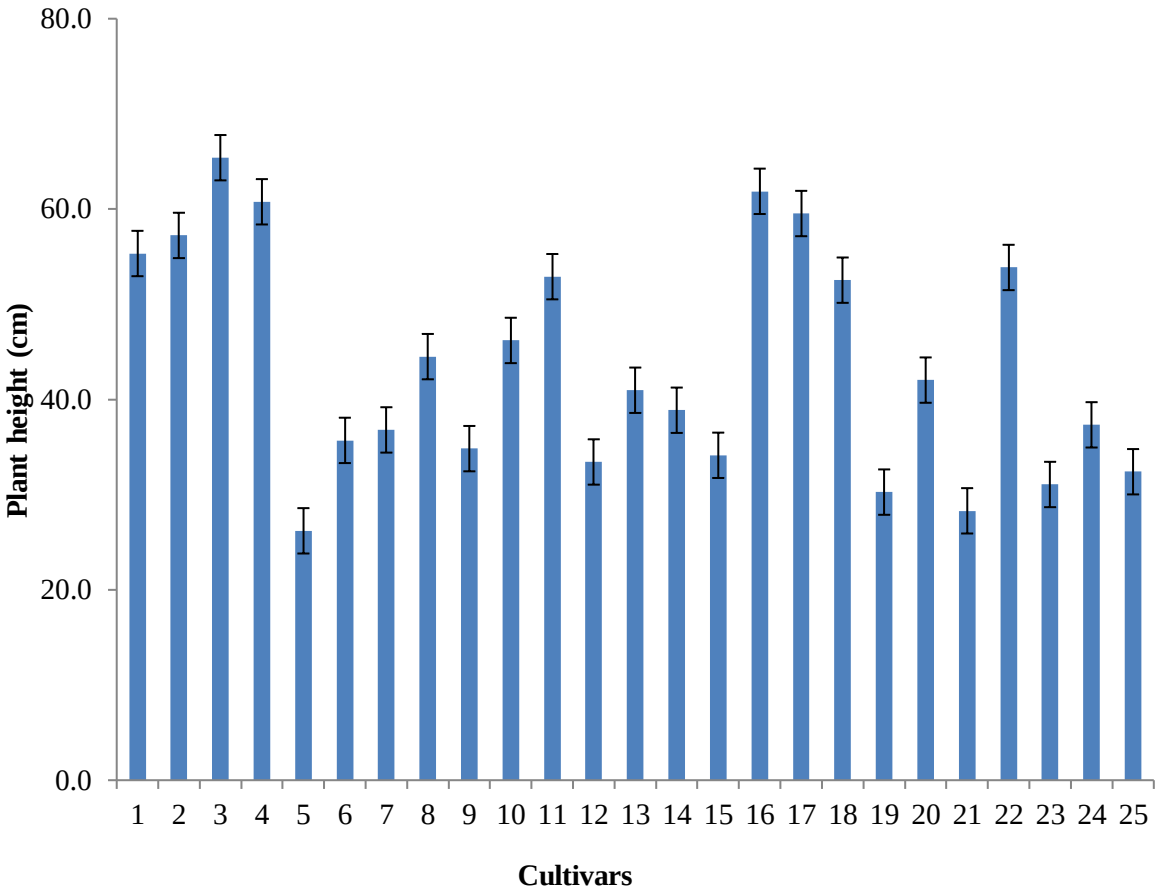


Fig 1: Plant height variation of chrysanthemum cultivars at 70 DAT **(**Days after transplanting

4.6 Number of flower buds/ plant

Number of flower buds varied in some extent among the 25 cultivars. The highest number of flower buds was found in V_5 (140.7/ plant) whereas the lowest was found in V_8 (55.3/plant) among the chrysanthemum cultivars (Table 2). V_5 cultivar (Pink Shasta Daisy) showed the best prospect in case of number of flower buds per plant. Flower buds number variation was also recorded in chrysanthemum cultivars by Uddin *et al.*, (2015b). Flower bud assures the blooming of flower later. So, the more bud, the more flowers in the plant.

4.7 Days taken to final bloom

Flower bud ends up in blooming. Significant variation was recorded in days taken to final bloom (Appendix III). Among the cultivars V_{20} took the maximum days to bloom (82.7 days) and V_{16} took the lowest days to bloom (51.7 days). Remaining cultivars had taken time to bloom in the intermediate

range. Such variation in completion of final bloom from bud initiation stage was also observed in chrysanthemum (Kim *et al.,* 2014 and Mehraj *et al.* 2015). This difference conveys that some cultivars are early flowering where some are late flowering. Genetic build up of the cultivars might be the prime reason behind this distinction in vegetative and flowering characteristics of different cultivars (Atul *et al.* 2018).

4.8 Number of ray florets per flower

Ray florets number per flower varied significantly among the cultivars (Appendix VI). The maximum number of ray florets was counted in V_9 (356.7) and the minimum was counted in V_{23} (43.3). Such kind of ray florets number range in chrysanthemum varieties was also found by S. Patil *et al.* (2017). A varietal study of eight lisianthus lines was executed by Uddin *et al.* (2015) who stated that petal number varied significantly among lisianthus lines. Petal number variation among lines was also observed in rose (Tabassum *et al.* 2002). Chrysanthemum flower being a composite head contains two types of florets: outer ray floret and inner disc floret. The number and shape of ray floret is important to evaluate chrysanthemum flower genotype. The variation in number of ray florets might be due to genetic makeup of the cultivars. Florets number and their arrangement are vital for the marketing of the flower as it draws the main attention of the consumers.

4.9 Flower head diameter (cm)

Significant variation in flower head diameter was recorded among the cultivars (Appendix VI). The maximum diameter was recorded at V_{16} (18.1 cm) whereas the minimal diameter was found at V_{10} (2.2 cm). N. Thakur *et al.,* (2018) also found distinction in chrysanthemum flower size. Similar observation was found by A. Siddiqua *et al.,* (2018). J. Uddin *et al.,* (2015) recorded flower head diameter variation in Gerbera cultivars and mentioned that maximum flower head diameter represented the best flower. Such variation in flower diameter might be due to the genetic makeup of the cultivars and their interaction with the prevailing environment conditions. Flower head diameter is an important morphological trait for deciding the quality of the flower.

Table 3: Performance of chrysanthemum cultivars related to days to bud initiation, bud number/ plant, days for flower bloom and flower number/ plant

Cultivars	Days to bud initiation		Bud number/plant		Days to flower bloom		Flower number/plant	
V_1	28.3	kl	64.7	o	69.3	gh	46.7	j
V_2	21.7	r	56.7	p	68.3	hi	37.3	k
V_3	27.3	lm	58.3	p	66.7	h-j	38.3	k
V_4	22.3	qr	65.3	o	62.3	kl	45.7	j
V_5	25.7	no	140.7	a	53.7	pq	100.0	a
V_6	24.7	op	105.3	i	59.7	l-n	76.3	f
V_7	23.3	pq	116.7	gh	53.7	pq	85.3	e
V_8	30.7	ij	112.3	h	60.7	k-m	83.7	e
V_9	35.7	gh	74.7	m	72.0	fg	53.3	i
V_{10}	37.7	f	124.7	ef	74.7	ef	92.7	d
V_{11}	26.3	mn	135.0	bc	56.7	n-p	101.3	a
V_{12}	28.3	kl	138.7	ab	55.7	op	99.7	ab
V_{13}	25.7	no	99.3	j	58.3	m-o	71.3	g
V_{14}	34.3	h	98.7	j	63.7	jk	70.7	g
V_{15}	47.3	c	120.7	fg	77.3	c-e	94.3	cd
V_{16}	31.7	i	88.3	k	51.7	q	60.3	h
V_{17}	49.3	b	68.3	no	79.7	abc	39.7	k
V_{18}	29.7	jk	55.3	p	57.3	no	33.7	l
V_{19}	26.7	mn	82.7	l	56.3	op	55.3	i
V_{20}	53.7	a	106.3	i	82.7	a	85.0	e
V_{21}	40.3	e	102.3	ij	78.7	b-d	70.3	g
V_{22}	36.3	fg	72.0	mn	65.7	ij	45.3	j
V_{23}	39.3	e	111.7	h	81.3	ab	78.3	f
V_{24}	43.7	d	133.3	cd	76.3	de	101.3	a
V_{25}	44.3	d	128.3	de	80.3	a-c	96.3	bc
CV (%)	2.86		3.20		2.95		2.95	
Lsd (0.05)	1.57		5.17		3.22		3.41	

Here, [x] V1: Crimson tide, V2: White snowball, V3: Yellow snowball V4: Purple snowball, V5: Pink shasta daisy, V6: Dark pink daisy, V7: Rose pink, V8: Orange pompon, V9: Orange paper white, V10: Orange mum, V11: Scaly mum, V12: Red mammoth, V13: Cream colored mum, V14: Ruby red, V15: Yellow spider mum, V16: White chrysanthemum, V17: Marigold mum, V18: White anemone, V19: Paper white, V20: Yellow daisy, V21: Red bronze, V22: Sunny yellow, V23: Magenta spray mum, V24: Magenta spoon mum, V25: Red-orange bicolor mum

[y]In a column means having similar letters are statistically identical and which are dissimilar in letter differ significantly in at 0.05 level of probability

4.10 Flowers number/ plant

Significant variation was found in flower number/ plant among the cultivars (Table 3). The range of flower per plant varied from 33.7 to 101.3 in number. The maximum number of flowers was found from V_{24} (101.3) and V_5 (100) where the minimum was recorded form V_{18} (33.7), V_2 (37.3) and V_3 (38.3). Higher yield might be the due to the increase in morphological parameters like plant height, number of leaves and leaf area which might have contributed in production of photosynthates resulting in the great accumulation of dry matter which leaded production of more flowers number in plant (Ramzan *et al*, 2014)

4.11 Flower stalk length (cm)

The variation in stalk length (Appendix III) among the chrysanthemum cultivars was recorded in the range of 3.8 cm (V_{11}) to 20.5 cm (V_{16}). The maximum stalk length was found in V_{16} (20.5 cm) and V_{22} (18.9 cm) and the minimum was found in V_{11} (3.8 cm). This variation might be inherited from the genotype of the flowers. Variation in stalk length among the different spray chrysanthemum cultivars was also recorded by A. Siddiqua *et al.* (2018), in carnation cultivars (Maitra *et al*. 2013) and in gerbera (Ahmad *et al.*, 2013). Another probable reason for the difference in stalk length among the varieties might be due to environmental conditions prevailed during the growth stage of stalk as reported by Baskaran *et al.* (2018). Stalk length is very important for quality of cut flower. It was reported by J. Uddin *et al.* (2015) that the cultivars with higher plant height produced the longer flower stalk compared to cultivars with smaller plant height in chrysanthemum.

4.12 Flower stalk diameter (mm)

Flower stalk diameter varied significantly among the cultivars (Appendix VI). The highest stalk diameter was found in V_{16} (6.5 mm) and the least diameter was recorded in V_{25} (2.8 mm). Distinction in stalk thickness was found in gerbera cultivars by Mahindiran *et al*. (2014). Similarly stem diameter variation was documented by Uddin *et al.* (2015) in lisianthus line. The flower stem diameter is one of the most valuable characteristics of cut branch flowers (Tomiozzo *et al*., 2015) and increases flower's resistance against transference from the garden to sale market (Azimi *et al*., 2012).

Table 4: Performance of chrysanthemum cultivars related to flower stalk length (cm), stalk diameter (mm), flower head diameter (cm) and ray florets number/ flower

Cultivars	Stalk length (cm)		Stalk diameter (mm)		Flower head diameter (cm)		Ray floret number/ flower	
V_1	13.4	i	3.5	e	15.7	c	116.7	o
V_2	18.0	c	3.6	b	13.6	d	167.7	m
V_3	16.6	d	6.1	c	12.8	e	211.7	i
V_4	14.8	gh	6.0	d	17.3	b	220.0	h
V_5	8.2	l	4.2	k	5.2	l	210.7	i
V_6	12.2	j	4.8	i	5.4	l	212.0	i
V_7	14.4	h	4.9	h	5.2	l	54.3	p
V_8	16.1	de	5.6	f	3.8	n	237.0	g
V_9	6.6	mn	3.3	q	7.3	gh	356.7	a
V_{10}	4.2	op	3.2	r	2.2	p	312.7	b
V_{11}	3.8	op	4.0	l	6.4	j	173.3	l
V_{12}	8.6	l	3.8	mn	5.9	k	170.3	lm
V_{13}	15.9	ef	5.3	g	7.5	g	170.7	lm
V_{14}	5.9	n	3.9	lm	6.1	jk	303.3	c
V_{15}	6.6	mn	4.0	l	4.6	m	189.7	j
V_{16}	20.5	a	6.5	a	18.1	a	262.7	f
V_{17}	7.2	m	3.2	s	8.8	f	182.7	k
V_{18}	10.5	k	3.5	p	6.9	i	220.0	h
V_{19}	11.6	j	3.6	o	4.7	m	292.3	d
V_{20}	15.2	fg	4.6	j	5.3	l	183.0	k
V_{21}	10.4	k	4.3	k	7.0	hi	266.7	e
V_{22}	18.9	b	6.4	a	7.3	g-i	121.3	mn
V_{23}	8.0	l	3.8	n	6.3	jk	43.3	q
V_{24}	4.6	o	2.8	t	5.2	l	186.7	j
V_{25}	4.7	o	2.9	t	3.3	o	223.0	h
CV (%)	4.0		1.09		3.49		0.96	
Lsd(0.05)	0.73		0.08		0.44		3.21	

*Here, V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

*In a column means having similar letters are statistically identical and which are dissimilar in letter differ significantly at 0.05 level of probability

4.13 Ray floret color measurement by CIELab colorimeter scale

Ray floret color was measured using a handy-type tristimulus colorimeter, NR-3000 (NIPPON Denshoku), followed by L* (lightness), a*, and b* (two Cartesian co-ordinates), based on the CIElab scale with the standard CIE observer (100 visual field) and the CIE standard illuminant D65 (CIE, 1986; McGuire, 1992). All the cultivars showed variation precisely in the case of ray floret color. This color variation attracts the consumers.

Table 5: Ray floret color variation in the 25 chrysanthemum cultivars

Cultivars	L*	a*	b*	C*	h_{ab}	Illustration
V_1	89.24	-1.36	6.61	6.75	101.61	
V_2	85.75	-3.39	53.67	53.78	93.62	
V_3	34.34	42.2	-10.77	43.55	345.68	
V_4	48.11	31.7	18.61	36.76	30.42	
V_5	61.32	24.06	-7.2	25.12	343.33	
V_6	78.52	11.9	-2.76	12.21	346.94	
V_7	60.87	21.39	-7.87	22.79	339.79	
V_8	69.7	6.95	31.58	32.34	77.59	
V_9	75.19	7.39	27.66	28.63	75.04	
V_{10}	58.76	13.09	39.17	41.3	71.52	
V_{11}	73.92	10.5	25.64	27.71	67.72	
V_{12}	59.23	22.72	29.19	36.99	52.1	
V_{13}	25.37	32.16	23.07	39.58	35.05	
V_{14}	55.83	24.65	14.28	28.48	30.08	
V_{15}	35.26	39.2	18.9	43.25	25.02	
V_{16}	82.32	0.51	58.71	58.72	89.5	
V_{17}	84.1	2.95	65.25	65.32	87.41	
V_{18}	88.52	-0.72	6.93	6.97	95.9	
V_{19}	83.46	-0.85	9.43	9.47	95.17	
V_{20}	86.92	-1	4.6	4.71	102.3	
V_{21}	88.93	-0.91	2.82	2.96	107.79	
V_{22}	82.1	0.81	61.01	61.01	82.24	
V_{23}	27.23	30.36	4.59	30.71	8.6	
V_{24}	25.56	37.29	0.4	37.29	0.61	
V_{25}	28.04	24.63	36.22	43.8	55.79	

4.13 Classification of chrysanthemum cultivars

During this research work, 25 cultivars of chrysanthemum were collected which were comprised with different growth habit behavior, flower forms and shapes, color variation and they were classified into different groups with the help of National Chrysanthemum Society Classification System and UPOV which are as follows:

4.13.1 Classification of cultivars based on class

In order to portray all the cultivars by evaluating their performance and to characterize those, all the cultivars were specified into the respective classes of the National Chrysanthemum Society Classification System where those were belong to Table 6.

Class 1: Irregular Incurve

This group of the chrysanthemum class is irregular incurve, giant blooming. Its form curves in with a loose, irregular appearance and give a skirted effect of ray florets.
Flower size: 6-8 inches
Characteristics: Can be grown as a disbud plant, plant moderately short.

Class 2: Decorative

This is a very common class of chrysanthemums. This kind of shape is very common. The flowers have a flattened shape compared with the first three classes. The florets tend to be short. Upper florets are generally incurved and lower florets tend to be reflex (bending down).
Flower Size: 5 inches or greater.
Characteristics: Can be grown as a pot mum or disbud plant short height and bushy.

Class 3: Single and semi double korean

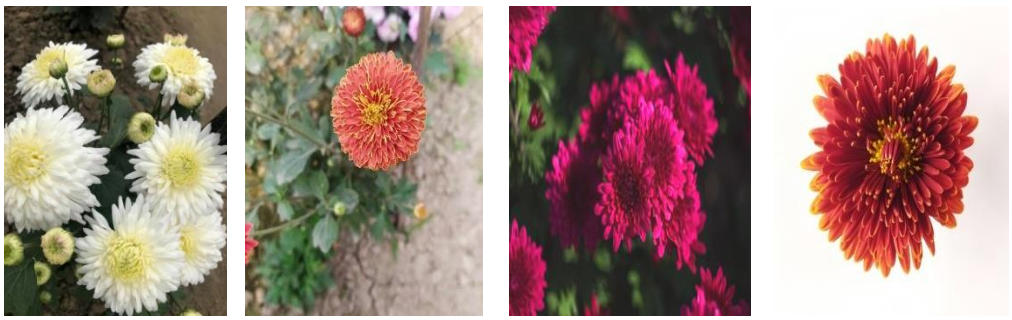
A daisy-like flower with a center disk and surrounded by one or more rows of ray florets.
Flower Size: Greater than 4 inches.
Characteristics: Can be grown as a disbud plant or spray, medium height.

A.

V_1 **V_2** **V_3** **V_4**

B.

V_7 **V_{10}** **V_{11}** **V_{14}**



V_{17} **V_{21}** **V_{23}** **V_{25}**

C.

V_5 **V_6** **V_{12}** **V_{20}**

Plate 4: Classification of cultivars based on class according to National Chrysanthemum Society. Here, A. Irregular incurve (V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball) B. Decorative (V_7: Rose pink, V_{10}: Orange mum, V_{11}: Scaly mum, V_{14}: Ruby red, V_{17}: Marigold mum, V_{21}: Red bronze, V_{23}: Magenta spray mum, V_{25}: Red-orange bicolor mum) C. Single and double Korean (: Pink shasta daisy, V_6: Dark pink daisy, V_{12}: Red mammoth, V_{20}: Yellow daisy)

Class-4: Quill

The florets in this Class are straight and tubular with open tips. The bloom is fully double with no open center.
Flower Size: 6 inches or greater.
Characteristics: Can be grown as a disbud plant with medium height.

Class-5: Anemone

These blooms are similar to the semi-doubles, but have a raised cushion-like center.
Flower Size: Greater than 4 inches.
Characteristics: Can be grown as a disbud plant with medium height.

Class 6: Pompon

Flowers in this class are somewhat flat in young but almost round or globular in shape when becomes mature.
Flower Size: 1-4 inches.
Characteristics: Can be grown as a spray with tall plant height.

Class 7: Spoon

This class has spoon like single or several layer of ray florets and daisy like round centre. Flower Size: 4 inches or greater.
Characteristics: Can be grown as a disbud or spray with tall plant height.

Class 8: Intermediate incurve

Flowers are more open and loose in form. The flowers in this class are not like fully incurve as regular incurve flowers
Flower Size: 6 inches or greater.
Characteristics: Can be grown as a disbud, plant medium height, good cut flower

Class 9: Spider

Flowers in this class are very popular of the chrysanthemum family. Flowers have large form, long and drooping petals.
Flower Size: Six inches or greater.
Characteristics: Can be grown as a disbud plant with medium height.

Table 6: Classification of chrysanthemum cultivars on the basis of class according to UPOV

Class	Type name	Cultivar
Class -1	Irregular incurve	V_1,V_2, V_3, V_4
Class - 2	Decorative	V_7, V_{10}, V_{11}, V_{14},, V_{17}, V_{21}, V_{23}, V_{25}
Class - 3	Single and semi double korean	V_5, V_6, V_{12}, V_{20}
Class - 4	Quill	V_9, V_{19}
Class - 5	Anemone	V_{18}
Class - 6	Pompon	V_8, V_{13}
Class -7	Spoon	V_{24}
Class-8	Intermediate incurve	V_{16}, V_{22}
Class- 9	Thistle	V_{15}

Here, V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

D.

V_9

V_{19}

E.

V_{18}

F.

V_8

V_{13}

G.

V_{24}

H.

V_{16}

V_{22}

I.

V_{15}

Plate 5: Classification of cultivars based on class according to National Chrysanthemum Society. Here, D. Quill (V_9: Orange paper white) E. Anemone (V_{18}: White anemone) F. Pompon (V_8: Orange pompon, V_{13}: Cream colored mum) G. Spoon (V_{24}: Magenta spoon mum) H. Intermediate incurve (V_{16}: White chrysanthemum, V_{22}: Sunny yellow) I. Thistle (V_{15}: Yellow spider mum)

4.13.2 Classification of on the basis of visual color of the ray floret

Flower color was determined by comparing two or more petals with the help of RHS (Royal Horticultural Society)color chart visually expressed with hues number, lightness, named A, B, C and D. All the color names were mentioned with the help of UCL (Universal color Language) name by the Inter- Society Color Council. On the basis of visual color of ray floret 25 cultivars were classified into following color range-

1. **White to greenish white:** Five cultivars were in white color range which started from white to greenish white V_{19}, V_2, V_{16}, V_{17} and V_{18} (Table 7).
2. **Yellow orange to pink orange:** Seven cultivars V_8, V_{10}, V_9, V_{21}, V_{25} and V_1, V_{13} were found in this color range (Table 7).
3. **Greenish yellow to light yellow:** Four cultivars V_{22}, V_3, V_{15} and V_{20} were found in this color range (Table 7).
4. **Red orange to vivid red:** Three cultivars V_{11}, V_{12} and V_{14} were found in this color range (Table 7).
5. **Pale pink to pale purplish pink:** Five cultivars V_5, V_4, V_{23}, V_{24}, V_6 and V_7 were found in this color range (Table 7).

Table 7: Classification of cultivars on the basis of color (visual observation)

RHS no.	UCL name	Cultivars
155A	White	V_{19}
155B	yellowish white	V_2, V_{17} , V_{18}
155C	Greenish white	V_{16}
2A	Vivid Greenish Yellow	V_{22}
2B	Vivid Greenish Yellow	V_3
3A	Brilliant greenish yellow	V_{15}
10B	Light Yellow	V_{20}
20A	Medium yellow orange	V_8
23D	Light Yellow orange	V_{10}
24A	Medium orange	V_9
25A	Medium orange	V_{21}
28B	Vivid orange	V_{25}
43A	Vivid Reddish Orange	V_1
29C	Light orange pink	V_{13}
34B	Orange red	V_{11}
45A	Dark red	V_{12}, V_{14}
49D	Pale Pink	V_5
54B	Deep Purplish Pink	V_4
55A	Deep Purplish Pink	V_{23}, V_{24}
55B	Strong Purplish Pink	V_6
55D	Pale Purplish Pink	V_7

Here. RHS means Royal Horticultural Society, UCL means Universal Color Language

V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

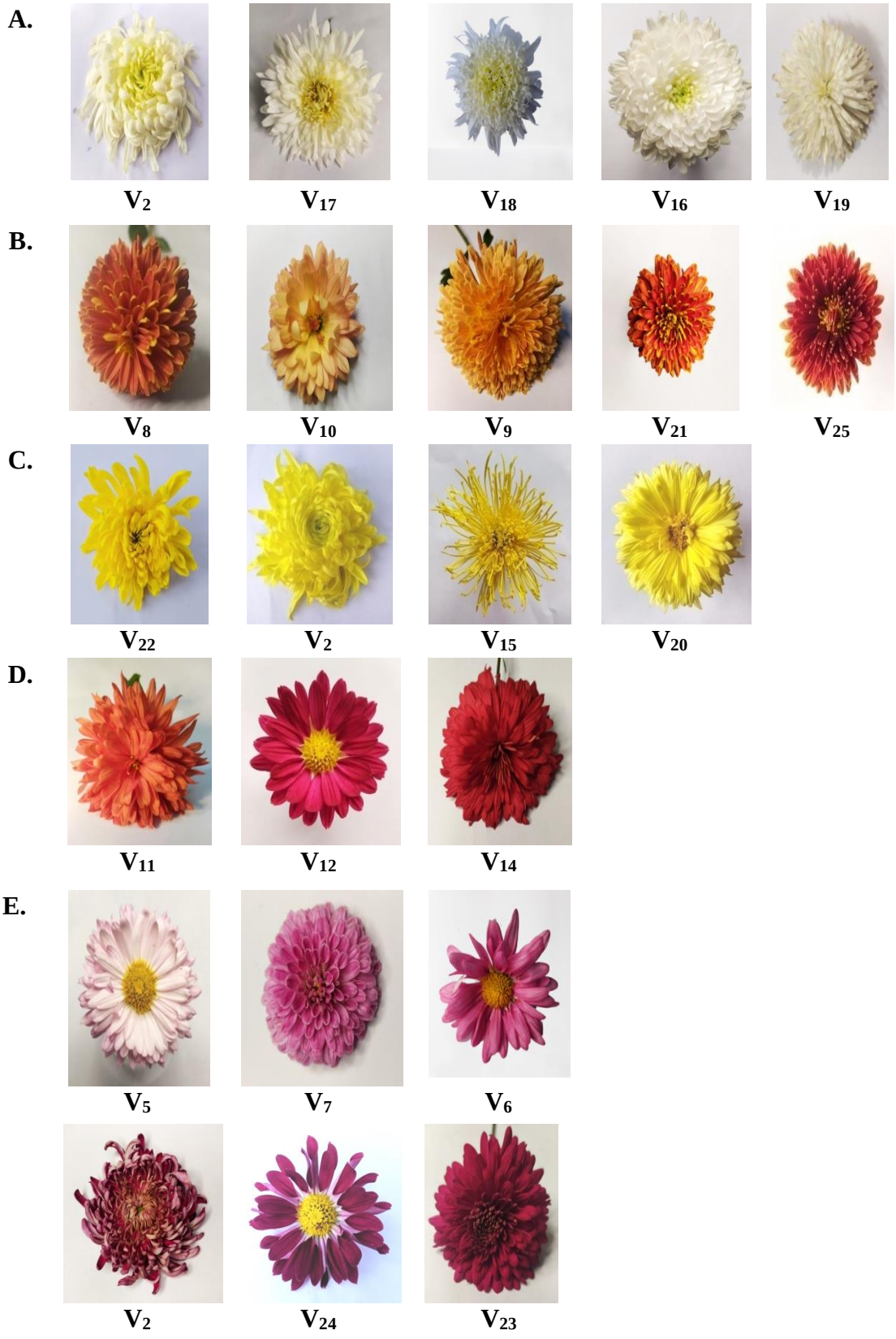


Plate 6: Visual color of the flower, A. White to greenish white (V_{19}, V_2, V_{16}, V_{17}, V_{18}**) B. Greenish yellow to light yellow (**V_{22}, V_3, V_{15}, V_{20}**) C. Yellow orange to pink orange (**V_8, V_{10}, V_9, V_{21}, V_{25}, V_1, V_{13}**) D. Red orange to vivid red (**V_{11}, V_{12}, V_{14}**) E. Pale pink to pale purplish pink (**V_5, V_4, V_{23}, V_{24}, V_6, V_7**)**

4.13.3 Classification of the cultivars on basis of flower head size

Flower head diameter was classified according to UPOV classification into three groups small, medium and large.

1. **Small** (2.2 cm – 4.99 cm): V_8, V_{10}, V_{15}, V_{19} and V_{25}
2. **Medium** (5.0 cm - 10.5 cm): V_5, V_6. V_7. V_9, V_{11}, V_{12}, V_{13}, V_{14}, V_{17}, V_{18}, V_{20}, V_{21}, V_{22}, V_{23} and V_{24}
3. **Medium to large** (10.6 cm –15.0 cm): V_2, V_3
4. **Large:** (>15.0 cm) : V_1, V_4 and V_{16}

Table 8: Classification of the cultivars on basis of flower head size

Class	Flower size (cm)	Cultivars
1	**Small** (2.2 cm – 4.99 cm)	V_8, V_{10}, V_{15}, V_{19} and V_{25}
2	**Medium** (5.0 cm - 10.5 cm)	V_5, V_6. V_7. V_9, V_{11}, V_{12}, V_{13}, $V1_4$, V_{17}, V_{18}, V_{20}, V_{21}, V_{22}, V_{23} and V_{24}
3	**Medium to large** (10.6 cm –15.0 cm)	V_2, V_3
4	**Large:** (>15.0)	V_1, V_4 and V_{16}

Here, V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

4.13.4 Classification of cultivars based on their dominant ray floret type

On the basis of ray floret type 25 cultivars were classified into four groups:

1. Ligulate: Seventeen cultivars V_1, V_5, V_6, V_7, V_8, V_{10}, V_{11}, V_{12}, V_{13}, V_{14}, V_{17}, V_{18}, V_{20}, V_{21}, V_{23}, V_{24} and V_{25} had ligulate type of floret.

2. Incurved: Five cultivars V_2, V_3, V_4, V_{16} and V_{22} had incurved type of floret.

3. Spatulate: Two cultivars V_9 and V_{19} had spatulate type of floret.

4. Quill: Only V_{15} cultivar had quill type of floret.

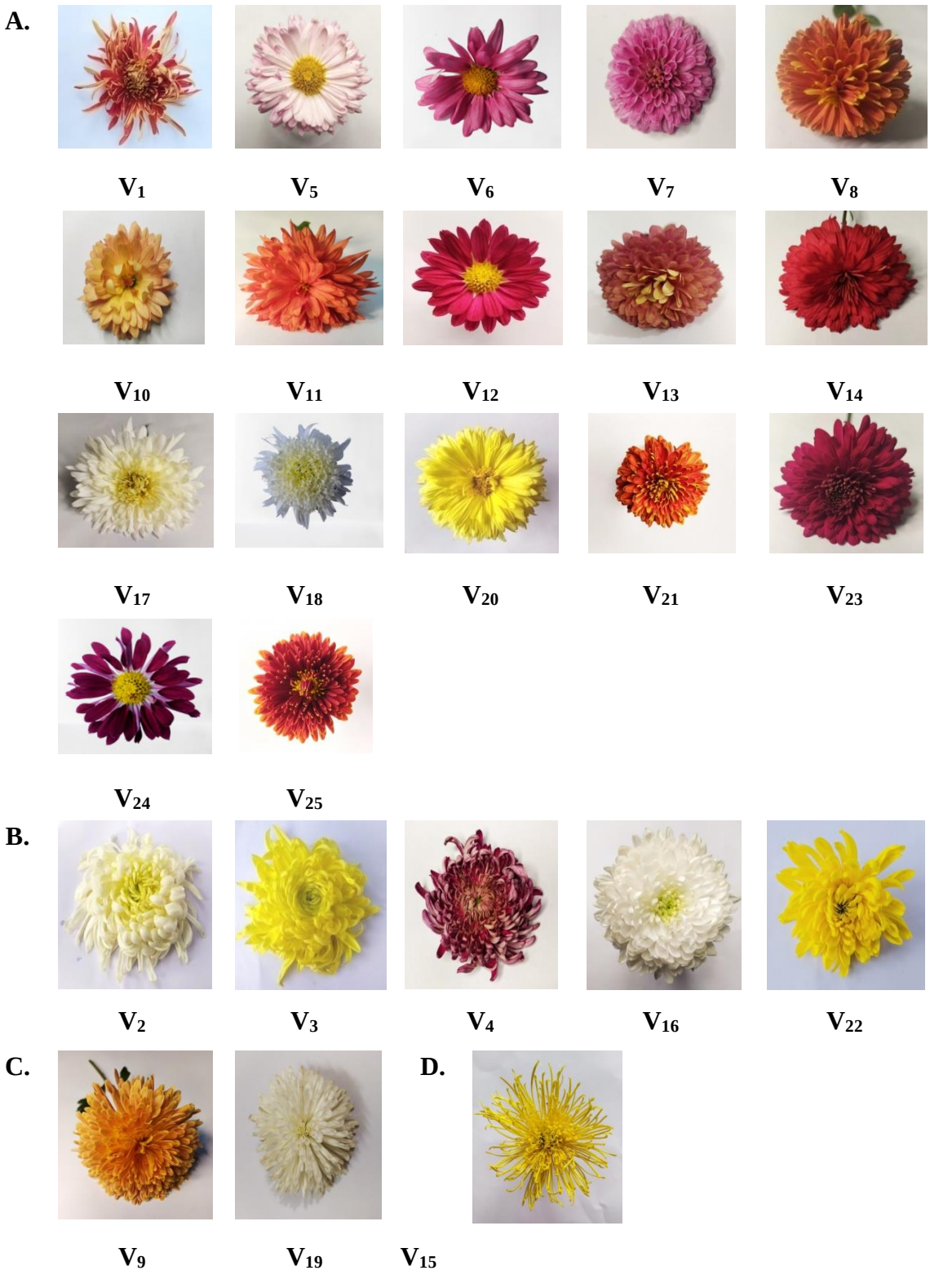


Plate 7: Pictures showing 25 cultivars on basis of dominant ray floret type, **A) Ligulate:** V_1, V_5, V_6, V_7, V_8, V_{10}, V_{11}, V_{12}, V_{13}, V_{14}, V_{17}, V_{18}, V_{20}, V_{21}, V_{23}, V_{24}, V_{25} **B) Incurved:** V_2, V_3, V_4, V_{16}, V_{22} **C) Spatualate:** V_9, V_{19} **D) Quill:** V_{15}

Table 9: Classification of cultivars on basis of their dominant ray floret type

Class	Dominant ray floret shape	Cultivars
1	Ligulate	V_1, V_5, V_6, V_7, V_8, V_{10}, V_{11}, V_{12}, V_{13}, V_{14}, V_{20}, V_{21}, V_{23}, V_{24} and V_{25}
2	Incurved	V_2, V_3, V_4, V_{16} and V_{22}
3	Spatualte	V_9, V_{19}
4	Quill	V_{15}

Here, V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

4.13.5 Classification of cultivars on the basis of predominant base shape of leaves

Chrysanthemum leaves show many variation in terms of shape, length of lobe, serration and many other characteristics. Here, the cultivars were classified into five groups considering base shape of leaves.

Table 10: Classification of 25 cultivars on the basis of predominant base shape of leaves

Class	Base shape	Cultivars
1	Obtuse	V_3, V_6, V_7, V_8, V_9, V_{10}, V_{12}, V_{14}, V_{18}, V_{20}, and V_{24}
2	Asymmetric	V_4, V_{11}
3	Acute	V_1, V_2, V_{15} andV_{16}
4	Rounded	V_5, V_{13}, V_{17} and V_{22}
5	Truncate	V_{19}, V_{21}, V_{23} and V_{25}

Here, V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

4.13.6 Classification of chrysanthemum cultivars on the basis of uses

This classification was done keeping under the consideration of how chrysanthemum cultivars can be used for cultivation on the basis of some traits like flower head size, stalk length and growing habit etc.

Class A: Cultivars which had comparatively long plant height, medium to large flower head, disbudded for single bloom and a long stalk are suitable as cut flower production. V_{16}, V_{22}, V_2, V_3 and V_4 cultivars had such quality.

Class B: Cultivars which had medium plant height, medium flower head size, medium stalk length and grown as spray type also are suitable for pot flower production. V_5, V_6, V_7, V_9, V_{11}, V_{12}, V_{14}, V_{17}, V_{19}, V_{21}, V_{23}, V_{24} and V_{25} cultivars were found in this category.

Class C: Cultivars which had short plant height, grown as multi stem with terminal bud removed to allow all lateral buds to bloom, small flower head and short stalk length are suitable for garden flower, pot plant, bonsai or landscape. V_1, V_8, V_{10}, V_{15}, V_{13}, V_{18} andV_{20} were found in this category.

Table 11: Classification of cultivars on the basis of use

Class	Production/Cultivation	Cultivars
Class-A	Cut flower	V_{16}, V_{22}, V_2, V_3 and V_4
Class-B	Potted flower	V_5, V_6, V_7, V_9, V_{11}, V_{12}, V_{14}, V_{17}, V_{19}, V_{21}, V_{23}, V_{24} and V_{25}
Class-3	Garden Flower	V_1, V_8, V_{10}, V_{15}, V_{13}, V_{18} andV_{20}

Here, V_1: Crimson tide, V_2: White snowball, V_3: Yellow snowball V_4: Purple snowball, V_5: Pink shasta daisy, V_6: Dark pink daisy, V_7: Rose pink, V_8: Orange pompon, V_9: Orange paper white, V_{10}: Orange mum, V_{11}: Scaly mum, V_{12}: Red mammoth, V_{13}: Cream colored mum, V_{14}: Ruby red, V_{15}: Yellow spider mum, V_{16}: White chrysanthemum, V_{17}: Marigold mum, V_{18}: White anemone, V_{19}: Paper white, V_{20}: Yellow daisy, V_{21}: Red bronze, V_{22}: Sunny yellow, V_{23}: Magenta spray mum, V_{24}: Magenta spoon mum, V_{25}: Red-orange bicolor mum

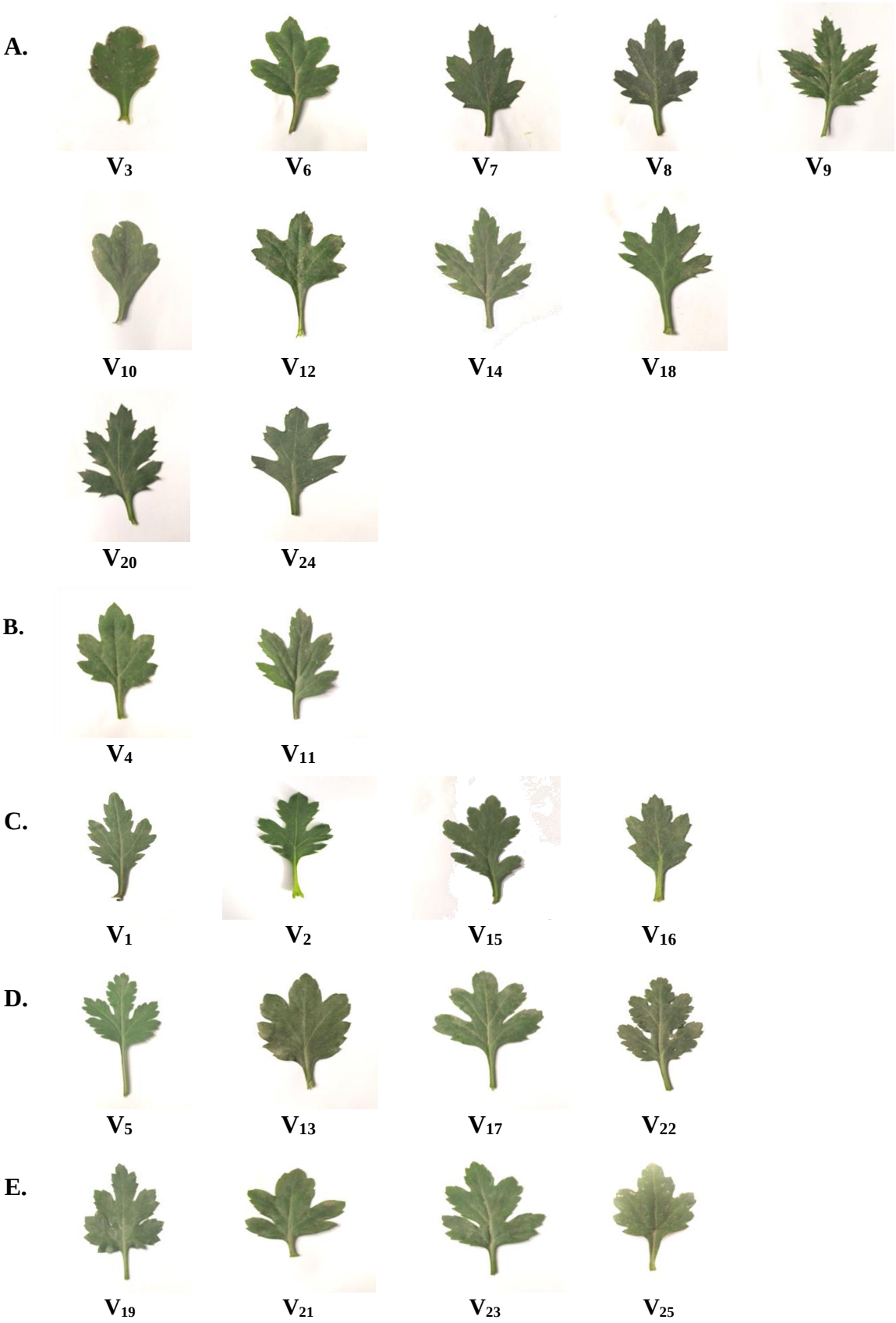


Plate 8: Classification of cultivars on the basis of predominant base shape of leaves **A. Obtuse (**V_3, V_6, V_7, V_8, V_9, V_{10}, V_{12}, V_{14}, V_{18}, V_{20} and V_{24}) **B. Asymmetric** (V_4, V_{11}) **C. Acute (**V_1, V_2, V_{15} and V_{16}) **D. Rounded (**V_5, V_{13}, V_{17} and V_{22}) **E. Truncate (**V_{19}, V_{21}, V_{23} andV_{25})

CHAPTER V

SUMMERY AND CONCLUSION

CHAPTER V

SUMMERY AND CONCLUSION

5.1 Summery

Chrysanthemum is a very popular cut flower around the world just after rose. It has been used as a cut flower for its versatile beauty and economy and those often remain in good condition for two to three weeks depending on cultivars. The number of varieties in the world is reported to be above 2000 till 2010. The environmental conditions of Bangladesh are quite favorable for growing chrysanthemum. Besides, flower production as well as market demand is quite visible during winter season. So, characterizing chrysanthemum cultivars might help the breeders to find out suitable cut flower cultivars for Bangladeshi floral market.

The research was executed at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, from the period of October, 2019 to April, 2020 to analyze the growth performance and characterize the growth along with flowering behavior of 25 chrysanthemum cultivars. The experiment was arranged in Randomized Complete Block Design with three replications. Chrysanthemum flowers showed good distinctions among the cultivars regarding morphological traits.

The tallest plant was found from V_3 (65.4 cm) whereas the shortest one from V_8 (26.2 cm) among the chrysanthemum cultivars.

The cultivars showed significant variation for number of leaves per primary branch. The maximum number of leaves/ primary branch was observed from V_3 (22.3) and the minimum from V_2 (13.7).

The maximum number of branches per plant (17.6) was recorded from V_{24} and the minimum number of branches (6.7) observed in V_{18}.

The highest SPAD value (chlorophyll content in leaf) was obtained from V_{16} (57.2) and lowest was obtained from V_{25} (34.7) and V_{23} (33.7) respectively at the mature stage of leaves.

Early flower bud initiation was found in V_2 (21.7 days) while late in V_{20} (53.7 days). White snowball was early bud initiating cultivar.

Flower buds were found highest in V_5 (140.7/plant) whereas lowest was found from V_8 (55.3/plant) among the chrysanthemum cultivars.

Among the cultivars V_{20} took the maximum days to bloom (82.7 days) and V_{16} took the lowest days to bloom (51.7 days).

The maximum flower head diameter (18.1 cm) was recorded in V_{16} while the minimal was (2.2 cm) in $V_{10.}$

The range of flower per plant varied from 33.7 to 101.3 in number. The maximum number of flower was found from V_{24} (101.3) and V_5 (100) where the minimum was recorded form V_{18} (33.7), V_2 (37.3) and V_3 (38.3).

The longest stalk length was found in V_{16} (20.5 cm) and V_{22} (18.9 cm) and minimum was found in V_{11} (3.8 cm) and V_{10} (4.2 cm).

The highest diameter of the stalk was found in V_{16} (6.5 mm) but the least diameter was recorded in V_{25} (2.8 mm)

The maximum number of ray florets was counted in V_9 (356.7) and the minimum was counted in V_{23} (43.3).

Chrysanthemum cultivars were classified into 9 classes according to National Chrysanthemum Society Classification system. Irregular Incurve class contains V_1, V_2, V_3, V_4 cultivars, decorative were V_7, V_{10}, V_{11}, V_{14}, V_{17}, V_{21}, V_{23}, V_{25} cultivars, single and semi double Korean were V_5, V_6, V_{12}, V_{20} cultivars. V_9, V_{19} were quill. V_{15} was spider, V_{18} was anemone, V_{16}, V_{22} were intermediate incurve, V_8 and V_{13} were pompon and V_{24} was spoon type.

Based on visual color of ray floret, 25 cultivars were classified into 5 groups. Among them V_{19}, V_2, V_{16}, V_{17}, V_{18} were in white to greenish white group; V_8, V_{10}, V_9, V_{21}, V_{25}, V_1, V_{13} were in yellow orange to pink orange group; V_{22}, V_3, V_{15}, V_{20} were found in greenish yellow to light yellow range; V_{11}, V_{12}, V_{14} were in red orange to vivid red group and V_5, V_4, V_{23}, V_{24}, V_6, V_7 were in pale pink to pale purplish pink group.

Flower head diameter was recorded when fully opened and classified according to UPOV classification into three groups: small, medium and large.V_8, V_{10}, V_{15}, V_{19}, V_{25} were in small head diameter group; V_5, V_6, V_7, V_9, V_{11}, V_{12}, V_{13}, V_{14}, V_{17}, V_{18}, V_{20}, V_{21}, V_{22}, V_{23}, V_{24} were in medium head diameter group and V_2, V_3 medium to large group, V_1, V_4, V_{16} were in large diameter group.

According to UPOV classification, based on ray floret shape chrysanthemum cultivars were classified into four groups. V_1, V_5, V_6, V_7, V_8, V_{10}, V_{11}, V_{12}, V_{13}, V_{14}, V_{17}, V_{18}, V_{20}, V_{21}, V_{23}, V_{24}, V_{25} were in ligulate shape ray floret cultivars; V_2, V_3, V_4, V_{16}, V_{22} were in incurved shape; V_9, V_{19} were in spatulate shape group and V_{15} were in quill shape group.

Based on the predominant shape of the leaf, chrysanthemum cultivars were categorized into five classes following UPOV classification. Cultivars V_3, V_6, V_7, V_8, V_9, V_{10}, V_{12}, V_{14}, V_{18}, V_{20}, V_{24} were obtuse type; V_4, V_{11} were Asymmetric type; V_1, V_2, V_{15}, V_{16} were acute type; V_5, V_{13}, V_{17}, V_{22} were round type; and V_{19}, V_{21}, V_{23}, V_{25} were truncate type.

A classification was done keeping under consideration how chrysanthemum cultivars can be used for cultivation on the bases of some characters like flower head size, stalk length and growing habit and so on. Among them, V_{16}, V_{22}, V_2, V_3 and V_4 cultivars were recorded to have characters like cut flower; V_5, V_6, V_7, V_9, V_{11}, V_{12}, V_{14}, V_{17}, V_{19}, V_{21}, V_{23}, V_{24} and V_{25} cultivars had potted flower like characters and V_1, V_8, V_{10}, V_{15}, V_{13}, V_{18} and V_{20} were found to have garden flower like characters.

5.1.2 Conclusion

From the above result and discussion, it can be articulated that V_{16}, V_{22}, V_2, V_3, V_4 cultivars had cut flower quality considering the characteristics of flower head size, stalk length, stalk diameter and visual color and they have great prospects as cut flower in the market. Furthermore, V_5, V_6, V_7, V_8, V_{11}, V_{13}, V_{15}, V_{17}, V_{18}, V_{20}, V_{21}, and V_{25} cultivars having bushy and small flower head with profuse lateral branching cultivars were suitable for pot plant. For flower bouquet V_9, V_{11}, V_{12}, V_{13}, V_{14}, V_{19} and V_{24} cultivars would be prominent due to medium flower head size with bright color.

5.1.3 Suggestions

Considering the findings of this research hereafter more studies can be done in following fields-

- ♣ Breeders can further improve the characteristics of cut chrysanthemum cultivars.
- ♣ Pot and garden flower cultivars can be introduced to the farmers which might create a new demand in the flower market.

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APPENDICES

Appendix I. Analysis of variance for plant height, branches number per plant and leaves number per branch of chrysanthemum

Source of variation	Degrees of freedom	Mean square of		
		Plant height (cm)	Number of branches/plant	Number of leaves/branch
Treatment (Chrysanthemum cultivars)	24	425.824*	29.6033*	11.9444*
Error	48	1.268	0.2009	1.2928

***Significant at 0.05 level of probability**

Appendix II. Analysis of variance for SPAD value, days to bud initiation and number of buds per plant of chrysanthemum

Source of variation	Degrees of freedom	Mean square of		
		SPAD value	Days to bud initiation	Number of buds per plant
Treatment (Chrysanthemum cultivars)	24	231.156*	245.620*	2353.37*
Error	48	5.105	0.912	9.93

***Significant at 0.05 level of probability**

Appendix III. Analysis of variance for days to flower bloom, number of flowers per plant and stalk length of chrysanthemum

Source of variation	Degrees of freedom	Mean square of		
		Days to flower bloom	Number of flowers per plant	Stalk length (cm)
Treatment (Chrysanthemum cultivars)	24	305.114*	1617.14*	76.9364*
Error	48	3.839	4.32	0.1965

***Significant at 0.05 level of probability**

Appendix IV. Analysis of variance for stalk diameter, flower head diameter and ray florets number per flower of chrysanthemum

Source of variation	Degrees of freedom	Mean square of		
		Stalk diameter (mm)	Flower head diameter (cm)	Ray florets number/flower
Treatment (Chrysanthemum cultivars)	24	4.18171*	56.4380*	16357.5*
Error	48	0.00243	0.0715	3.8

*** Significant at 0.05 level of probability**

Appendix V. Predominant leaf base shape standard by UPOV

Characteristics	UPOV class	Illustration
Leaf	Obtuse	
	Acute	
	Rounded	
	Truncate	
	Asymmetric