PHENOTYPIC CHARACTERIZATION OF CHRYSANTHEMUM CULTIVARS

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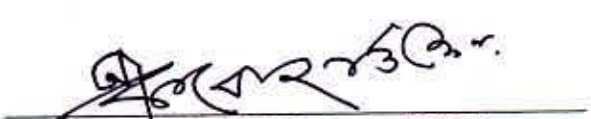

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Thanks to the all mighty Allah

All that I am or hope to be I owe to my parents

Dedicated to

The teacher who taught me how to learn, how to be responsible, how to be generous and who will be a inspiration in my every step of life

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This is to certify that thesis entitled **"PHENOTYPIC CHARACTERIZATION OF CHRYSANTHEMUM CULTIVARS"** submitted to the Department of Horticulture, 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 *bona fide* research work carried out by **TROPA TAUFIQUE,** Registration No. **07-02227** under my supervision and guidance. No part of the thesis has been submitted for 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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ABSTRACT

A pot experiment was conducted at Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from October 2012 to March 2013 to characterize chrysanthemum cultivars on the basis of phenotypic traits. This experiment had 32 chrysanthemum cultivars coded from V_1 to V_{32} using Completely Randomized Design (CRD) with three replications. These cultivars were categorized into 13 groups provided by National Chrysanthemum Society Classification, USA. The cultivar V_7 (Yellow Glow) was the top scored cultivars for the studied phenotypic characteristics. The cultivars V_1 (Crimson Tide), V_2 (Samsan), V_3 (White Snowball), V_4 (Chandramukhi), V_{10} (Sunny Yellow), V_{13} (Purple Mum), V_{16} (Pink Shasta Daisy) and V_{25} (Red Wing) were categorized as cut flowers and rest of the cultivars were categorized in pot or bedding flowers. All the 32 chrysanthemum cultivars were divided into a wide color range in accordance to Royal Horticultural Society (RHS) Color Chart. These findings will be helpful for commercial users as well as flower breeders.

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ABBREVIATIONS AND ACRONYMS

SAU	Sher-e-Bangla Agricultural University
SAURES	Sher-e-Bangla Agricultural University Research System
BARI	Bangladesh Agricultural Research Institute
et al.	And others (at elli)
i.e.	That is
%	Percentage
@	at the rate of
mm	Milimeter
cm	Centimeter
cm^2	Centimeter square
m^2	Meter square
g	Gram
kg	Kilogram
CV.	Cultivars
DAT	Days After Transplanting
AEZ	Agro-Ecological Zone
ANOVA	Analysis of Variance
df	Degrees of freedom
CV%	Percentage of Coefficient of Variation
UNDP	United Nations Development Programme
FAO	Food and Agriculture Organization
UPOV	Union for the Protection of Plant Varieties
CRD	Completely Randomized Design
USA	United States of America
LSD	Least Significant Difference
SPSS	Statistical Program for Social Science

CHAPTER I

INTRODUCTION

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INTRODUCTION

Chrysanthemum (*Chrysanthemum sp.*) belonging to Asteraceae family is a highly attractive and charming flowering plant, native to Asia and Northern Europe. Chrysanthemum is commonly known as "mum" or "chrysanths" that behaves both as annual and perennial flowering herbs. Chrysanthemum flowers are gaining popularity for using in floral bouquets and flower arrangement in our country and for its versatile colours and forms. The number of varieties in the world is reported to be above 2000 (Joshi *et al.*, 2010). Chrysanthemums are used either as cut flowers or grown in pots (Vidrascu and Teodorescu, 1993). Flowers are divided into different groups dependent on their various color, types, bloom size, bloom forms and flowering time. Their blooms are divided into 13 different bloom forms by US National Chrysanthemum Society, which is in keeping with the international classification system. It is one of the most important and popular flowers among public as well as breeders of many countries for its great variety of colors, shapes and long lasting capability as well as potential for marketing as cut flowers and potted plants. These plants have a number of ornamental, culinary, environmental, insecticidal, and medicinal uses that are known to man since centuries.

A large number of chrysanthemum cultivars are the results of conscious and unconscious selection by growers and breeders over the centuries and many new forms of colors and varieties that have larger bloom and varying growth habits. The success in cultivation of this plant is due principally 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 the consumer (Barbosa, 2003).

Chrysanthemums are available in variety of shapes and sizes and the flowers differ between species. These are available in hues of red, pink, lavender, orange, deep gold, white, yellow green cream and bicolour, flowers themselves can be ball or globe shaped, daisy-shaped or even button shaped. According to the classification, different classes exhibit different forms of bloom and arrangement of ray and disk florets. Bangladesh is well adapted for cultivation of chrysanthemum and it is now one of the major cultivated flowers. Morphological variables of a set of germplasm were determined to provide information for breeders (Mehraj *et al.*, 2014).

Morphological categorization will help in identification of varieties and for selection of desirable characters for cultivar (Gupta and Dutta, 2005). Characterization is the description of plant germplasm, it is essential to provide information on the accerted traits ensuring the maximum utilization of the germplasm collection to the final users. It is necessary to assess the information on nature and magnitude of variability present in the existing cultivars and association among various qualitative traits. It is done by growing a large number of accessions of a collection in a normal growing season specifically for this purpose (Tay, 1987). It will help to establish a degree of similarity or number of shared characters among the cultivars, to obtain descendents with superior qualitative characters also variability among different cultivars that can be used in commercial breeding.

Although the plant has been known and grown for a longer period of time and having several germplasm, a few performance based experiment has been done. Characterization of available commercial chrysanthemum cultivars and evaluation of different traits is not done yet and no relationship has been build up among various available cultivars. The initiative act of the research work would be the characterization of these available cultivars and evaluation of distinctly identifiable and distinguishable characters considered to be important in crop improvement.

Hence keeping above points in view, present investigation has been undertaken with following objectives.

1. To characterize chrysanthemum cultivars based on different morphological traits; and
2. To evaluate the performance of the cultivars and association between traits of cultivars.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Chrysanthemum cultivars exhibits a wide range of diversity in morphological traits like flower number, size, color and flowering duration etc. This flower has earned tremendous popularity as an ornamental flower for the garden, as cut flower for interior decoration or for the green house cultivation. Its demand and production area is increasing day by day in Bangladesh. The literature pertaining to the performance of rose cultivars as studied by several workers so far been done in home and abroad related to this experimentation have been presented (Year wise) in this chapter this chapter under the following sub headings.

2.1 Cultivars performance related literature

Variation in stalk length may be attributed to varietal difference nineteen hybrid rose cultivars were evaluated under agro climatic conditions of Islamabad. He observed variation in stalk length may be attributed to varietal difference. Cultivar Double Delight achieved maximum stalk length (24.6cm), which was significantly superior over other cultivars and was followed by Signature (24 cm) and Bara Bara (22.3 cm). heighest stalk length was observed in case of tallest cultivars (Ramzan *et al.*, 2014)

(Tarannum and Hemla, 2014) evaluated eight genotypes of Carnation for growth, flowering, flower yield, flower quality and vase life parameters to assess spectrum of genetic variability between these characters under NVPH at Department of Floriculture and Landscape Architecture, College of Horticulture, Karnataka , India. Variations with respect to flower weight was recorded among varieties might be attributed to higher water and carbohydrates level in the flower. Water plays a very important role to maintain flower turgidity, freshness and petal

orientation. Similarly, carbohydrates serve as energy source for growing bud, flower opening and longevity. The ultimate effect of all these factors resulted into strong and long flower stalks, large sized buds or flower.

The suitability of 6 spray carnation cultivars namely 'Chabaud Extra Mix', 'Enfont De Nice', 'Chabaud Mix', 'Chabaud Super Mix', 'Chabaud Finest Mix' and 'Lilipot Mix grown' from seeds were studied in the plains of West Bengal, India in this experiment. The variations in bud diameter as resulted by different varieties were found statistically significant . 'Chaud Super Mix' produced longest buds (4.25 cm) and Buds of 'Lilipot Mix' were observed as the lowest in length (2.89 cm) (Maitra and Roychowdhury, 2014).

Hamblin *et al.* (2014) reported that differences between genotypes were found in levels of chlorophyll content per unit leaf area in spring wheat either on single plants or in short rows at one time using a SPAD 502.

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 III) 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 d).

An experiment as conducted at Department of Floriculture and Landscape, NARC, Islamabad, Pakistan during May to July 2011 to assess the performance of Nineteen hybrid rose cultivars under agro climatic conditions of Islamabad. Maximum numbers of flowers (52) were produced by cultivar 'Honey Perfume'

followed by 'Pink Peace' (50) and 'Allice Red' (34). It was investigated that increase in flower number might be due to increase in morphological parameters like plant height, number of leaves and leaf area which help in production of more photosynthates which resulting in greater accumulation of dry matter which in turn leads to production of more number of flowers per plant (Ramzan *et al.*, 2014) .

Mahmood *et al.* (2013) evaluated ten gerbera cultivars ('Labinel', 'Lilla', 'Alp', 'Alberino', 'Bonnie','Avemaria', 'Mammut', 'Lexus', 'Terramixa ' & 'Sarolta') for their growth, yield and quality characteristics under protected conditions during 2011. Among he cutivars the bigger diameter of 'Alberino' might be due to the inherent characters of individual cultivars.

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

A study was conducted under the AICRP-Floriculture, at the Agricultural Research Institute, Hyderabad during the year 2008-09 to identify suitable China aster cultivars *under open conditions of Hyderabad.* Among the cultivars 'Phule Ganesh Pink' (57.20) and 'Phule Ganesh White' (61.33) significantly took less number of days for floral bud initiation while 'Local' recorded the longest number of days (65.93). The variations in flower bud initiation and flower opening may be due to genetic trait (Zosiamliana, *et al.*, 2012).

An experiment was conducted an experiment during rabi season of 2006-2007and 2007-2008 at High tech Horticultural Project , Saidapur Farm, University of agricultural Science, Dharwad with a aim to evaluate suitable varieties of growth and flower yield of china aster under transitional tract of north Karnataka. Among

the varieties 'Phule Ganesh' performed as the tallest cultivar (74.56 cm) Munikrishnappa *et al.* (2012).

Various snapdragon (*Antirrhinum majus* L.) cultivars were evaluated as cut flower in Punjab, Pakistan during 2011. It was observed that the cultivars with maximum plant height produced longer flower stalk length as compared to cultivars with smaller plant heights (Shafique *et al.*, 2011).

Exotic cultivars of hybrid roses respond uncertainly to new habitat makeup. Nurjehan produced maximum flowers per plant (58.80). Variations in number of flowers per plant were attributed to recurrent blooming habit due to their genetic makeup (Nadeem *et al.*, 2011).

Punetha, *et al.* (2011) assessed fifteen chrysanthemum (*Chrysanthemum morifolium* Ramat.) genotypes for their performance under mid hill conditions of Garhwal Himalaya during 2009–10. The highest number of flowers/branch (10.43) was produced by genotype 'White Anemone' followed by 'Gauri' (9.08) and 'Appu' (7.66), but number of flowers/plant was higher (301.00) in 'Paris White' and minimum (66.33) was recorded with genotype Suneel.

Twenty five dahlia accessions were evaluated to ascertain genetic parameters of variability. The genotypic coefficient of variation and phenotypic coefficient of variation were found higher for growth parameters like leaf area, stalk length, longevity of flower, vase life, and number of flowers per plant (Vikas *et al.*, 2011).

Raghuvanshi *et al.* (2011) reported highly significant variation among cultivars for all the traits studied. Cultivar 'Safari Queen' recorded maximum plant height (35.80 cm).

An experiment was conducted to determine the effects of short-day treatments on the growth, flowering and cut flower quality of chrysanthemum and to determine the best time of the day for the application of the short-day treatment. There were four treatments i.e., applying short-day by covering the plants with black-polythene sheet from 5.00 to 9.00 AM, 11.00 AM to 3.00 PM, 4.00 PM to dusk and control (no covering). The higher plant height in chrysanthemum is obtained from plants that were not covered, could be due to high photosynthetic capacity resulting from high light intensity (Nxumalu and Wahome, 2010).

Baskaran *et al.* (2010) evaluated the performance of chrysanthemum cultivars ('Ravikiran', 'Chandrika', 'Yellow Sta'r, 'Red Gold', 'Nilima', 'Kasturi Shaventigae', 'Cassa', 'Arka Swarna', 'Arka Ravi' and Button Type Local) under the open field conditions at UAS Bangalore. The tallest plants (54.03 cm) were recorded by cv. Cassa, whereas the shortest plants were observed in cv. Button type local.. The duration of flowering was longest (51.66 days) in cv. Yellow Star and shortest (23.33 days) in cv. The highest flower diameter (8.14 cm) was observed in cv. Ravikiran, whereas the lowest (2.07 cm) was recorded in Button Type Local. Cultivar Button Type Local recorded the highest number of flowers per plant (287.00), whereas cv. 'Cass' recorded the lowest (37.00). The results indicate that 'Red Gold', 'Nilima', 'Yellow Star' and 'Ravi Kiran' can be exploited commercially for different purposes in Karnataka.

Joshi *et al.* (2010) tested performance of seven chrysanthemum varieties *viz.*, 'IIHR-6', 'Shyamal', 'Mayur', 'Red Gold', 'Honey Comb', 'Panchon' and 'Nilima' under North Gujrat condition. The variety Mayur recorded minimum days taken for initiation of first flower (31.25 days).

Gharge *et al.*, (2009) carried out an investigation on evaluation of ten cultivars of carnation *(Dianthus caryophyllus* L.) with respect to vegetative and yield parameters of carnation cut flowers was carried out under naturally ventilated poly house condition at Hi-tech Horticulture Unit, Main Agricultural Research Station, Saidapur Farm, University of Agricultural Sciences, Horticulture Unit, Main Agricultural Research Station, Saidapur Farm, University of Agricultural Sciences, Dharwad Maximum leaf length was recorded in variety Buemonde (12.48 cm) followed by Dali (12.09 cm), Pink Shiva (12.03) Gaudina (11.83 cm) and Diana (11.71 cm) and minimum leaf length (8.74 cm) was in variety Firato (8.74 cm).

A study was carried out to evaluate 15 monopodial orchid genotypes belonging to the genera *Aranda, Aranthera, Kagawara, Mokara, Renanthera* and *Vanda*, which are commercially popular. These genotypes were studied with respect to quantitative and qualitative floral characters. Leaf chlorophyll content was maximum in the variety Sonia-17 (80.53 SPAD units) and minimum was registered in Burana fancy (58.90 SPAD units). The variation in chlorophyll content of leaf among the varieties might be attributed to the genetic constitution. (Thomas and Lekharani, 2008).

A study was conducted at Bidhan Chandra Krisshi Viswavidyalaya (BCKV) to note the difference in growth habit of chrysanthemum x morifolium Ramat, c.v. Chandrama under the influence of different plant dencities and stem maintained per plant. Greater leaf size (47.12 cm^2) was recorded in unpinched single stemed plant (Mitra and Paul, 2008).

Vrsek *et al.* (2006) studied on growing New England aster, cv. September Ruby, as a flowering pot plant in the late summer period; determine the influence of day

length. It was found that the higher value plant height could be attributed to increased photosynthetic capacity of the plants.

Mantur *et al.* (2005) conducted an experiment on bending and pruning on six exotic varieties of roses under naturally ventilated polyhouse and reported that, among the varieties, significantly maximum number of flowers were recorded in the variety Sweetness (114.50/m^2), followed by Passion (105.98/m^2). Flower stem length in Polo variety was significantly superior (64.18 cm), followed by First red (59.63 cm), while flower diameter was significantly higher in First red (2.62 cm), followed by Polo (2.52 cm).

An investigation was carried out at identifying a suitable and stable genotype for higher flower production of tall marigold (*Targets erecta* L.) across the environments. It was revealed that the genotype, African Marigold Orange (AMO) recorded significantly higher flower yield (16.47 t/ha) to the local check (Orange Double) (Hemla Naik *et. al.*, 2005)

Thirty small flowered cultivars of chrysanthemum were selected and their different morphological characters and chlorophyll content of leaves both at vegetative and flowering stages were determined and categorized on the basis of their flower types for preparation of chrysanthemum check list. This will help in identification of varieties and for selection of desirable characters for cultivar (Gupta and Dutta, 2005).

Sarkar and Ghimaray (2004) Observed that the stalk length is a genetic factor therefore it is expected to vary among the cultivars as earlier.

Among the different cultivars of rose, 'Grand Gala' and 'First Red' had maximum field life or senescence period in plant in gerbera. The cultivars variation recorded in different flowering characters may be due to differences in the inherent make up of these cultivars. (Nair and Medhi, 2004)

Hussain and Khan (2004) evaluated two rose cultivars and reported that 'Rosa bourboniana' produced maximum plant height (94.3 cm) as compared to Rosa gruss-an-teplitz (42 cm).

An experiment was conducted in progressive farmer polyhouse of Belgaum, Karnataka on vegetative characters of nine cultivars of carnation (*Dianthus caryophyllus* L.). Leaf area was maximum in cultivars 'Pirandello', 'Madame Collette', 'Desio' and 'Sugar Baby', whereas it was minimum in cv. 'Sorisso'. Cultivars 'Madame Collette', 'Alma', 'Pirandello' and 'Desio' recorded maximum leaf length while, cv. 'Sorisso' had recorded the minimum leaf length. and total chlorophyll contents of leaf were maximum in cultivars 'West Pretty', 'Sugar Baby', 'Desio' and 'Madame Collette', whereas these were minimum in cv. 'Sorisso' (Shiragur *et al.*, 2004).

Chandragiri *et al.* (2004) evaluated 20 exotic spay varieties of chrysanthemum for their performance under naturally ventilated greenhouse. Among them, Solomon Impala recorded to be the tallest cultivar (132.16 cm) at harvesting stage.

An experiment was carried out to assess the variability and heritability of severaltraits for breeding in seven Chrysanthemum cultivars .Maximum flower diameter of chrysanthemum was found to 12.4 cm and minimum was from 8.0 cm (Kunigunda, 2004)

Correlation and path coefficient analysis were carried out for 25 genotypes of gerbera, during two seasons for 11 characters. The widest range of variation was observed in leaf area, which indicate additive gene action (Nair and Shiva, 2003).

A research on the evaluation of rose cultivars as cut flower production was carried out at Rose Progeny Garden, Gomal University, Pakistan. Cultivar named Golden time took maximum days to senescence (17.17) and White regret berg too least days (5.33). The difference in persistence life may be due to varietal characteristics (Tabassum *et. al.*, 2002).

Mishra and Saini (1997) studied the genetic variability for related parameters in twenty varieties of dahlia obtained from different sources. There was a wide range of variability for all the characters. High heritability was found for days taken to flower bud initiation.

Variation in leaf area among cultivars was also observed in carnation . Lesser number of leaves and shorter the leaves in this cultivars resulted in minimum leaf area. Since the cultivars varied for their number of leaves and length of leaves, leaf area also varied (Mahesh 1996).

Charles (1995) observed variations in number leaves per branches for various chrysanthemum cultivars were might be due to their genetic composition.

Kanamadi and Patil (1993) studied the performance of eight chrysanthemum cultivars in the transitional tract of Karnataka and found that the cv. Basanthi was found to be the tallest cultivar (29.50 cm), maximum number of leaves was observed in cultivars Red Gold (168.33)and minimum in CO-1 (58.0), the cultivar CO-1 produced the highest number of branches (20.33), while Basanthi produced the lowest number of flowers (4.0).

Over 15 genotypes of chrysanthemum were evaluated for their relative performance during kharif 1990 at floriculture garden of UAS, Dharwad. cultivar proved best for plant height (84.75 cm) and number of branch per plant (18.58). Genotype 64 showed maximum number of leaves and maximum leaf area (482.62 cm^2). Flowering period was ranged from 50.59 to 132.99 days among chrysanthemum genotypes. It was concluded that variation among chrysanthemum genotypes were due to the genetic makeup (Barigidad and Patil , 1992).

Cultivars of *marigold* were evaluated for flowering and plant characteristics. Ninety-four cultivars in spring 1989 and 108 cultivars in autumn 1989 were grown in field plots on raised, polyethylene-mulched beds. Subjective ratings for both seasons indicated that variation in flower yield was present cultivars. (Howe and Waters, 1991).

The difference in response to irradiance on lateral branching of stock plant can be attributed to interaction between genotype and irradiance or other environmental factors (Moe *et al.*,1988).

Supplemental photosynthetically active radiation (PAR; 77, 148 and 231. mu. mol s-1 m-2) was provided to C. morifolium Ramat 'Paragon' during 14 days each of rooting (24 h daily), long days (LD; 24 h daily) or short days (SD; 9 h daily) in a greenhouse, where it was found that branching response of chrysanthemum is controlled by genotype and environmental stimuli. (Hicklenton, 1985)

Chezhian *et al.* (1985) initially evaluated 73 cultivars of chrysanthemum for flower yield. Seven of them were advanced to comparative yield trial. Several local cultivars were compared and the new cultivars CO-1, which started flowering earlier by 15 to 20 days, and flowered for a longer time. The mean of two years yield of CO-1 was 16.7 tons per hectare as compared to 9.28 to 16.00

tons per hectare as compared to 9.28 to 16.00 tons per hectare in the local cultivars.

Negi *and Raghava (*1985) evaluated 12 chrysanthemum varieties along with three local varieties for three years under Bangalore conditions. The varieties exhibited significant differences for all the vegetative and floral characters. The variety 'Indira' was earliest to flower (107.97 days) followed by 'IIHR-Sel-5' (114.18 days), while 'IIHR-Sel-4' was late to flower (140.52 days). In red or pink colored flower group, the variety 'Red Gold' produced the highest flower yield (419.22 g/plant) followed by 'IIHR-Sel-5' (363.62 g/plant) and were good for loose flower purpose. In white colored flower group, 'IIHR-Sel-6' gave the highest flower yield.

Rajashekaran *et al.* (1985) evaluated 33 chrysanthemum cultivars and it was found that, cultivar MDU -1 flowered late (140 days) as compared to 120 days in local cultivar. The plants of this variety were medium in height (42.60 cm) and yield on an average 92 flowers per plant and the diameter of the flower was 3.90 cm.

Chaugule (1985) reported that in chrysanthemum there was a significant correlation between yield per plant and characters like plant height, number of leaves, number of shoots per plant.

In African marigolds the highest flower yield was noted in the cvs Cracker Jack and African Giant Double Orange, and in French marigolds in the cvs Rusty Red, F1 hybrid, Sussana and Butterscotch (Arora and Singh, 1980).

Lundstad (1975) evaluated 45 new cultivars of Floribunda and Polyantha roses during the period 1968-1972. It was found that cultivar Scarlet Elizabeth (84 cm)

was the tallest cultivar. The cultivars Gold Rausch and Tiptop produced flowers with high diameter (9.50 cm). Based on the results of evaluation, the cultivars Janspeck, Pernille, Pouisen and Tiptop were recommended as best.

Wilfret *et al.* (1973) evaluated 42 chrysanthemum cultivars as single plants in 4 in" dia pots for their potential use as a mass market product. The majority of the chrysanthemum cultivars were found to produce 6-8 flowers per lateral. Total number of potential flowers per plant was ranged from 25 to 100 by "BGA Sunnyside Up" and "CFPC Gold Pot" cultivars respectively.

Wesenberg *et al.* (1964) reported that the differences in longevity for several potted chrysanthemum were greatly related to cultivars whereas 1.9 to 15.4 cm range of flower diameter was reported.

2.2 Methodology related literature

Mehraj *et al.* (2014) conducted an experiment at Sher-e-Bangla Agricultural University for morphological characterization of three strawberry germplasm viz. V_1 (Germplasm-01), V_2 (Germplasm-02) and V_3 (Germplasm-03). It was stated that morphological variables of a set of germplasm were determined to provide information for breeders. Grouping was done to classify strawberry germplasm based on morphology. It was found from the experiment that Germplasm-01 commercially suitable (except the seedling production) germplasm for the farmers. But the grower who desired the both seedling and yield with quality can select Germplasm-03. Germplasm-01 was found as the best for commercial production in Bangladesh.

Chrysanthemum morifolium Ram is a perennial type has considerable number of varieties which differ in the size of the plant, shapes, size and colour of flower, weight and number of flowers, plant girth and flowering season. The number of varieties in the world is reported to be above 2000, which are in existence which include exotic as well as indigenously developed in many countries. (Joshi *et al.*, 2010).

The colour, or decorative value of a given cultivar, is determined by pigments contained mainly in ray (ligulate) florets (Lema-Rumi and Zalewska, 2005).

Thirty small flowered cultivars of chrysanthemum were selected and their different morphological characters and chlorophyll content of leaves both at vegetative and flowering stages were determined and categorized on the basis of their flower types for preparation of chrysanthemum check list. This will help in identification of varieties and for selection of desirable characters for cultivar (Gupta and Dutta, 2005).

The success in cultivation of chrysanthemum due principally 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 the consumer (Barbosa, 2003).

A study was carried out at the National Institute of Agricultural Botany to develop a machine vision system that assesses the shape of chrysanthemum The characters used to describe the leaf shape the paper illustrates the methods used to classify shape and concludes with a comparison of the results obtained by the machine with more conventional assessments (Warren, 1997).

Vidrascu and Teodorescu (1993) mentioned that Chrysanthemums are used either as cut flowers or grown in pots .

Dhaka, Gazipur, Narsingdi, Narayangonj, Tangail, Jamalpur, Mymensingh, Kishoregonj districts covering 4244 km^2 area belongs to Agro-Ecological Zone of Madhupur Tract (AEZ No. 28) among 30 AEZ in Bangladesh having upland area with well drained red brown soil, mean annual rainfall is about 2000 mm in south and 2300 mm in north, annual temperature is about 25.3^{0}C (UNDP – FAO, 1988).

Preservation of herbaceous ornamental crop germplasm has been traditionally achieved by private and public sector flower breeding programs. There are numerous challenges in germplasm preservation and accessibility, including collection of germplasm, determining crop centers of origin, conservation methodologies, genepool creation, conservation concepts, genebank procedures. Characterization is the description of plant germplasm, it is essential to provide information on the accerted traits ensuring the maximum utilization of the germplasm collection to the final users.It is done by growing a large number of accessions of a collection in a normal growing season specifically for this purpose (Tay, 1987).

The color inheritance of chrysanthemum is additionally complicated. Color classes and responsible pigments for color in chrysanthemum flowers are white, due to flavonols; yellow, conditioned by carotinoids; pink to purples caused by anthocyanins and flavonols; and bronze (orange to red) determined by anthocyanins with carotenoids (Kawase and Tsukamoto, 1974).

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter illustrates information concerning methodology that was used for execution of the experiment. It comprises a short portrayal of location of experimental site, climatic condition, materials used for the experiment, treatments of the experiment, data collection procedure and statistical analysis etc.

3.1 Experimental site

The experiment was accomplished at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period from June 2011 to March 2012. Location of the site is $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 condition

Experimental site was located in the subtropical monsoon climatic zone, set aparted by heavy rainfall during the months from April to September (Kharif season) and scantly of rainfall during the rest of the year (Rabi season). Plenty of sunshine and moderately low temperature prevails during October to March (Rabi season), which is suitable for chrysanthemum growing in Bangladesh.

3.3 Planting materials

Growing chrysanthemum plants from a sucker is, for most, the easiest and quickest way to propagate. Suckers of chrysanthemum were collected from the Horticulture farm. New plant was generated by planting sucker of the chrysanthemum.

3.4 Treatment of the experiment

The experiment was conducted for characterization and phenotypic evaluation of chrysanthemums. Single factorial experiment was conducted and treatments consisted 32 chrysanthemum cultivars (Plate 1) which were as follows:

V_1 : Crimson Tide
V_2 : Samsan
V_3 : White Snowball
V_4 : Chandramukhi
V_5 : Lexy
V_6 : Rose Pink
V_7 : Yellow Glow
V_8 : Ruby Red
V_9 : Gold Apricot
V_{10} : Sunny Yellow
V_{11} : Lavender Mum
V_{12} : Giant Bronze
V_{13} : Purple Mum
V_{14} : Moon Ball
V_{15} : Yellow Bay
V_{16} : Pink Shasta Daisy
V_{17} : Bernadette Yellow
V_{18} : Mammoth Yellow
V_{19} : Auburn Daisy
V_{20} : Sweet Vase
V_{21} : First Light
V_{22} : Flying Saucer
V23 : Zipsy
V24 : Gold Mundial
V_{25} : Red Wing
V_{26} : Trendy Time
V_{27} : Rising Sun
V_{28} : BARI chrysanthemum 2
V_{29} : Rayonnate spider
V_{30} : Flair spider
V_{31} : Wisp of Red
V_{32} : Satin Ribbon

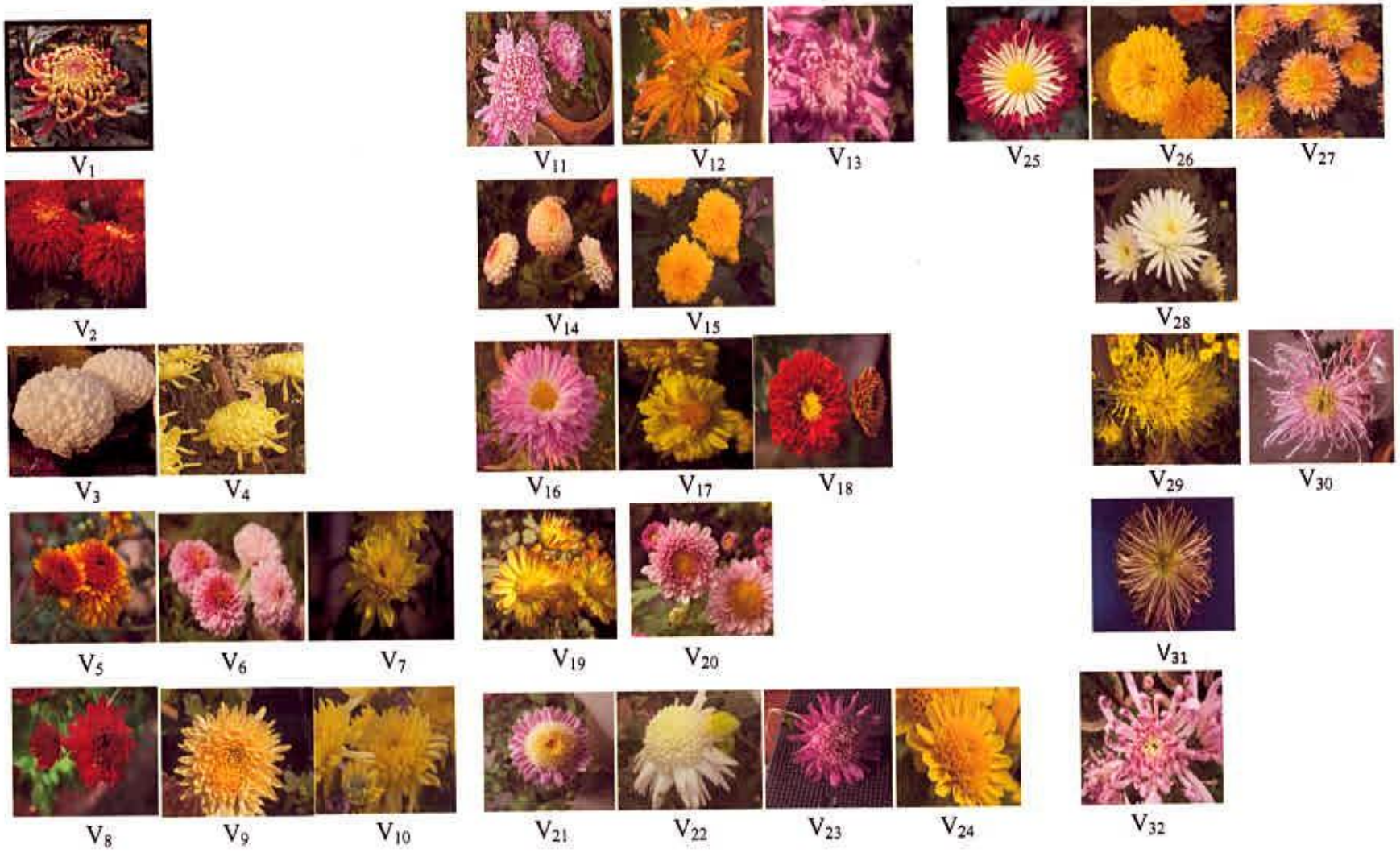

Plate 1. Pictorial presentation of 32 chrysanthemum cultivars

3.5 Design and layout of experiment

Single factor experiment was laid out in Completely Randomized Design (CRD) with three replications, with three plants for each replication thus comprised total 288 pots. The size of each pot was 25 cm (10 inches) in diameter and 20 cm (8 inches) in height.

3.6 Production technology

3.6.1 Pot preparation

Soil (approx.2.5kg/pot) and cow dung (approx. 1.5kg/pot) were mixed and pots were filled 7 days before transplanting. Weeds and stubbles were completely removed from the soil. No chemical fertilizer was used.

3.6.2 Planting of suckers

Suckers were planted at 7cm depth in pot on 10th October, 2012 with sufficient care for minimum injury of suckers. Total 288 pots were used in the experiment and single plant was planted in each pot. Three plants were used for a single replication.

3.6.3 Tagging of plants

Plants were marked with tags according to 32 cultivars to collect data.

3.6.4 Intercultural Operations

Weeding

Weeding was done in all pots as and when required to keep the plants free from weed by hand picking.

Watering

Chrysanthemums require a good amount of water to maintain optimum health water logging is avoided as it is harmful to plants. Frequency of watering depended upon the moisture status of soil.

Disease and pest management

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 attacked by aphids during the growing stage. Aphid was controlled by spraying Malathion @ 1.5 ml/L. Insecticides were sprayed two times at seven days interval.

3.6.5 Parameters

Data were collected on following parameters

1. Plant height
2. Number of branch
3. Leaf area
4. Number of leaf per branch
5. Chlorophyll content
6. Days to flower bud initiation
7. Days to first petal spread
8. Days to final bloom
9. Number of flower bud per plant
10. Number of flower per branch
11. Number of flower per plant
12. Bud diameter at initiation stage
13. Bud diameter at mature stage
14. Flower head diameter
15. Flower color
16. Stalk length
17. Flower durability in plant (Days to 50% flower senescence)

3.7 Data collection

Data were collected in respect of the following parameters from each pot within the mentioned period.

3.7.1 Plant height

Height of plant refers to the length of the plant from ground level up to the tip of the longest leaf and it measured in cm at every 10 days interval after 30 days of transplanting (DAT) and continued up to 50 days.

3.7.2 Number of branches per plant

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

3.7.3 Leaf description

In this study chrysanthemums are described as a set of characters that describe features ranging from plant height to bloom color. Among these characters, some are used to describe the shape of the leaves of each respective cultivar. Based on these characters leaves of 32 chrysanthemum cultivars are classified according to different shapes and concluded with a comparison within class similarity and between class similarities. Leaf shape was assessed as the flower buds were 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).

3.7.4 Leaf area measurement

Leaf area was measured by destructive method using CL-202 Leaf Area Meter (USA) (Plate 2c). Mature leaf from each plant were measured after flowering and expressed in cm^2. Five mature leaves from each plant were measured and then average it after that mean was calculated.

3.7.5 Number of leaves per branch (20 cm)

Number of leaves per branch was recorded by counting all the leaves from the 20 cm middle length of selected branch from each tagged plant /20 cm of a single branch from each plant of each pot. It was measured in number.

3.7.6 Chlorophyll content

Fully mature leaves were selected. Then chlorophyll were estimated by SPAD-502 and expressed in percentage. Three mature leaves from each plant were measured and then average it after that mean was calculated.

3.7.7 Days to flower bud initiation

Days to flower bud initiation were measured by counting the number of days from transplanting to bud initiation when buds were visible.

3.7.8 Days to first petal spread

Days to first petal spread were measured by counting the number of days from bud initiation to when flower started to open.

3.7.9 Days to final bloom

Days to final bloom were measured by counting the number of days from bud initiation to when flower are fully open.

3.7.10 Number of flower buds per plant

Number of flower buds produced in each plant was recorded by counting all the flowering buds of each plant.

3.7.11 Number of flower per branch (20 cm)

Number of flower per branch was recorded by counting the entire flower from the 20 cm middle length of selected branch from each tagged plant. It was measured in number.

3.7.12 Number of flower per plant

Number of flower produced in each plant was recorded by counting all the flowers of each plant.

3.7.13 Flower bud diameter

Flower bud diameter at initiation stage and fully mature stage that are about to open in the next day both were measured using Digital Caliper-515 (DC-515) in millimeter (mm).

3.7.14 Flower head diameter

Diameter of fully opened flower head was taken using meter scale and expressed in centimeter (cm).

3.7.15 Flower color

The color of flower was noted by visual observation. Varieties of colors were recorded by following Royal Horticultural Society Color Chart for each cultivar.

3.7.16 Stalk length

The total length from base of the branch to terminal node of flower was taken as stalk length and expressed in centimeter.

3.7.17 Flower durability in plant (Days to 50% flower senescence)

Flower durability in plant was measured by counting the duration of time in days that flower remains good condition in plant.

3.7.18 Classification of the chrysanthemum flower

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; similar to other members of Asteraceae, the chrysanthemum flower is born in capitulum (or flower head) inflorescence with petal like disk florets in the center and smaller ray florets in the perimeter.

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, fuji, 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 divides bloom with varying forms into 13 classes (Plate 2).

Class 1: 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

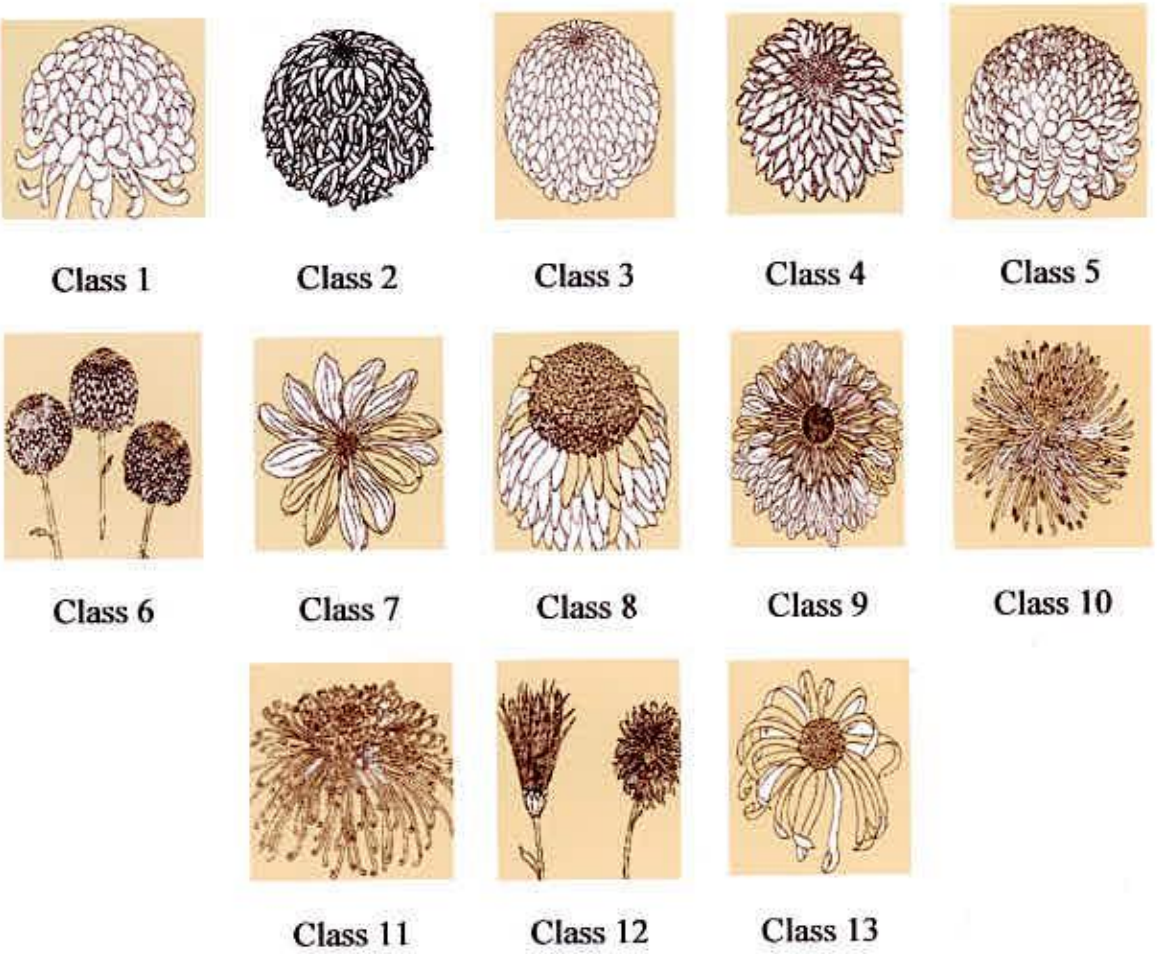

Plate 2. Pictorial representation of classification of chrysanthemum according to floret (National Chrysanthemum Society Classification, USA)

3.8.19 Statistical analysis

Collected data were statistically analyzed using MSTAT-C computer package programme. Mean for every treatments were calculated and analysis of variance for each one of characters was performed by F–test (Variance Ratio). Difference between treatments was assessed by Least Significant Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984). Correlations between different cultivars i.e., dendrogram was build up by SPSS computer program (SPSS 19.0.1).

a.

b.

c.

d.

e.

Plate 3: a. Measurement of plant height using meter scale in cm; **b.** Leaf area measurement using CL-202 Leaf Area Meter (USA) in cm2; **c.** Measurement of percentage of chlorophyll using SPAD-501 meter; **d.** Flower bud diameter measurement using Digital Caliper -515 (DC- 515) in millimeter (mm); **e.** Measurement of flower head diameter using meter scale in cm

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

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The research work was accomplished for the characterization of chrysanthemum cultivars and evaluated their performance on the basis of phenotypic characteristics. Crops characteristics differed among the cultivars due to their genetic variation. 32 chrysanthemum cultivars were evaluated on the experiment that was differentiated in terms of different characters.

4.1 Plant height

Significant variation was found among chrysanthemum cultivars performance in terms of plant height (Appendix I). Plant height of chrysanthemum exposed statistically significant variation among 32 cultivars at 30, 40 and 50 DAT (Figure 1). The range of plant height was from 71.8 cm to 23.7 cm. The tallest plant was found from V_{13} (71.8 cm) whereas the shortest from V_8 (23.7 cm) at 50 DAT of chrysanthemum cultivars (Table 1). Present study referred that V_{13} (Sunny Yellow) exposed as the tallest plant among the cultivars at mature stage. Kim *et al.* (2014) found a range of 19.3–64.6 cm plant height in 15 Taxa of Korean chrysanthemum species and Ara *et al.* (2012-2013) found a range of 36-70 cm. While Chandragiri *et al.* (2004) recorded maximum 132.16 cm plant height from Solomon Impala variety of chrysanthemum. Some cultivars of chrysanthemum were vigorous in growth and some were less vigorous, this might be caused by varietal characters responsible by a gene. As a genetically controlled factor, plant height varied among the cultivars of chrysanthemum (Kanamadi and Patil, 1993; Barigidad and Patil, 1992 and Baskaran *et al.*, 2004). Similar variation in plant height among varieties was also observed in marigold (Raghuvanshi *et al.*, 1982) and in rose (Lundstad, 1975; Hussain and Khan, 2004). The higher plant height obtained from plants could be attributed to increased photosynthetic capacity of the plants (Nxumalu and Wahome, 2010). Similar results were reported in asters (Vrsek *et al.*, 2006).

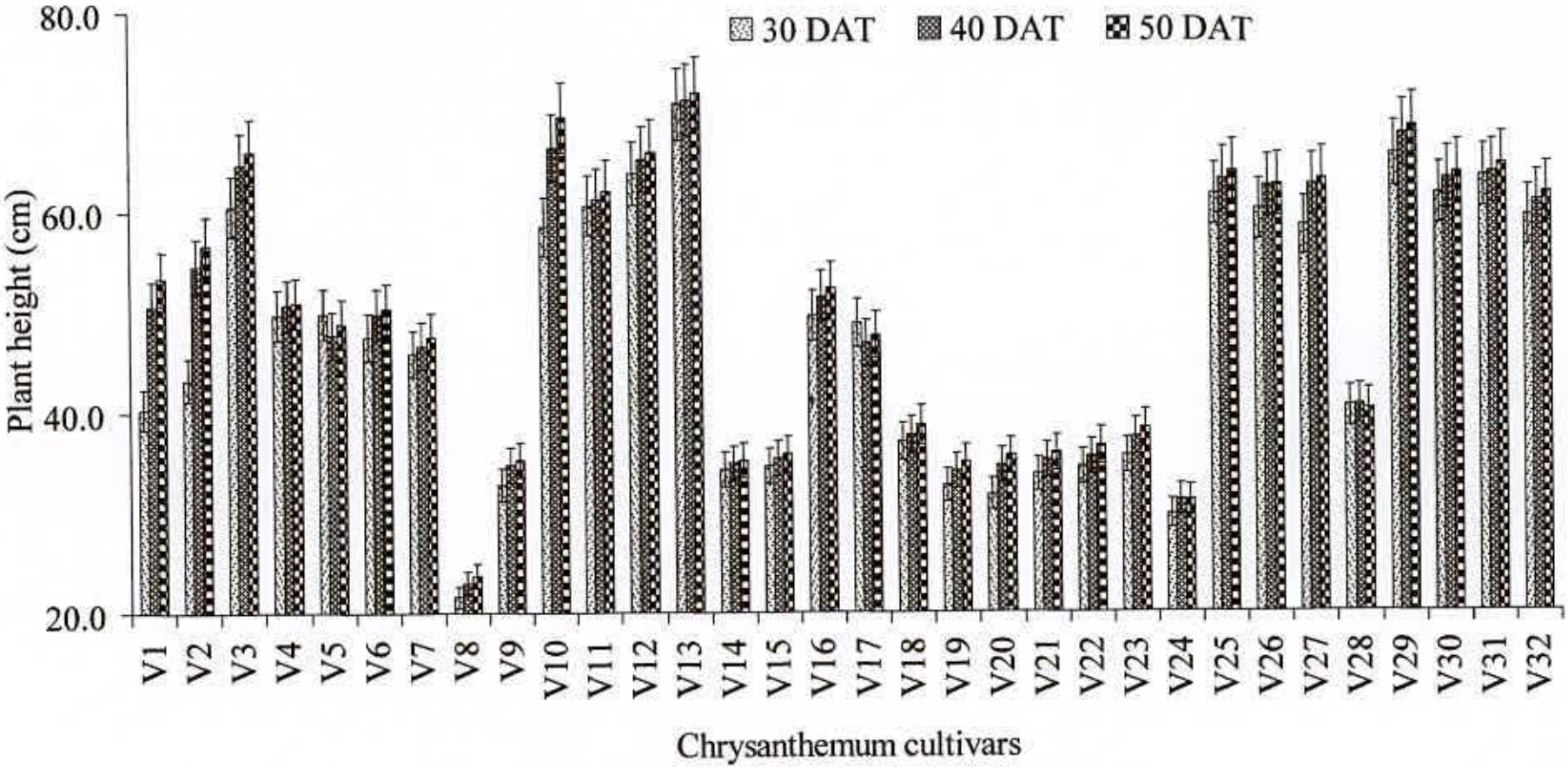

Fig. 1. Performance of 32 chrysanthemum cultivars for plant height at different days after transplanting

4.2 Number of branches per plant

Chrysanthemum cultivars showed significant variation for number of branches per plant (Appendix II). The 32 cultivars showed statistically significant difference at 30, 40 and 50 DAT (Figure 2) for number of branches per plant. Maximum number of branch was recorded from V_6 (19.7/ plant) while minimum from V_2 (2.5/ plant) at 50 DAT of chrysanthemum cultivars (Table 2). V_7 cultivar (Yellow Glow) performed best in case number of branches per plant. Chaugule (1985) recorded a maximum 16.56 branches in chrysanthemum. Barigidad and Patil (1992) recorded a range of 2.75 to 18.58 branches in case of chrysanthemum cultivar. Difference in branches among the chrysanthemum cultivars could be due to influence of genetical make up of chrysanthemum cultivars (Hicklenton, 1985; Moe, 1988; Chezian *et al.*, 1985 and Kanamadi and Patil, 1993). Similar variations for number of branches was also observed in China aster (Munikrishnappa *et al.*, 2012)

4.3 Number of leaves per 20 cm branch

Chrysanthemum cultivars showed significant variation for number of leaves per 20 cm branch (Appendix III). Maximum number of leaves was observed from V_{11} (13.3/20 cm branch) and minimum from V_{14} and V_{24} (4.5/20 cm branch) (Table 1). The result referred that V_{11} (Lavender Mum) produced maximum number of leaves per branch (20 cm). Similar result on number of leaves was observed by Barigidad and Patil (1992) in chrysanthemum. Variation in number of leaves was previously reported by Wilfret *et al.* (1973). This difference for number of leaf per branch among cultivars was due to their genetic composition (Charles, 1995).

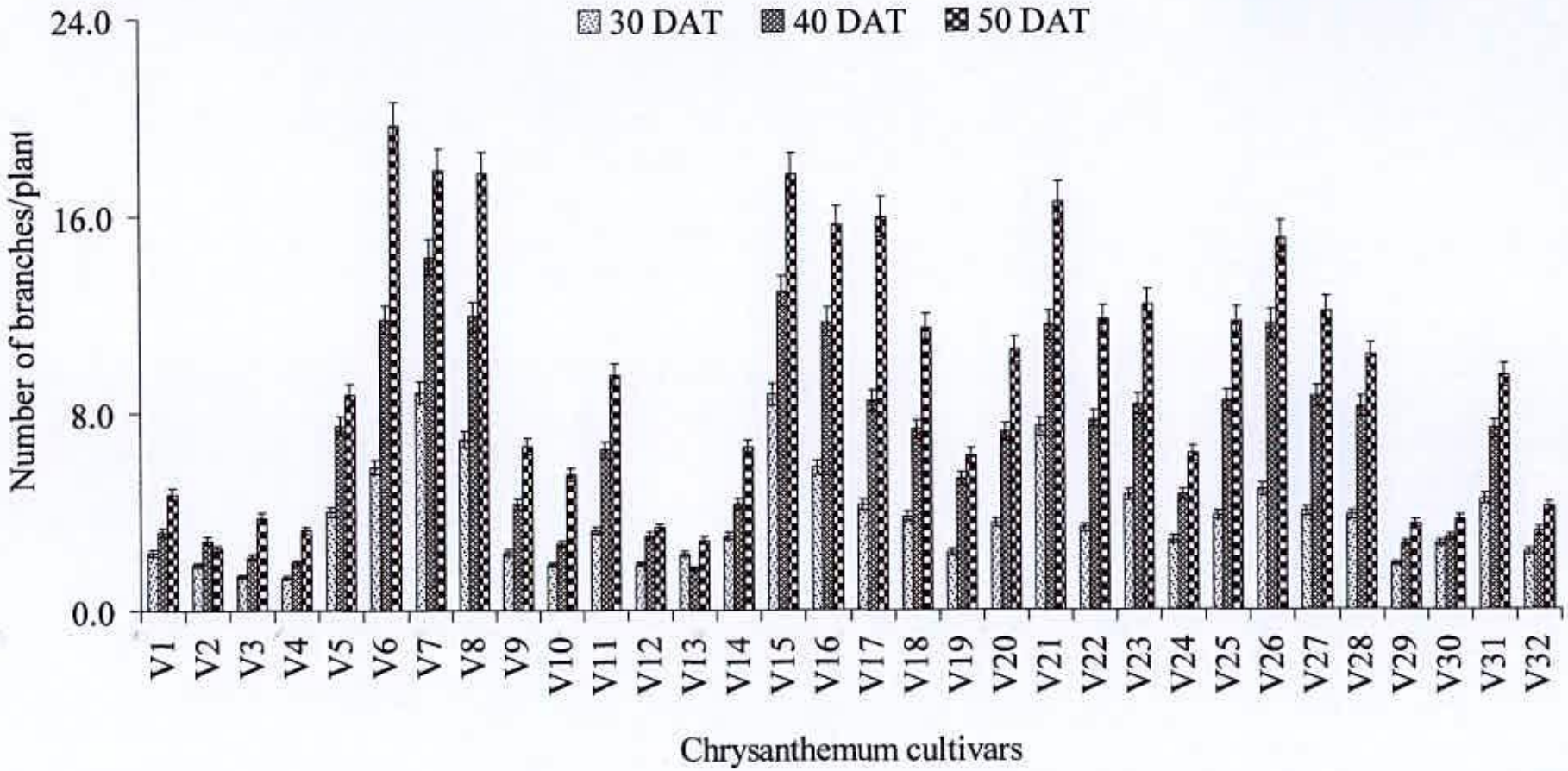

Fig. 2. Performance of 32 chrysanthemum cultivars for number of branches/plant at different days after transplanting

4.4 Leaf area

Leaf area showed significant variation among chrysanthemum cultivars performance in respect of leaf area (Appendix III). Maximum leaf area was found from V_1 (52.9 cm^2) whereas minimum from V_{29} (5.9 cm^2) which scored lowest after flowering (Table 1). The result showed that V_1 (Crimson Tide) provided maximum leaf area. Mitra and Paul (2008) recorded 47.2 cm^2 leaf area in unpinched single stem cultivar of chrysanthemum. Greater leaf area may lead to more dry matter accumulation, which resulted in the accumulation of maximum photosynthates that contributed to produce bigger sized flower or more number of flowers. Similar variation in leaf area among cultivars was found in carnation (Gharge *et al.*, 2009; Shiragur *et al.*, 2004). Variation in leaf area indicates additive gene effects would be effective in Gerbera (Nair and Shiva, 2003), Dahlia (Vikas *et al.*, 2011) and in Chrysanthemum (Barigidad and Patil, 1992). Leaf area was found to be positively related with flower yield in carnation (Mahesh *et al.*, 1996).

4.5 Chlorophyll content

Chlorophyll content varied significantly among chrysanthemum cultivars (Appendix III). Maximum chlorophyll content was obtained from V_{10} (59.0 %) and lowest was obtained from V_{29} (23.9 %) at mature stage (Table 1). This finding referred that V_{10} (Sunny Yellow) produced maximum chlorophyll percentage. Similar findings were obtained in wheat by Hamblin *et al.* (2014). This variation in chlorophyll percentage might be attributed to genetical differences. This variation might be due to the varietal characters as reported by (Thomas and Lekharani, 2008) in orchid. Chlorophyll content in leaf enhanced photosynthetic activity, which produce carbohydrates. Carbohydrates serve as energy source for growing bud, flower opening and longevity. The ultimate effect of all these factors resulted into strong and long flower stalks, large sized buds or flower (Tarannum, 2014).

Table 1: Performance of 32 chrysanthemum cultivars on plant height, number of branch, number of leaf per branch (20cm), leaf area and chlorophyll content[Y]

Cultivar[X]	50 DAT		No. of leaf/branch (20 cm)		Leaf area (cm^2)		Chlorophyll content (%)	
	Plant height (cm)	Number of branch/plant						
V_1	53.4 h	4.7 m	6.3	ghijk	52.9	a	48.7	l
V_2	56.8 g	2.5 q	5.8	ijklm	50.0	b	47.8	n
V_3	66.0 c	3.8 no	5.3	lmno	23.8	gh	52.2	gh
V_4	50.9 ij	3.3 op	5.6	klmno	42.2	c	49.0	l
V_5	48.9 kl	8.8 j	6.9	efg	20.9	l	41.8	q
V_6	50.4 jk	19.7 a	9.4	c	10.8	r	48.5	lm
V_7	47.6 l	17.8 b	9.5	c	35.8	e	55.9	c
V_8	23.7 r	17.7 b	10.4	b	15.9	q	53.7	ef
V_9	35.3 op	6.7 k	6.5	ghij	31.2	f	57.7	b
V_{10}	69.5 b	5.5 l	4.8	op	18.6	m	59.0	a
V_{11}	62.1 f	9.5 i	13.3	a	20.8	l	45.6	o
V_{12}	65.9 c	3.3 op	6.3	ghijk	20.6	l	50.5	j
V_{13}	71.8 a	2.8 pq	6.5	ghij	49.7	b	50.3	jk
V_{14}	35.2 op	6.6 k	4.5	p	18.0	mn	50.6	j
V_{15}	35.8 op	17.7 b	12.8	a	15.8	q	49.7	k
V_{16}	52.3 hi	15.6 de	5.7	jklmn	22.2	k	43.0	p
V_{17}	47.7 l	16.0 cd	7.4	de	17.2	op	40.4	r
V_{18}	38.7 n	11.5 g	7.7	d	17.6	no	51.6	hi
V_{19}	35.0 p	6.2 k	6.7	efgh	7.3	s	30.3	t
V_{20}	35.6 op	10.6 h	6.5	ghij	7.2	st	31.0	s
V_{21}	36.0 op	16.6 c	6.0	hijkl	6.5	tu	28.7	u
V_{22}	36.6 o	11.8 fg	8.8	c	24.2	g	55.0	d
V_{23}	38.3 n	12.4 f	6.6	fghi	15.6	q	54.4	de
V_{24}	31.1 q	6.3 k	4.5	p	7.4	s	28.6	u
V_{25}	63.9 de	11.7 fg	7.5	de	39.4	d	50.9	ij
V_{26}	62.6 ef	15.0 e	6.3	ghijk	16.7	p	47.8	mn
V_{27}	63.2 def	12.1 fg	5.7	jklmn	22.4	jk	53.5	f
V_{28}	40.3 m	10.3 h	5.9	ijkl	23.1	hi	57.0	b
V_{29}	68.5 b	3.5 nop	5.8	ijklm	5.9	u	23.9	v
V_{30}	63.9 de	3.7 no	5.1	mnop	23.0	ij	52.5	g
V_{31}	64.7 cd	9.5 i	5.0	nop	23.2	hi	52.4	g
V_{32}	61.9 f	4.2 mn	7.3	def	23.9	g	51.8	gh
CV%	0.6	4.4	7.0		1.9		0.9	
$LSD_{(0.05)}$	1.5	0.7	0.8		0.7		0.7	

[X]Chrysanthemum cultivars

[Y]In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.6 Days to flower bud initiation

Significant variation in case of days taken for flower bud emergence (from days after transplantation of chrysanthemum suckers) was found (visual observation) among 32 chrysanthemum cultivars (Appendix IV). Late flower bud initiation was found in V_9 (52.7 days) while earlier in V_3 (17.8 days) (Table 2). This findings referred that V_3 (White Snowball) was early flower bud initiating cultivar. Difference in number of days for flower bud initiation, number of days for flowering among different cultivars might be due to presence of sufficient genetic variability. Similar findings were obtained in Dahlia by Mishra and Saini (1997).

4.7 Days to first petal spread

Significant variation was received among the chrysanthemum cultivars in respect of days taken to first petal spread (from days after transplantation of chrysanthemum suckers) (Appendix IV). The shortest period was required for first petal spread in V_3 (39.5 days) while the longest period in V_4 (71.6 days) (Table 2). The result showed that V_3 cultivar (Sweet Vase) required minimum days for first petal spreading. Chrysanthemum required maximum 74.2 days for flower initiation (Wilfret, 1985) and minimum 31.25 days for first flower initiation (Joshi *et al.*, 2010b). This difference was due to genetical makeup of the cultivars. Similar variation was found in chrysanthemum (Baskaran *et al.*, 2010) and China aster (Zosiamliana *et al.*, 2012).

4.8 Days to final bloom

Significant difference was found among the chrysanthemum cultivars for days taken from planting to final bloom (Appendix IV). The shortest period was required for final bloom in V_6 (52.8 days) while the longest period in V_4 (77.5 days) which was statistically identical with V_{10} (77.3 days) ,V_1 (77.2 days),V_9 (76.7 days) and V_{30} (76.7 days) (Table 2). The result showed that V_6 (Rose Pink) was early blooming cultivar. Flowering period was ranged from 50.59 to

132.99 days in chrysanthemum (Barigidad and Patil, 1996), which resulted late and early flowering habits among cultivars Flowering times in chrysanthemum are affected by varietal characters, habitat and species type (Kim *et al.*, 2014 and Rajashekaran *et al.*, 1985).

4.9 Number of flower buds per plant

Significant difference was observed for cumulative number of flower buds per plant in chrysanthemum cultivars (Appendix V) at 30, 40 and 50 DAT (Figure 3). Maximum cumulative number of flower bud was found from V_{15} (199.0/plant) whereas minimum was found from V_2 (4.3/plant) at 50 DAT of chrysanthemum cultivars (Table 2). V_{15} cultivar (Yellow Bay) showed the best result in case of number of flower bud per plant.

4.10 Number of flowers per branch (20 cm)

Significant variation was found among the chrysanthemum cultivars in case of number of flower per branch (Appendix VI). Maximum number of flower was found in V_{15} (9.4/ 20 cm branch) while minimum from V_1, V_2, V_{10}, V_{21}, V_{24}, V_{30} and V_{31}, (1/ 20 cm branch) (Table 2). This findings referred that V_{15} (Yellow Bay) produced maximum number of flower per branch. Numbers of maximum potential flowers per lateral branches were recorded, ranged from 6 to 8 (Wilfret *et al.*, 1973). The highest number of flowers/branch (10.43) was produced by genotype White Anemone followed by Gauri (9.08) and Appu (7.66) (Punetha *et al.*, 2011) Variation in number of flowers per plant is related to recurrent blooming habit due to their genetic makeup (Nadeem *et al.*, 2011). Variation in flower yield was also observed previously in China aster (Negi and Raghava, 1985), in chrysanthemum (Chezhian *et al.*, 1985) and marigold (Howe and Waters, 1991).

4.11 Number of flowers per plant

Significant variation was recorded among chrysanthemum cultivars performance in respect of number of flower per plant (Appendix VI). Maximum number of flower was found from V_{15} (194.6/plant) whereas minimum was recorded form V_2 (4.3/plant) (Table 2). The result showed that V_{15} (Yellow Bay) performed as maximum flower producing cultivar. Chrysanthemum flower number was ranged from 25.0 to 100.0/ plant (Wilfret *et al.,* 1973) and 66.0 to 301.0 /plant (Punetha *et al.*, 2011). Cultivar Button Type Local recorded the highest number of flowers per plant (287.00), whereas cv. Cass recorded the lowest (37.00) (Baskaran *et al.,* 2004). In an experiment Ara et al. (2012-13) recorded maximum 70 flower per plant in Chrysanthemum. Variation in number of flowers per plant was also observed previously in chrysanthemum (Chezhian *et al.,* 1985) and in gerbera (Mahmood *et al.*, 2013). Further these genotypes had fairly high dry matter accumulation which might have contributed for increase flower yield. Similar results were obtained in chrysanthemum (Negi and Raghava, 1985) and in marigold (Arora and Singh, 1980) and in gerbera (Nair and Mehedi, 2002). Higher yield might be due to increase in morphological parameters like plant height, number of leaves and leaf area which might have contributed in production of more photosynthates resulting in greater accumulation of dry matter which in turn leads to production of more number of flowers per plant (Ramzan *et al.*, 2014).

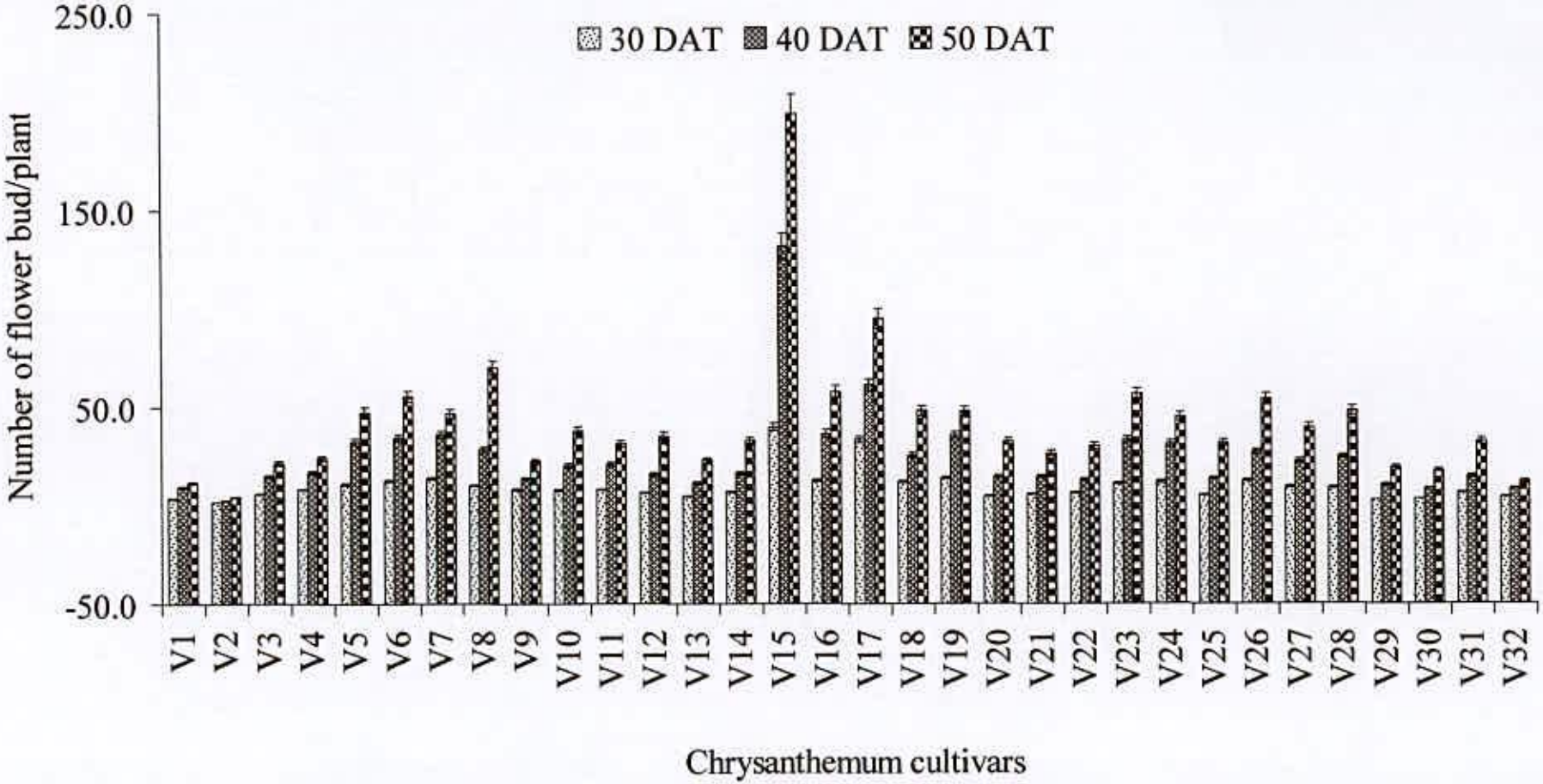

Fig. 3. Performance of 32 chrysanthemum cultivars for number of flower bud/plant at different days after transplanting

Table 2: Performance of 32 chrysanthemum cultivars on days to flower bud initiation, days to first petal spread, days to final bloom, number of flower bud/plant, number of flower/branch (20 cm) and number of flower/plant[Y]

Cultivar[X]	Days to flower bud initiation		Days to first petal spread		Days to final bloom		No. of flower bud/plant at 50 DAT		No. of flower /branch (20 cm)		No. of flower /plant	
V_1	49.3	b	66.6	de	77.2	a	11.7	x	1.0	k	10.3	t
V_2	38.8	c	58.7	kl	73.5	d	4.3	y	1.0	k	4.3	v
V_3	17.8	r	39.5	v	59.9	o	21.4	u	2.8	i	20.3	q
V_4	34.4	de	71.6	a	77.5	a	24.3	s	2.8	i	22.6	p
V_5	31.7	f	55.3	o	68.7	jk	47.5	hi	5.1	e	46.7	f
V_6	26.5	lm	44.0	t	52.8	r	55.5	f	8.5	b	54.7	d
V_7	24.8	n	52.7	pq	64.5	m	46.8	i	6.8	d	45.6	g
V_8	33.7	e	58.3	lm	70.3	hi	70.2	c	7.9	c	67.6	c
V_9	52.7	a	67.4	cd	76.7	a	22.5	t	2.8	i	20.3	q
V_{10}	29.3	gh	69.5	b	77.3	a	38.1	l	1.0	k	36.3	j
V_{11}	27.6	jk	56.6	n	72.6	e	31.4	p	6.5	d	29.3	m
V_{12}	32.5	f	62.7	f	72.4	ef	35.3	m	3.0	hi	30.7	k
V_{13}	23.8	o	62.5	fg	74.5	bc	22.8	t	3.8	f	20.5	q
V_{14}	29.3	gh	57.5	m	71.5	fg	33.2	n	3.5	fg	30.3	kl
V_{15}	28.2	ij	60.2	ij	74.6	bc	199.0	a	9.4	a	194.6	a
V_{16}	22.7	p	48.0	r	73.8	cd	58.0	d	1.8	j	55.5	d
V_{17}	23.9	no	55.4	o	69.2	j	95.0	b	3.6	f	92.0	b
V_{18}	24.4	no	46.0	s	54.6	q	48.2	h	3.1	ghi	45.9	g
V_{19}	28.8	hi	53.6	p	69.2	j	47.6	h	3.4	fgh	45.4	g
V_{20}	28.4	ij	42.2	u	56.6	p	32.6	n	3.0	hi	29.7	lm
V_{21}	31.9	f	52.8	pq	65.2	m	26.6	r	1.0	k	26.7	o
V_{22}	28.0	ijk	67.6	c	74.4	bc	30.3	q	3.0	hi	27.6	n
V_{23}	26.6	lm	61.6	gh	74.3	bcd	56.4	e	3.0	hi	55.3	d
V_{24}	25.8	m	55.7	no	67.7	l	44.8	j	1.0	k	42.4	h
V_{25}	28.5	hi	59.4	jk	68.0	kl	31.8	op	3.5	fg	29.7	lm
V_{26}	34.8	d	60.9	hi	71.8	efg	54.7	g	3.0	hi	51.7	e
V_{27}	34.3	de	65.7	e	74.9	b	39.6	k	2.0	j	38.5	i
V_{28}	19.1	q	52.4	q	62.0	n	48.2	h	2.9	i	45.8	g
V_{29}	21.2	kl	59.3	jk	71.0	gh	19.5	v	1.8	j	17.5	r
V_{30}	29.3	gh	61.8	g	76.7	a	17.7	w	1.0	k	14.5	s
V_{31}	30.2	g	57.7	m	69.5	ij	32.5	no	1.0	k	30.5	kl
V_{32}	30.0	g	55.7	o	69.4	j	11.8	x	3.0	hi	9.5	u
CV%	1.8		1.0		0.8		1.1		8.1		1.2	
$LSD_{(0.05)}$	0.9		0.9		0.9		0.8		0.4		0.8	

[X]Chrysanthemum cultivars

[Y]In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.12 Bud diameter at initiation stage

Bud diameter of chrysanthemum cultivars varied significantly at initiation stage (Appendix VI). Maximum bud diameter was obtained from V_4 and V_{10} (7.1 mm) cultivars whereas minimum was obtained from V_{19} and V_{24} (1.7 mm) cultivars at initiation stage (Table 3). This result showed that V_4 (Chandramukhi) and V_{10} (Sunny Yellow) provided maximum bud diameter at initiation stage.

4.13 Bud diameter at mature stage

Significant variation was observed among chrysanthemum cultivars in terms of bud diameter at mature stage (Appendix VI). Maximum bud diameter was found from V_1 (19.1 mm) whereas minimum was found from V_{24} (6.3 mm) which was statistically identical with V_{15} (6.5 mm) and V_8 (6.9 mm) (Table 3). The findings referred that V_1 (Crimson Tide) provided maximum bud diameter at mature stage. Small sized flowers are produced due to the less number of petals in its flower bud and large sized flowers are produced due to more number of petals in flower bud. Similar findings were found in carnation by (Maitra and Roychowdhury, 2014)

4.14 Flower head diameter

Flower diameter showed significant variation among chrysanthemum cultivars after blooming (Appendix VII). Maximum flower diameter was recorded from V_1 (17.6 cm) while minimum from V_{14} (2.8 cm) which was statistically identical with V_{15} (2.9) (Table 3). This result indicated that V_1 (Crimson Tide) cultivar produced maximum flower diameter. Flower diameter of chrysanthemum ranged from 8.0 to 12.4 cm (Kunigunda, 2004) whereas 1.9 to 15.4 cm (Wesenberg *et al.*, 1964) and 2.5 to 7.8 cm (Ara *et al.*, 2012-13). The maximum diameter of 'Crimson Tide' might be due to inherent character of individual cultivars. Similar variations have been reported previously in Chrysanthemum (Kanamadi and Patil, 1993 and Rajashekaran *et al.*, 1985), in Gerbera (Mahmood *et al.*, 2013).

4.15 Stalk length

Significant variation was recorded for stalk length among chrysanthemum cultivars (Appendix VII). The longest stalk of chrysanthemum flower was found from V_1 (20.1 cm) which was statistically identical with V_{13} (19.8 cm) and V_2 (19.7 cm) while the shortest was found from V_{11} (4.4 cm) which was statistically identical with V_5 (4.5 cm), V_6 (4.7 cm), V_9 (4.7 cm), V_{19} (4.8 cm), V_{24} (4.8 cm), V_{23} (4.9 cm) and V_{26} (5.0 cm) (Table3). The result indicated that V_1 (Crimson Tide) cultivar performed as the longest stalk length producing cultivar. This difference in stalk length could be attributed to a genetic factor which is expected to vary among cultivars. Similar findings were found in gerbera by Sarkar and Ghimaray (2004). It was observed that the cultivars with higher plant height produced the longer flower stalk as compared to cultivars with smaller plant heights. Similar findings were reported by Ramzan *et al.* (2014) in rose and Shafique *et al.* (2011) in snapdragon. Similar results were reported in rose by Mantur *et al.* (2005) and Fascella and Zizzo (2007).

4.16 Flower durability (Days to 50% flower senescence)

Chrysanthemum cultivars showed significant variation in terms of days taken to 50% flower senescence (Appendix VII). Late flower senescence was recorded in V_{21} (20.7 days) which was statistically identical with V_{11} (19.8 days) while early flower senescence was observed in V_{24} (11.3 days) (Table 3). The result indicated that V_{21} (First Light) and V_{11} (Lavender Mum) cultivars performed best in case of flower durability. It was found that durability of potted chrysanthemum varied greatly according to the cultivars. Similar findings were found by Wesenberg *et al.* (1964). Generally being ethylene non-sensitive flower the difference in days taken to flower senescence may be due to varietal characteristics of different chrysanthemum cultivars. Similar findings were found in rose by Tabassum *et al.* (2002) and in gerbera (Nair and Mehedi, 2004).

Table 3: Performance of 32 chrysanthemum cultivars on bud diameter at initiation stage (mm) and mature stage (mm), flower head diameter, stalk length and days to 50% flower senescence[Y]

Cultivar[X]	Bud diameter at initiation stage (mm)		Bud diameter at mature stage (mm)		Flower head diameter (cm)		Stalk length (cm)		Days to 50% flower senescence	
V_1	4.8	d	19.1	a	17.6	a	20.1	a	13.9	jk
V_2	4.6	de	18.1	b	16.0	b	19.7	a	13.7	k
V_3	2.8	kl	16.9	c	14.6	c	16.6	de	15.3	ghi
V_4	7.1	a	16.0	d	13.6	d	16.1	e	16.3	def
V_5	1.9	mn	8.6	p	3.7	pq	4.5	o	15.9	defg
V_6	2.6	jk	8.9	op	4.7	lmn	4.7	no	15.8	efg
V_7	2.8	j	10.5	lm	4.9	lm	5.7	lm	17.8	b
V_8	3.2	i	6.9	r	5.0	l	5.2	mn	17.7	bc
V_9	2.4	kl	11.9	ij	7.8	i	4.7	no	16.8	cd
V_{10}	7.1	a	14.7	e	6.8	jk	16.8	d	18.3	b
V_{11}	1.8	mn	10.0	mn	8.8	g	4.4	o	19.8	a
V_{12}	4.2	fg	14.2	e	8.7	g	19.0	b	14.5	ijk
V_{13}	4.4	ef	18.0	b	9.8	f	19.8	a	14.2	jk
V_{14}	2.9	j	12.6	gh	2.8	r	7.5	jk	14.7	hij
V_{15}	3.0	j	6.5	r	2.9	r	11.6	g	17.7	bc
V_{16}	2.7	jk	11.6	jk	6.9	j	18.0	c	17.7	bc
V_{17}	3.9	gh	9.5	no	4.6	mn	9.7	h	16.5	de
V_{18}	2.1	lm	7.6	q	4.0	p	5.7	lm	17.8	b
V_{19}	1.7	n	7.7	q	3.9	p	4.8	no	17.7	bc
V_{20}	1.9	mn	8.7	p	4.1	op	6.9	k	18.4	b
V_{21}	2.1	lm	8.9	op	3.8	p	8.3	i	20.7	a
V_{22}	2.9	j	8.7	p	4.7	lmn	6.0	l	14.4	ijk
V_{23}	2.0	lm	7.5	q	4.9	lm	4.9	no	16.7	de
V_{24}	1.7	n	6.3	r	3.3	q	4.8	no	11.3	l
V_{25}	6.7	b	13.0	fg	6.6	jk	7.6	j	15.9	efg
V_{26}	5.2	c	13.6	f	4.4	no	5.0	no	15.8	efg
V_{27}	6.6	b	13.3	f	6.4	k	11.6	g	13.7	k
V_{28}	2.1	lm	11.0	kl	6.7	jk	5.7	lm	18.3	b
V_{29}	4.6	de	12.3	hi	8.1	hi	7.8	ij	15.5	fgh
V_{30}	3.8	hi	11.4	jk	8.2	h	7.9	ij	16.0	defg
V_{31}	4.4	ef	13.3	f	7.9	hi	13.5	f	13.7	k
V_{32}	3.9	gh	15.8	d	11.3	e	17.7	c	14.5	ijk
CV%	6.1		3.0		3.5		3.9		3.5	
$LSD_{(0.05)}$	0.4		0.6		0.4		0.6		0.9	

[X]Chrysanthemum cultivars

[Y]In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.17 Ranking cultivars

32 chrysanthemum cultivars were scored on different characteristics like plant height, number of branch, leaf area, chlorophyll percentage, days taken to final bloom, number of flower per plant, flower head diameter and days to 50% flower senescence. If any of the cultivars attained the desirable characters, than it was scored by highest point (1-5). After that, scores from all characters were added and grading was done on the basis of total score (Nahiyan *et al.*, 2015).

It was found that maximum total score was obtained by V_7 (28), followed by V_{25}, whereas minimum score was obtained by V_{29} (12) (Table 4). So, the V_7 (Yellow glow) of Class 4, decorative flower attained the top position in the ranking which is followed by V_{25} (Red wing) from class 9, spoon type flower. Thus all 32 cultivars can be ranked by placing V_7 as top scorers and V_{25} was the second top scorer (on the basis of desirable characters).

At last, it can be concluded that V_7 performed as best cultivar for the desirable characteristics followed by V_2, V_6, V_{11}, V_{15} and V_{27}. V_{12}, V_{29} and V_{24} gave minimum score. It is expected that identification of the best chrysanthemum cultivars would be a major asset among the breeders as well as farmers in Bangladesh.

Table 4: Scoring of the different characters of 32 chrysanthemum cultivars and making point

Cultivar	Plant height	Number of branch	Leaf area	Chlorophyll content	Days to final bloom	Number of flower/plant	Flower head diameter	Days to 50% flower senescence	Total score	Ranking based on total score
V_1	4	1	5	4	1	1	5	2	23	3
V_2	5	1	5	4	2	1	5	2	25	2
V_3	1	1	2	4	5	2	4	3	22	3
V_4	4	1	4	4	1	3	4	3	24	3
V_5	3	2	2	3	3	3	1	3	20	4
V_6	3	5	1	4	5	3	1	4	26	2
V_7	3	5	3	5	4	3	1	4	28	1
V_8	0	5	2	4	3	4	1	3	22	3
V_9	2	2	3	5	1	2	2	3	20	4
V_{10}	1	2	2	5	1	2	2	5	20	4
V_{11}	4	3	2	4	2	2	2	5	24	2
V_{12}	1	1	2	4	2	2	2	2	16	5
V_{13}	0	1	5	4	2	2	3	2	19	4
V_{14}	2	2	2	4	2	2	1	2	17	4
V_{15}	2	5	2	4	2	5	1	4	25	2
V_{16}	4	4	2	3	2	3	2	4	24	3
V_{17}	3	4	2	3	3	4	1	3	23	3
V_{18}	2	3	2	4	5	3	1	4	24	3
V_{19}	2	2	1	2	3	3	1	4	18	4
V_{20}	2	3	1	2	5	2	3	5	23	3
V_{21}	2	4	1	2	4	2	3	5	23	3
V_{22}	2	3	2	4	2	2	2	2	19	4
V_{23}	2	3	2	4	2	3	1	3	20	4
V_{24}	2	2	1	2	3	3	1	1	15	5
V_{25}	4	3	4	4	3	3	3	3	27	2
V_{26}	4	4	2	4	2	2	2	2	22	3
V_{27}	4	3	2	4	2	3	3	5	26	2
V_{28}	2	3	2	5	4	2	3	3	24	3
V_{29}	1	1	1	1	2	1	2	3	12	5
V_{30}	4	1	2	4	1	1	2	3	18	4
V_{31}	4	2	2	4	3	2	3	2	22	3
V_{32}	4	1	2	4	3	1	3	2	20	4

Plant height (cm): >70=0, 25.1-30=1, 65.1-70=1, 30.1-35=2,35.1-40=2,40.1-45=3,45.1-50=3,50.1-55=4,60.1-65=4,55.1-60=5
Number of branch: 0-4=1, 5-8=2, 9-12=3, 13-16=4, >17=5
Total number of flower: 1-20=1, 21-40=2, 41-60=3, 60-90=4, >91=5
Leaf area: 45.1-55=5, 35.1-45=4, 25.1-35=3, 15.1-25=2, 5-15=1
Chlorophyll percentage: 21.1-25=1, 25.1-35=2, 35.1-45=3, 45.1-55=4, >55.1=5
Flower diameter (cm): 2-6: 1, 6.1-9=2, 9.1-12=3, 12.1-15, 15.1-18=5
Days to final bloom: 50-60=5, 61-65=4,66-70=3,71-75=2, >72=1
Days to flower senescence: 11-13=1, 13.1-15=2, 15.1-17=3, 17.1-18=4, >18.1=5

Table 5. Ranking of 32 chrysanthemum cultivars

Chrysanthemum Cultivars	Ranking
V_7	1
$V_2, V_6, V_{11}, V_{15}, V_{25}, V_{27}$	2
$V_1, V_3, V_4, V_8, V_{16}, V_{17}, V_{18}, V_{20}, V_{21}, V_{28}, V_{31}$	3
$V_5, V_9, V_{10}, V_{13}, V_{14}, V_{19}, V_{22}, V_{23}, V_{30}$,	4
V_{12}, V_{29}, V_{24}	5

4.18 Dendrogram analysis

Dendrogram is a graphically present branching diagram that represents the relationships of the information concerning which observations are grouped together at various levels of similarity and dissimilarity. Each observation is considered its own cluster. Horizontal lines extend up for each observation to show the distance and dissimilarity value and at various similarity and dissimilarity values; these lines are connected to the lines from other observations with a vertical line to represent the cluster. The observations continue to combine until.

The results of the cluster analysis (Ward's method) based on morphological characteristics of 32 chrysanthemum cultivars are presented in the Fig. 4; the cluster diagram (also called cluster trees).

The cultivars were randomly clustered into different groups based on different characteristics/traits (leaf area, number of leaf per 20 cm branch, chlorophyll percentage, days to flower bud initiation, days to first petal spread, days to final bloom, number of flower per branch, number of flower per plant, bud diameter both at initiation stage and mature stage, flower head diameter, stalk length, flower durability). The cultivars formed two clusters/two major groups; Group A and Group B. Group A included two clusters; Cluster I and Cluster II. Cluster I was the smallest group containing one cultivar (V_9). Cluster II included four cultivars (V_1, V_2, V_4, and V_{13}). Cluster II included four cultivars (V_2, V_4 and V_{13}). Group B consisted of two clusters (Cluster III and Cluster

IV). Cluster III concluded five cultivars (V_{19}, V_{21}, V_{24}, V_{29} and V_{20}). Cluster IV could be further divided into two sub-groups (Cluster IVa and Cluster IVb)at the average linkage distance of 11. Cluster IVa included five cultivars (V_6, V_8, V_{28}, V_3 and V_{16}) and Cluster IVb was the largest group included 17 cultivars (V_{31}, V_{32}, V_{12}, V_{27}, V_{30}, V_{22}, V_{14}, V_{26}, V_8, V_{23}, V_{15}, V_{17}, V_{11}, V_{10}, V_7 and V_{25}). The dendrogram showed/interpreted that the cultivars in one cluster were mostly similar characteristics and had less diversity variation.

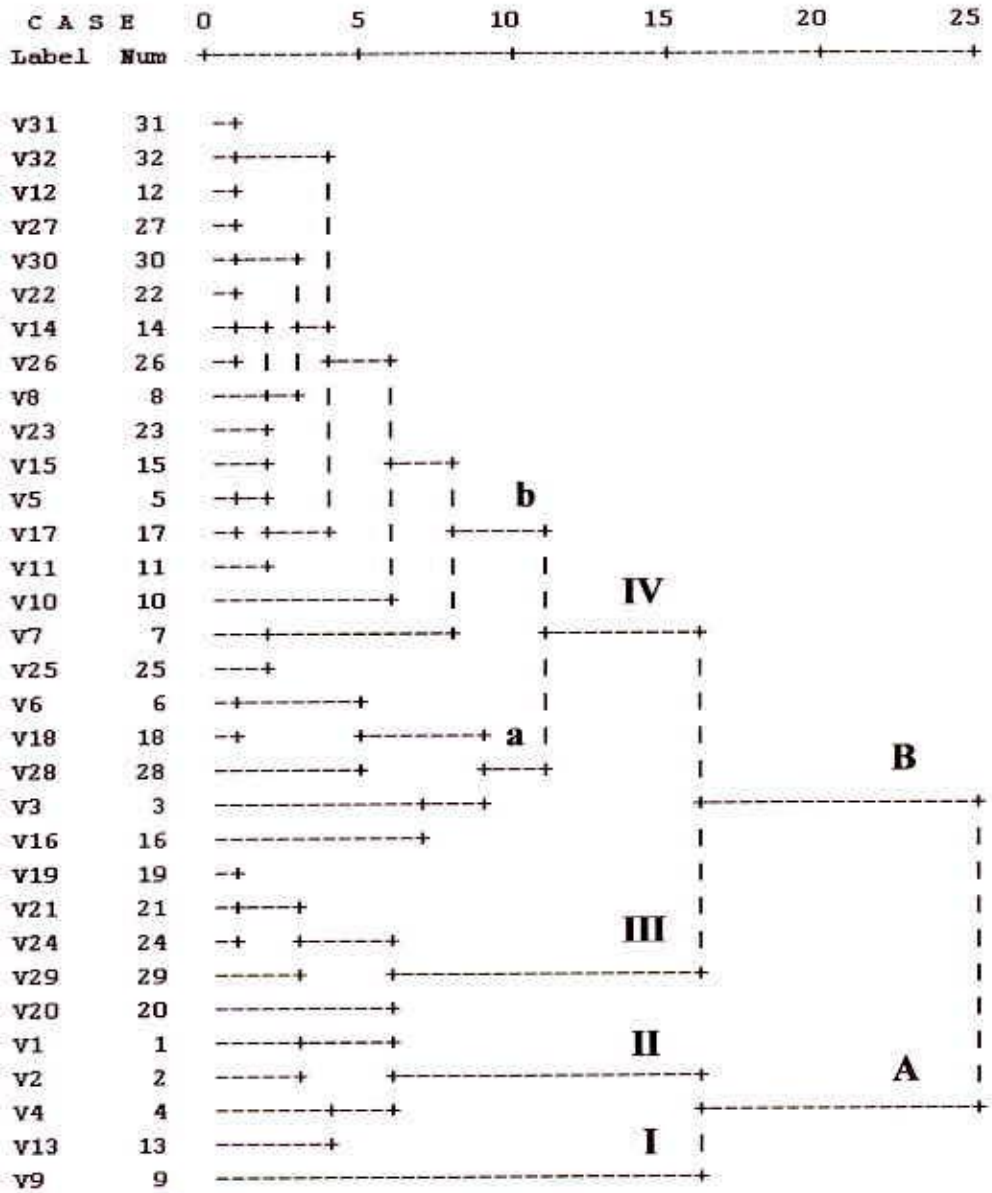

Fig. 4: Dendrogram of 32 chrysanthemum cultivars using average linkage (between groups) rescaled distance cluster combine (WARD's method). The cluster diagram revealed two major lineage groups at linkage distance 25. Lineage 'A' at linkage distance 11 was further divided into two clusters (I and II). Lineage 'B' at linkage distance 16 was further divided into two clusters (III and IV).

4.19 Classification of the chrysanthemum flower

In this research work, available 32 cultivars of chrysanthemum species were collected which are consist of different growth habit behavior, flower forms and shapes, variety of colors. In order to describe all the cultivars/evaluate the performance of the cultivars and characterize them, all the cultivars were identified into the types/respective classes of the National Chrysanthemum Society Classification system where they were belong to (Plate 2 and Table 6).

Classification of 32 chrysanthemum cultivars

Class characteristics	Cultivars belong to the classes

1. Class 1: Irregular Incurve

These are the giant blooms of the chrysanthemum genus. Many of the chrysanthemums in single stem display come from this class. Some of the 'Thousand Bloom' comes from this class as well. The florets (petals) loosely incurve and make fully closed centers. The lower florets present an irregular appearance and may give a skirted effect.

V_1 (Crimson Tide)

Flower Size: 6-8 inches

Flower Characteristics: Grown as a disbud, plant moderately short.

2. Class 2: Reflex

In this category the florets curve downward. The tops of the blooms have a somewhat flattened appearance when they are fully open. Some describe the flowers as having a mop-like appearance. Others say the florets tend to overlap to make a appearance like plumage on a bird.

V_2 (Samsan)

Flower Size: 4-6 inches
Flower Characteristics: Grown as a disbud, plant medium height.

3. Class 3: Regular Incurve

A true globular bloom concludes equal breadth and depth. The florets smoothly incurve and form a ball . This category used to be named "Chinese."

V_3 (White Snowball)

Flower Size: 4-6 inches
Flower Characteristics: Grown as a disbud, plant moderately short

V_4 (Chandramukhi)

4. Class 4: Decorative

This is a very common class of mums consists of a flattened bloom with short petals. As in classes 1-3 the center disk should not be visible. The upper florets tend to incurve, but the lower petals generally reflex .

Flower Size: 5 inches or greater
Flower Characteristics: Grown as a pot mum or disbud, plant height short

V_5 (Lexy)

V_6 (Rose Pink)

V_7 (Yellow Glow)

V_8 (Ruby Red)

V_9 (Gold Apricot)

V_{10} (Sunny Yellow)

5. Class 5: Intermediate Incurve

This bloom class is smaller than the irregular incurve, with shorter florets, only partially incurving with full centers, but giving a more open appearance. Many of the popular commercial incurving types are in this intermediate class. Blooms of this class look like a hybrid between Irregular Incurve and Regular Incurve.

Flower Size: 6 inches or greater
Flower Characteristics: Grown as a disbud, plant medium height

V_{11} (Lavender Mum)

V_{12} (Giant Bronze)

V_{13} (Purple Mum)

6. Class 6: Pompon

A small globular bloom, somewhat flat when young but fully round when mature. The florets incurve or reflex in a regular manner and fully conceal the center.

Flower Size: 1-4 inches
Flower Characteristics: Grown as a spray, plant height tall

V_{14} (Moon Ball)

V_{15} (Yellow Bay)

7. Single and Semi-Doubles

This is the quintessential daisy-shape bloom like many members of the Asteraceae family. A central section of disk florets is surrounded by several rows of ray florets (generally between 1 and 7 rows).

Flower Size: Greater than 4 inches
Flower Characteristics: Grown as a disbud or spray, plant medium height

V_{16} (Pink shasta Daisy)

V_{17} (Bernadette Yellow)

V_{18} (Mammoth Red)

V_{19} (Auburn Daisy)

V_{20} (Sweet Vase)

8. Class 8: Anemone

The flowers in this class are similar to Semi-Double chrysanthemums except that they have a raised center that looks like a pincushion.

Flower Size: Greater than 4 inches.
Flower Characteristics: Grown as a disbud, plant medium height.

V_{21} (First Light)

V_{22} (Flying Saucer)

V_{23} (Zipsy)

V_{24} (Gold Mundial)

9. Class 9: Spoon

This bloom looks very similar to Semi-Double, except the ray florets are in this class are long, tubular and spatulate, meaning they look like a spoon at the tips. The center disk is round and visible.

Flower Size: 4 inches or greater
Flower Characteristics: Grown as a disbud or spray, plant height tall

V_{25} (Red Wing)

V_{26} (Rising Sun)

V_{27} (Trendy Time)

10. Class 10: Quill

The florets are straight and tubular with open tips that look like quills. The bloom is fully double with no open center.

Flower Size: 6 inches or greater.

Flower Characteristics: Grown as a disbud, plant height medium

V_{28} (BARI chrysanthemum 2)

11. Class 11: Spider

This class has long tubular ray florets that hook or coil at the end. The florets can be fine or coarse. The florets fall in a loose mass and look like they have barbs on their ends. Intricate spider mums look like firework displays.

Flower Size: Six inches or greater.

Flower Characteristics: Grown as a disbud, plant medium height.

V_{29} (Rayonnate Spider)

V_{30} (Flair Spider)

12. Class 12: Brush and Thistle

These chrysanthemums have tubular florets which grow parallel to the stem and resemble an artist's paint brushes or in the thistle form the florets are flattened, twisted and dropping

Flower Size: less than 2 inches.
Flower Characteristics: Grown as a spray, plant medium height

V_{31} (Wisp of Red)

13. Class 13: Unclassified (Unusual)

Those chrysanthemum blooms which fit in none of the other classes. They are often exotic, with twisted florets. The florets can be flat, spoon-like, or quill-like. They may also exhibit characteristics of more than one bloom class.

Flower Size: 6 inches or greater.
Flower Characteristics: Grown as a disbud, plant medium height.

V_{32} (Satin Ribbon)

Table 6. Classification of the thirty two chrysanthemum cultivars

CLASS	TYPE	NAME
Class 1	Irregular Incurve	V_1 (Crimson Tide)
Class 2	Reflex	V_2 (Samsan)
Class 3	Regular Incurve	V_3 (White Snowball)
		V_4 (Chandramukhi)
Class 4	Decorative	V_5 (Lexy)
		V_6 (Rose Pink)
		V_7 (Yellow Glow)
		V_8 (Ruby Red)
		V_9 (Gold Apricot)
		V_{10} (Sunny Yellow)
Class 5	Intermediate incurve	V_{11} (Lavender Mum)
		V_{12} (Giant Bronze)
		V_{13} (Purple Mum)
Class 6	Pompon	V_{14} (Moon Ball)
		V_{15} (Yellow Bay)
Class 7	Single and Semi double korean	V_{16} (Pink Shashta Daisy)
		V_{17} (Bernadette Yellow)
		V_{18} (Mammoth Yellow)
		V_{19} (Auburn Daisy)
		V_{20} (Sweet Vase)
Class 8	Anemone	V_{21} (First Light)
		V_{22} (Flying Saucer)
		V_{23} (Zipsy)
		V_{24} (Gold Mundial)
Class 9	Spoon	V_{25} (Red Wing)
		V_{26} (Trendy Time)
		V_{27} (Rising Sun)
Class 10	Quill	V_{28} (BARI chrysanthemum 2)
Class 11	Spider	V_{29} (Rayonnate Spider)
		V_{30} (Flair Spider)
Class 12	Brush or Thistle	V_{31} (Wisp of Red)
Class 13	Unclassified	V_{32} (Satin Ribbon)

4.20 Description of leaves of 32 chrysanthemum cultivars

Chrysanthemum is herbaceous plant with deeply lobed leaves with deep green on the upper surface and grey green on under surface. Leaves are simple, alternately arranged and with no petiole. Chrysanthemum shows a almost an infinite number of variation in terms of shape, texture, leaf edge, length of lobe, margin of sinus, serration and other characteristics (Warren, 1997) (Plate 3). These variations are available within chrysanthemum classes and also different varieties.

In this research work leaves of 32 chrysanthemum cultivars were classified on the basis of different shape. Leaf shape was assessed as the flower buds were initiated. Leaves were found ovate, oblong, obviate, palmate and pinnetified. Leaves within the classes were described on the basis of certain characteristics.

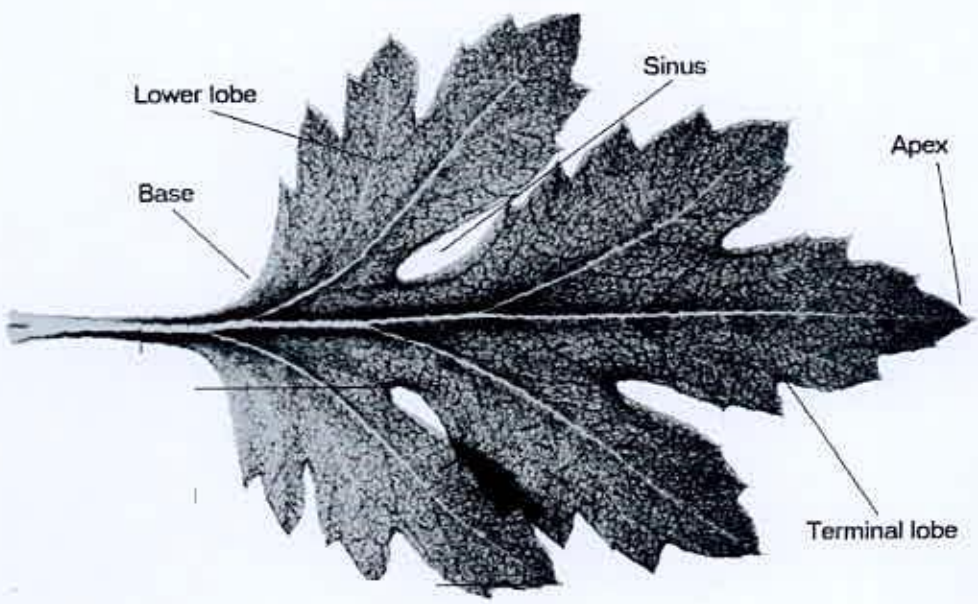

Plate 4. A typical chrysanthemum leaf showing the characters used in description

Chrysanthemum leaf description based on characteristics

A. Thickness
    1. Thin
    2. Medium
    3. Thick

B. Texture
    1. Fleshy
    2. Leathery

C. Margin of sinus: Plate 4 represented the margin of sinus of leaf.
    1. Divergent
    2. Parallel
    3. Convergent

Divergent Parallel Convergent

Plate 5. Chrysanthemum leaves showing three types of margin of sinus

D. Margin of terminal lobe
    1. Toothed
    2. Lobed and toothed

E. Length of lower lobe
    1. Very short
    2. Very short to short
    3. Short
    4. Short to medium
    5. Medium
    6. Medium to long

7. Long
8. Long to very long
9. Very long

Based on this characters leaves of 32 chrysanthemum cultivars were classified according to different shapes and the classification were as follows:

A. Class 1

Class 1 was grouped by ovate shaped leaves. This class was the second largest group. 8 cultivars consisting same type of leaves (regular incurve, decorative, intermediate incurve, pompon single, anemone, Brush, spoon). Leaves of this class showed very short to short terminal lobe, occasionally medium with toothed margin (Plate 5). Margin of sinus mostly showed parallel structure, divergent was also seen. These were V_3, V_9, V_{13}, V_{14}, V_{19}, V_{24}, V_{26} and V_{31} (Plate 6).

B. Class 2

Class 2 was the smallest group of 3 cultivars (reflex, decorative, unclassified) consisting of oblong shaped leaves. This class was identified by short to medium length of terminal lobe with toothed margin. Margin of sinus showed convergent type (Plate 5). These three cultivars were V_2, V_{10} and V_{32} (Plate 6).

C. Class 3

Class 3 was classified by obovate shaped leaves of 4 cultivars (irregular incurve, intermediate incurve, pompon and spoon). Terminal lobes of this type of leaves were normally medium to long. All three types of margin of sinus was shown; divergent parallel and convergent in different cultivars. Margin of terminal lobe was normally toothed and lobed (Plate 5). These cultivars were V_1, V_{12}, V_{15} and V_{27} (Plate 6).

D. Class 4

Class 4 was consisted of palmate shaped leaves. This type of leaves was mostly of thick and fleshy texture. Margin of sinus was divergent in most cultivars, rest of showed parallel and convergent. Lower lobe was short to very short. Terminal lobe showed toothed structure. This class had 7 cultivars containing decorative (2), intermediate incurve, single, anemone, spoon and quill flower (Plate 5). The cultivars of this class were V_6, V_8, V_{11}, V_{16}, V_{22}, V_{25} and V_{28} (Plate 6).

E. Class 5

Class 5 was classified by pinnate shape leaves. Leaves of most of the cultivars (10) belonged to this class; regular incurve, decorative (2), single or semi double (3), anemone (2) and spider (2). These leaves were identified by 2 to 3 deep lobes on each side and long to very long lower lobe. Margin of sinus was mostly convergent, parallel margin was also seen. Margin of terminal lobe was mostly toothed (Plate 5). The cultivars of this class were V_4, V_5, V_7, V_{17}, V_{18}, V_{20}, V_{21}, V_{23}, V_{29} and V_{30} (Plate 6).

Class 1 Class 2 Class 3 Class 4 Class 5

Plate 6. Classification of chrysanthemum leaves

This classification concludes with a comparison that different leaf shapes represented different classes and cultivars of flower. Cultivars from decorative classes contained all types of leaf/four different types of leaf except obovate shape. Leaves from anemone class represented leaf Class 1, 4 and 5. Leaves of single and semi double cultivars mostly showed Class 5 and then Class 4 and 1. Leaves from spider cultivars represented Class 5.

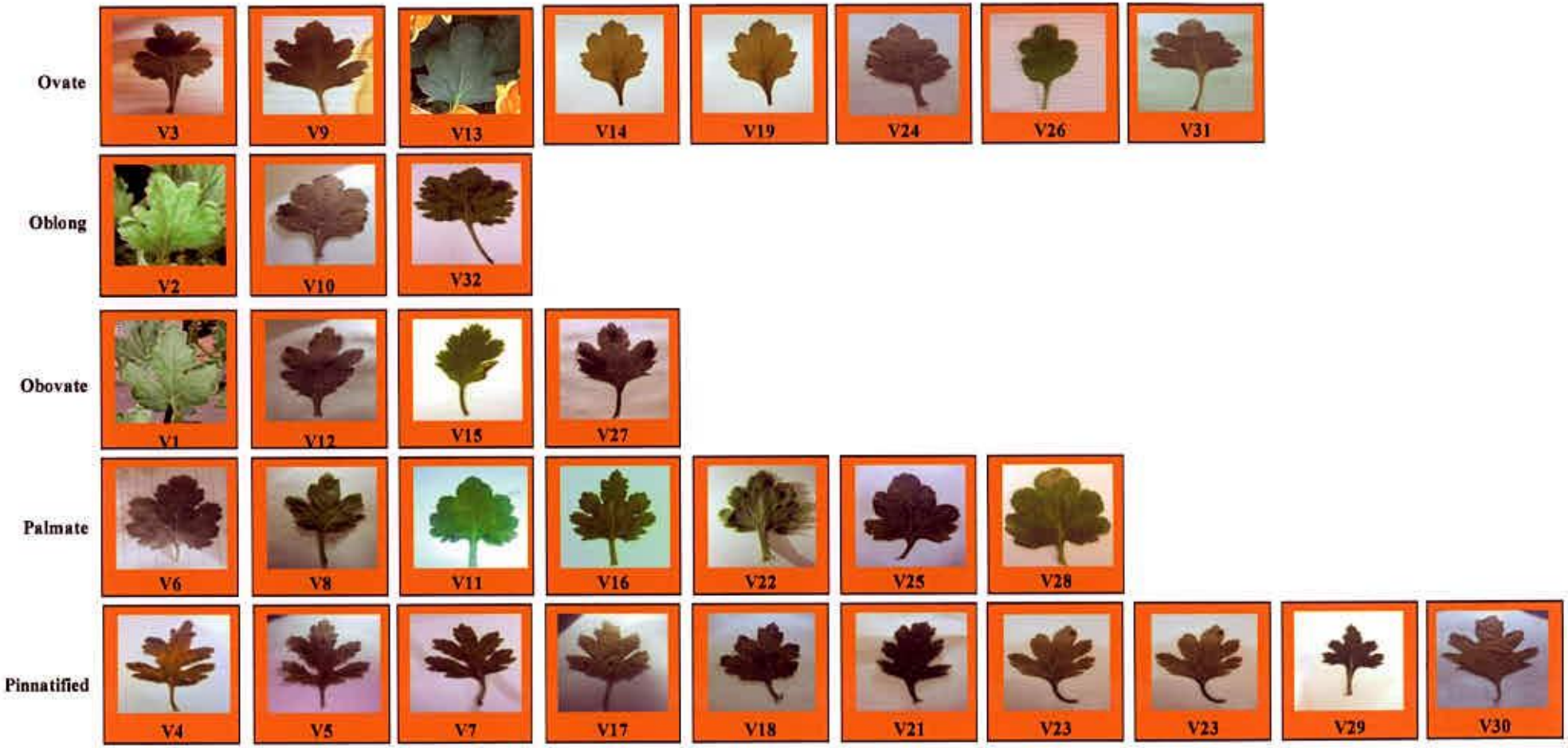

Plate 7. Classification leaves of 32 chrysanthemum cultivars according to different shapes

Table 7. Leaf pattern regarding to the flower

Cultivar	Flower	Leaf	Description of Leaf
Crimson Tide (V_1)			Leaf shape: Obovate, Margin: Lobed, 1-2 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Lobed Length of lower lobe: Long
Reflex Mum (V_2)			Leaf shape: Oblong Margin: Lobed, 2-3 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Convergent Length of lower lobe: Medium Margin of terminal lobe: Toothed
White Snowball (V_3)			Leaf shape: Ovate Margin: Lobed, 2 lobes at each side Thickness: Medium Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: Short to medium
Chandra-mukhi (V_4)			Leaf shape: Pinnetified Margin: Lobed, 2-3 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Convergent Margin of terminal lobe: Lobed and toothed Length of lower lobe: Long

continued

continued

Cultivar	Flower	Leaf	Description of Leaf
Lexy (V_5)			Leaf shape: Pinnetified Margin: Lobed, 2 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Convergent Margin of terminal lobe: Lobed and toothed Length of lower lobe: Long
Rose Pink (V_6)			Leaf shape: Palmate Margin: Lobed, 2 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Convergent Margin of terminal lobe: Toothed Length of lower lobe: Short to vary short, overlapped
Yellow Glow (V_7)			Leaf shape: Pinnetified, Margin: Lobed, 2 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Convergent 3 Margin of terminal lobe: Toothed Length of lower lobe: Long to very long
Ruby Red (V_8)			Leaf shape: Palmate Margin: Lobed, 2 -3 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: Medium to long

continued

continued

Cultivar	Flower	Leaf	Description of Leaf
Gold Apricot (V_9)			Leaf shape: Ovate Margin: Lobed, 2 lobes at each side Thickness: Medium Texture: Lathery Margin of sinus: Divergent or Parallel Margin of terminal lobe: Lobed and toothed Length of lower lobe: Medium to long
Sunny Yellow (V_{10})			Leaf shape: Oblong Margin: Lobed, 2-3 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Convergent Margin of terminal lobe: Toothed Length of lower lobe: Short to medium
Lavender Mum (V_{11})			Leaf shape: Palmate Margin: Lobed, 2-3 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Divergent Margin of terminal lobe: Toothed Length of lower lobe: Very short to short
Giant Bronze (V_{12})			Leaf shape: Obovate Margin: Lobed, 2 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: very short to short

continued

continued

Cultivar	Flower	Leaf	Description of Leaf
Purple Mum (V_{13})			Leaf shape: Ovate Margin: Lobed, 2 lobes at each side Thickness: Medium Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: Very short to short
Moon Ball (V_{14})			Leaf shape: Ovate Margin: Lobed,2-3 lobes at each side Thickness: Medium Texture: Lathery Margin of sinus: Divergent Margin of terminal lobe: Lobed and toothed Length of lower lobe: Very short to short
Yellow Bay (V_{15})			Leaf shape: Obovate Margin: Lobed, 2-3 lobes at each side Thickness: Thick ,Texture: Fleshy Margin of sinus: Divergent Margin of terminal lobe: Lobed and toothed Length of lower lobe: Very short to short, over lobed
Pink Shasta Daisy (V_{16})			Leaf shape: Palmate Margin: Lobed, 2-3 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Convergent Margin of terminal lobe: Toothed Length of lower lobe: Medium to long

continued

continued

Cultivar	Flower	Leaf	Description of Leaf
Berna-dette Yellow (V_{17})			Leaf shape: Pinnetified Margin: Lobed, 2 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Convergent 3 Margin of terminal lobe: Lobed and toothed Length of lower lobe: Long to very long
Mammoth Red (V_{18})			Leaf shape: Pinnetified Margin: Lobed, 2-3 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Convergent Margin of terminal lobe: Toothed Length of lower lobe: Medium to long, overlapped
Auburn Daisy (V_{19})			Leaf shape: Ovate Margin: Lobed, 2-3 lobes at each side Thickness: Medium Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: Very short to short
Sweet Vase (V_{20})			Leaf shape: Pinnetified Margin: Lobed, 2-3 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: Medium to long

continued

continued

Cultivar	Flower	Leaf	Description of Leaf
First Light (V_{21})			Leaf shape: Pinnetified Margin: Lobed, 2-3 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: Medium to long
Flying Saucer (V_{22})			Leaf shape: Palmate Margin: Lobed, 2 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Divergent Margin of terminal lobe: Toothed Length of lower lobe: Short to medium overlapped
Zipsy (V_{23})			Leaf shape: Pinnetified, Margin: Lobed, 2-3 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Convergent Margin of terminal lobe: Toothed Length of lower lobe: Medium to long
Gold Mundial (V_{24})			Leaf shape: Ovate Margin: Lobed, 2-3 lobes at each side Thickness: Medium Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: toothed Length of lower lobe: short

continued

continued

Cultivar	Flower	Leaf	Description of Leaf
Red Wing (V_{25})			Leaf shape: Palmate Margin: Lobed, 2-3 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Divergent Margin of terminal lobe: Toothed Length of lower lobe: Medium
Trendy Time (V_{26})			Leaf shape: Ovate Margin: Lobed, 2 lobes at each side Thickness: Medium Texture: Lathery Margin of sinus: Divergent Margin of terminal lobe: lobed Length of lower lobe: Very short to short
Rising Sun (V_{27})			Leaf shape: Obovate Margin: Lobed,1-2 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: Medium to long
BARI chrysanthemum-2 (V_{28})			Leaf shape: Palmate Margin: Lobed, 2-3 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Divergent Margin of terminal lobe: Toothed. Length of lower lobe: Short

continued

Cultivar	Flower	Leaf	Description of Leaf
Rayonnate Spider (V_{29})			Leaf shape: Pinnetified Margin: Lobed, 2 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: Toothed Length of lower lobe: Medium to long
Flair Spider (V_{30})			Leaf shape: Pinnetified Margin: Lobed, 2-3 lobes at each side Thickness: Thin Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: Lobed and toothed Length of lower lobe: Medium
Wisp of Red (V_{31})			Leaf shape: Ovate Margin: Lobed, 2 lobes at each side Thickness: Thin to Medium 5,Texture: Lathery Margin of sinus: Parallel Margin of terminal lobe: toothed Length of lower lobe: short to medium
Satin Ribbon (V_{32})			Leaf shape: Oblong Margin: Lobed, 2-3 lobes at each side Thickness: Thick Texture: Fleshy Margin of sinus: Convergent Margin of terminal lobe: Lobed and toothed Length of lower lobe: Medium

4.23 Classification of the chrysanthemum cultivars on the basis colour

Approximations of the colors was done according to the RHS Colour Chart (with hues number, 4 lightnesses, named A, B, C and D) along with the corresponding Universal Color Language names. The Universal Color Language (UCL) was defined by the Inter-Society Color Council. Chrysanthemum can exhibit red, purple, pink, yellow and white flowers, but lack bright red and blue flowers. In this study, we identified 32 chrysanthemum cultivars with a wide color range. The colour, or decorative value of a given cultivar, is determined by pigments contained mainly in ray (ligulate) florets. (Lema-Rumi and Zalewska, 2005). Currently, color classes and responsible pigments for color in chrysanthemum flowers are white, due to flavonols; yellow, conditioned by carotinoids; pink to purples caused by anthocyanins and flavonols; and bronze (orange to red) determined by anthocyanins with carotenoids (Kawase and Tsukamoto, 1974).

According to the color 32 chrysanthemum cultivars were classified into six category and these were as follows:

1. **Red to purplish red:** Five cultivars belonged to this category and these were V_1, V_{25}, V_8, V_{18} and V_{31} (Table 10).
2. **Yellow to greenish yellow**: Eight cultivars belonged to this category and these were V_4, V_{15}, V_{17}, V_{24}, V_{26}, V_{29}, V_7, and V_{10} (Table 10).
3. **White**: Three cultivars belonged to this category and these were V_3, V_{22} and V_{28} (Table 10).
4. **Orange to orangish yellow:** Six cultivars belonged to this category and these were V_5, V_9, V_{12}, V_{19}, V_{27} and V_2 (Table 10).
5. **Pink to purplish pink:** Seven cultivars belonged to this category and these were V_6, V_{14}, V_{16}, V_{20}, V_{30} and V_{11} and V_{32} (Table 10).
6. **Purple**: Three cultivars belonged to this category and these were V_{13}, V_{21} and V_{23} (Table 10).

Table 10. Classification of 32 chrysanthemum cultivars on the basis of colour

RHS	UCL name	Cultivars
63A	Strong purplish red	Crimson Tide (V_1), Ruby Red (V_8)
46C	Vivid Red	Mammoth Yellow (V_{18})
66A	Vivid Purplish Red	Red Wing (V_{25}),Wisp of Red (V_{31})
1A	Brilliant greenish yellow	Chandramukhi (V_4)
3C	Light greenish yellow	Yellow Glow (V_7), Rayonnate Spider (V_{29})
2A	Vivid greenish yellow	Sunny Yellow (V_{10})
3B	Brilliant greenish yellow	Yellow Bay (V_{15})
4B	Light greenish yellow	Bernadette Yellow (V_{17})
9C	Brilliant yellow	Gold Mundial (V_{24})
13A	Vivid yellow	Trendy Time (V_{26})
155B	Yellowish white	White Snowball (V_3)
155C	Greenish white	BARI chrysanthemum 2 (V_{28}), Flying Saucer (V_{22})
23B	Brilliant orangish yellow	Auburn Daisy (V_{19})
24B	Strong orangish yellow	Giant Bronze (V_{12})
16B	Light orangish yellow	Gold Apricot (V_9)

RHS	UCL name	Cultivars
40C	Strong reddish orange	Samsan (V_2)
28B	Vivid orange	Rising Sun (V_{27})
32A	Vivid reddish orange	Lexy (V_5)
65C	Pale purplish pink	Flair Spider (V_{30})
68B	Strong purplish pink	Pink Shasta Daisy (V_{16})
62A	Strong purplish pink	Sweet Vase (V_{20})
73B	Strong purplish pink	Rose Pink (V_6)
68C	Moderate purplish pink	Satin Ribbon (V_{32})
73C	Light purplish pink	Lavender Mum (V_{11})
66C	Deep purplish pink	Moon Ball (V_{14})
78C	Light purple	First Light (V_{21})
74A	Vivid reddish purple	Zipsy (V_{23})
78B	Strong Reddish Purple	Purple Mum (V_{13})

4.21 Classification of the chrysanthemum cultivars on the basis of flower size

On the basis of the size of the flowers, chrysanthemum cultivars were classified into four groups.

Class A: Flowers which were more than 15.6 cm in size belonged to Class A. V_1 and V_2 were in the Class A (Table 8).

Class B: Flowers having 10.6-15.5 cm in size belonged to the Class B. V_3, V_4, and V_{32} were in the Class B (Table 8).

Class C: Flowers having 4.6-10.5 cm in size belonged to the Class C. V_6, V_7, V_8, V_9, V_{10}, V_{11}, V_{12}, V_{13}, V_{16}, V_{17}, V_{22}, V_{23} ,V_{25}, V_{27},V_{28},V_{29},V_{30} and V_{31} were in the Class C (Table 8).

Class D: Flowers having 2.5-4.5 cm in size belonged to Class D. V_5, V_{14}, V_{15}, V_{18}, V_{19}, V_{20}, V_{21}, V_{24} and V_{26} were in the Class D (Table 8).

Table 8. Classification of the 32 chrysanthemum cultivars on the basis of flower size

Class	Flower size	Varieties
Class A	Large (>15.6)	V_1 and V_2
Class B	Medium to large (10.6-15.5)	V_3, V_4 and V_{32}
Class C	Medium (4.6-10.5)	V_6, V_7, V_8, V_9, V_{10}, V_{11}, V_{12}, V_{13}, V_{16}, V_{17}, V_{22}, V_{23} ,V_{25}, V_{27},V_{28},V_{29},V_{30} and V_{31}
Class D	Small (2.5-4.5)	V_5, V_{14}, V_{15}, V_{18}, V_{19}, V_{20}, V_{21}, V_{24}, V_{26}

4.22 Classification of the chrysanthemum cultivars on the basis of use for production/cultivation

This classification was based on how the chrysanthemum cultivars can be handled /used in production in terms of some certain flower characteristics like flower size, stalk length strength, longevity, growing habit and others/etc. Based on the upper mentioned characteristics the 32 chrysanthemum cultivars were classified into three groups as followed:

Class A: This class concluded cultivars of standard type with large bloom and single stem. Lateral flower buds removed to develop one large, terminal flower head. These were usually suitable for cut flower production. V_1, V_2, V_3, V_4, V_{10}, V_{13}, V_{16} and V_{25} were in this class (Table 9).

Class B: These types of cultivars were usually medium sized and grown as disbuds with multi-stem (plants are pinched as rooted cuttings) with the lateral flower buds removed to develop one large, terminal flower head on each lateral, but also may be grown to spray. These would be suitable for pot crop production, cascade and espalier with mass of flower (Table 9).

Class C: Cultivars of this class were of spray type which are usually grown multi-stem with only the terminal flower bud removed to allow all lateral flower buds to flower. These cultivars could perform best for excellent pot crop production, bonsai and landscape plant (Table 9).

Table 9. Classification of the chrysanthemum cultivars on the basis of use for production/cultivation

Class	Production/cultivation	Cultivars
Class A	Cut flower	V_1, V_2, V_3, V_4, V_{10}, V_{13}, V_{16} and V_{25},
Class B	Pot flower	V_{11}, V_{12}, V_9, V_{29}, V_{30}, V_{31}, V_{22}, V_{27} and V_{32}
Class C	Pot flower	V_5, V_6, V_7, V_8, V_{14}, V_{15}, V_{17}, V_{18}, V_{19}, V_{20}, V_{21}, V_{23}, V_{24}, V_{26} and V_{28}.

CHAPTER V

SUMMARY AND CONCLUSION

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5.1 Summary

The experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period from October 2012 to March 2013 to study the phenotypic characterization of 32 chrysanthemum cultivars. The experiment was conducted in Completely Randomized Design with three replications using 32 cultivars as treatments. The main objectives of the study were to characterize chrysanthemum cultivars based on different morphological traits and evaluate the performance of the cultivars and association between traits of cultivars. The salient findings of the investigation are summarized here under

The chrysanthemum cultivars showed great variations for different morphological parameters.

Tallest cultivar was found from V_{13} (71.8 cm) whereas the shortest from V_8 (23.7 cm)

Maximum number of branch was recorded from V_6 (19.7/ plant) cultivar while V_2 (2.5/ plant) showed minimum number of branches.

The maximum number of leaves per 20 cm branch were observed from V_{11} (Lavender Mum) (13.3) and the minimum from V_{14} and V_{24} (4.5)

The maximum leaf area was found from V_1 (52.9 cm^2) and V_{29} (5.9 cm^2) scored the lowest after flowering.

Among the cultivars V_{10} (Sunny Yellow) produced the maximum chlorophyll percentage (59.0%).

Late flower bud initiation was found in V_9 (52.7 days) while earlier in V_3 (17.8 days). V_3 required the shortest period (39.5 days) for first petal spread days and V_4 required the longest period (71.6 days). V_6 was found to be the early blooming cultivar (52.8 days) while V_4 (77.5 days),V_{10} (77.3 days) ,V_1 (77.2 days),V_9 and V_{30} (76.7 days) were found late blooming.

Maximum cumulative number of flower bud per plant was found from V_{15} (199.0). Among the cultivars V_{15} (Yellow Bay) produced maximum number of flower (9.4) per 20 cm branch while V_1, V_2, V_{10}, V_{21}, V_{24}, V_{30} and V_{31} produced minimum (1.0/20 cm branch) flower. Among the cultivars V_{15} (Yellow Bay) performed as maximum flower (194.6/plant) producing cultivar.

Maximum flower bud diameter was found from V_1 (19.1 mm) at mature stage.

V_1 (Crimson Tide) cultivar produced maximum flower diameter (17.6 cm) with the longest stalk of chrysanthemum flower (20.1 cm) whereas minimum flower diameter was found from V_{14} (2.8 cm).

Late flower senescence was recorded in V_{21} (20.7 days) and V_{11} (19.8 days) while early flower senescence was observed in V_{24} (11.3 days)

Based on certain characters leaves of 32 chrysanthemum cultivars were classified according to different shapes. Class 1 was grouped by ovate shaped leaves concluding V_3, V_9, V_{13}, V_{14}, V_{19}, V_{24}, V_{26} and V_{31} cultivars. Class 2 was grouped by oblong shaped leaves with V_2, V_{10} and V_{32} cultivars. Class 3 was classified by obovate shaped concluding V_1, V_{12}, V_{15} and V_{27} cultivars. Class 4 was consisted of palmate shaped leaves with V_6, V_8, V_{11}, V_{16}, V_{22}, V_{25} and V_{28} cultivars. The cultivars of class 5 were V_4, V_5, V_7, V_{17}, V_{18}, V_{20}, V_{21}, V_{23}, V_{29} and V_{30} with pinnetified leaves.

All the 32 chrysanthemum cultivars were scored and ranked on the basis different characteristics like plant height, number of branch, leaf area,

chlorophyll percentage, days taken to final bloom, number of flower per plant, flower head diameter and days to 50% flower senescence.

It was be concluded that V_7 performed as best cultivar with maximum score for the desirable characteristics followed by V_2, V_6, V_{11}, V_{15}. It is expected that identification of the best chrysanthemum cultivars would be a major asset among the breeders as well as farmers in Bangladesh.

The dendrogram analysis was done to group together the 32 chrysanthemum cultivars at various levels of similarity and dissimilarity based on morphological characteristics. Cultivars in one cluster are mostly similar characteristics and have less diversity v. The collected cultivars formed two clusters/two major groups; Group A and Group B. Group A included two clusters; Cluster I and Cluster II. Cluster I was the smallest group with one cultivar (V_9). Cluster II included four cultivars (V_1, V_2, V_4, and V_{13}). Group B consisted of two clusters (Cluster III and Cluster IV). Cluster III concluded five cultivars (V_{19}, V_{21}, V_{24}, V_{29} and V_{20}). Cluster IV was further divided into two sub-groups (Cluster IVa and Cluster IVb) Cluster IVa included five cultivars (V_6, V_8, V_{28}, V_3 and V_{16}) and Cluster IVb was the largest group included 17 cultivars (V_{31}, V_{32}, V_{12}, V_{27}, V_{30}, V_{22}, V_{14}, V_{26}, V_8, V_{23}, V_{15}, V_{17}, V_{11}, V_{10}, V_7 and V_{25}).

The 32 chrysanthemum cultivars were classified on the basis of flower size. V_5, V_{18}, V_{19}, V_{14}, V_{15}, V_{20}, V_{21}, V_{24} and V_{26} were classified as large flower cultivars. V_3, V_4, and V_{32} were medium to large sized flower, V_6, V_7, V_8, V_9, V_{10}, V_{11}, V_{12}, V_{13}, V_{16}, V_{17}, V_{22}, V_{23} and V_{25} were found to be medium sized flower. V_5, V_{14}, V_{15}, V_{18}, V_{19}, V_{20}, V_{21}, V_{24} and V_{26} cultivars were grouped as small sized flower.

The chrysanthemum cultivars were grouped on the basis of use for cultivation. V_1, V_2, V_3, V_4, V_{10}, V_{13}, V_{16} and V_{25} were classified as standard flower. Rest of the cultivars was classified as spray or disbud type flower.

According to the color 32 chrysanthemum cultivars were classified into six categories. These are Red to purplish red (V_1, V_{25}, V_8, V_{18} and V_{31}), Yellow to greenish yellow (V_4, V_{15}, V_{17}, V_{24}, V_{26}, V_{29}, V_7, and V_{10}), White (V_3, V_{22} and V_{28}), Orange to orangish yellow (V_5, V_9, V_{12}, V_{19}, V_{27} and V_2), Pink to purplish pink (V_6, V_{14}, V_{16}, V_{20}, V_{30} and V_{11} and V_{32}), Purple (V_{13}, V_{21} and V_{23}).

5.2 Conclusion

Finally it can be concluded that V_1, V_2, V_3, V_4, V_{10}, V_{13}, V_{16} and V_{25} cultivars were suitable for cut flower production. These cultivars have the huge potentiality to grow as disbudded, standard flower and potent cut flower in the market. Among the 32 cultivars of chrysanthemum V_7 (Yellow Glow) and V_{25} (Red Wing) cultivars performed as best cultivars in case of desirable characteristics. V_{15} (Yellow Bay) performed as maximum flower producing cultivar but some cultivars were also suitable for pot culture and bedding plants due to their morphological characteristics and growth habit. Variations in range of flower color and flower size of chrysanthemum cultivars were excellent traits for flower crop production. From the above circumstances it can easily be articulated that the 32 chrysanthemum cultivars were categorized into different floriculture commodity groups with their prospective traits for genetics and breeding.

Suggestions:

Judging the findings of the present research, further studies in the subsequent areas may be suggested:

- Prospective cultivars and desirable traits could be used as important attribute for breeders.
- Research could be done on improvement of the cut chrysanthemum cultivars.
- Potential chrysanthemum cultivars can be made aesthetically rewarding and commercially prospective to farmers.

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APPENDICES

APPENDICES

Appendix I: Analysis of variance of the data on plant height at different DAT of different chrysanthemum cultivars

Source of Variation	Degrees of Freedom (df)	Mean Square of plant height (cm) at		
		30 DAT	40 DAT	50 DAT
Replication	2	2.347	0.962	0.744
Factor A (variety)	31	523.357*	551.707*	566.14*
Error	62	1.282	0.088	0.888

* : Significant at 0.05 level of probability

Appendix II: Analysis of variance of the data on number of branch at different DAT of different chrysanthemum cultivars

Source of Variation	Degrees of Freedom (df)	Mean Square of number of branch at		
		30 DAT	40 DAT	50 DAT
Replication	2	0.386	0.348	0.423
Factor A (variety)	31	12.18*	41.35*	84.752*
Error	62	0.172	0.269	0.18

* : Significant at 0.05 level of probability

Appendix III: Analysis of variance of the data on leaf area, number of leaf per 20 and chlorophyll content of different chrysanthemum cultivars

Source of Variation	Degrees of Freedom (df)	Mean Square of		
		Leaf area	Number of leaf per 20 cm	Chlorophyll content
Replication	2	0.778	0.229	0.146
Factor A (variety)	31	482.098*	13.74*	258.762*
Error	62	0.184	0.235	0.172

* : Significant at 0.05 level of probability

Appendix IV: Analysis of variance of the data on days to flower bud initiation, days to first petal spread and days to final bloom of different chrysanthemum cultivars

Source of Variation	Degrees of Freedom (df)	Mean Square of		
		Days to flower bud initiation	Days to first petal spread	Days to final bloom
Replication	2	0.068	0.118	0.412
Factor A (variety)	31	153.024*	181.458*	130.307*
Error	62	0.289	0.298	0.319

* : Significant at 0.05 level of probability

Appendix V: Analysis of variance of the data on number of flower bud at different DAT of different chrysanthemum cultivars

Source of Variation	Degrees of Freedom (df)	Mean Square of number of flower bud at		
		30 DAT	40 DAT	50 DAT
Replication	2	1.527	0.887	0.339
Factor A (variety)	31	185.838*	1566.09*	3480.43*
Error	62	0.23	0.266	0.222

* : Significant at 0.05 level of probability

Appendix VI: Analysis of variance of the data on number of flower per 20 cm, number of flower per plant, bud diameter at initiation stage and bud diameter at mature stage of different chrysanthemum cultivars

Source of Variation	Degrees of Freedom (df)	Mean Square of			
		Number of flower per 20 cm	Number of flower per plant	Bud diameter at initiation stage(mm)	Bud diameter at mature stage(mm)
Replication	2	0.118	0.657	0.184	0.149
Factor A (variety)	31	181.458*	3387.576*	8.161*	39.376*
Error	62	0.298	0.222	0.047	0.125

* : Significant at 0.05 level of probability

Appendix VII: Analysis of variance of the data on Flower head diameter, stalk length and 50% flower senescence of different chrysanthemum cultivars

Source of Variation	Degrees of Freedom (df)	Mean Square of		
		Flower head diameter(cm)	Stalk length(cm)	50% flower senescence
Replication	2	0.132	0.722	0.177
Factor A (variety)	31	44.846*	95.904*	12.303*
Error	62	0.062	0.152	0.324

*** : Significant at 0.05 level of probability**