EFFECT OF COVERING MATERIALS ON OFF SEASON FLOWER PRODUCTION OF CHRYSANTHEMUM (*Dendranthema* x *grandiflora* Tzvelev.) CULTIVARS UNDER LOW HILLS OF HP

Thesis

by

ALI HAIDAR SHAH
(H-2020-11-D)

submitted to

Dr. YASHWANT SINGH PARMAR UNIVERSITY OF HORTICULTURE AND FORESTRY SOLAN (NAUNI) HP- 173 230 INDIA

in

partial fulfilment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY
FLORICULTURE AND LANDSCAPE ARCHITECTURE

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE
COLLEGE OF HORTICULTURE

2024

Dr. Priyanka Thakur
Major Advisor

Floriculture and Landscape Architecture
Dr. Yashwant Singh Parmar University of Horticulture and Forestry (Nauni) Solan (HP) – 173 230 India

CERTIFICATE – I

This is to certify that the thesis titled **"Effect of covering materials on off season flower production of Chrysanthemum (*Dendranthema* x *grandiflora* Tzvelev.) cultivars under low hills of HP"** submitted in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy Floriculture and Landscape Architecture** in the discipline of **Horticultural Sciences** to Dr. Yashwant Singh Parmar University of Horticulture & Forestry, (Nauni) Solan (HP) – 173 230 is a bonafide research work carried out by **Mr. Ali Haidar Shah (H-2020-11-D)** son of Shri Khadim Hussain Shah under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation has been fully acknowledged.

Place: Nauni (Solan)
Dated:

Dr. Priyanka Thakur
Major Advisor

CERTIFICATE - II

This is to certify that the thesis titled **"Effect of covering materials on off season flower production of Chrysanthemum (*Dendranthema* x *grandiflora* Tzvelev.) cultivars under low hills of HP"** submitted by **Mr. Ali Haidar Shah (H-2020-11-D)** son of Sh. Khadim Hussain Shah to the Dr. Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173 230 India in partial fulfilment of the requirements for the degree of **Doctor of Philosophy Floriculture and Landscape Architecture** in the discipline of **Horticultural Sciences** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

27/2/24

Dr. Priyanka Thakur
Major Advisor

27.2.2024

Dr. YC Gupta
Former Dean, COH&F Thunag
External Examiner

Members of the Advisory Committee

1. **Dr. Bharti Kashyap**
   Associate Professor — Bharti 27.2.24
2. **Dr. Pradeep Kumar**
   Senior Scientist — 27/02/2024
3. **Dr. Anju Sharma**
   Assistant Professor — 27/02/2024

Head of Department

Countersigned

Dean of College

ACKNOWLEDGEMENTS

With all humility and sincerity, I bow my head with reverence and accord my gratitude to "ALLAHA" whose grace and blessings gave me courage and wisdom to accomplish this important task of my life. It was a dream, reaching at this stage of completing my PhD. studies, and I would not have been able to make it real without the aid and support of countless people over the past three years.

First of all, for my parents' words are inadequate to express my illimitable veneration, adoration and gratitude towards my Father (Sh. Khadim Hussain Shah), Mother (Smt. Shamim Akhter) whose constant inspiration, blessings and everlasting love have encouraged me in every step of my life, not only to go through gigantic task but to have pride to succeed in every walk of my life. Mere words cannot substitute my feeling towards my sister (Sageera Akhter) brothers (Ashiq Hussain Shah And Imran Hussain Shah) and jiju (Ayaz Hussain Shah) for their love, affection and moral backup in needful time.

For the most, I would like to express my gratitude towards my advisor, Dr. Priyanka Thakur Principal Floriculturist, for her highly inspiring, enthusiastic guidance with never never-ending spirit, sound counselling, unfailing courtesy, painstaking efforts, enduring encouragement and constructive criticism which led this work to its successful completion and shall remain a lifelong gifted memory for me.

I emphatically owe my cordial and sincere thanks to members of my advisory Committee Dr Bharti Kashyap, Dr Pradeep Kumar Scientist and Dr Anju Sharma for their constructive criticism in preparation of manuscript.

It is my privilege to record my sincere thanks to Dr SR Dhiman HOD FLA UHF, for all his help,support and guidenace, Dr BS Dilta, Dr Pooja Sharma, Dr Suman Bhatia, Dr Meenakshi Basoli, Dr Sapna Kaushal, for their motivation and encouragement towards self-refinement and better performance.

Its honor to thanks on of the most supportive and mentor personality Dr Ajay Thakur, Scientist G, FRI, Dehradun for all his help and support, Dr Manish Sharma Dean CoH, Sh Lalit Bhardwaj, Dr Arvinder Singh, Dr Nomita Laishram, Dr Bhupesh Sharma, Dr SK Gupta

It is indeed a pride and personal gratification to have my friend Komal and friends Arun, Irfan, Vivek, Tanuj, Madhurjit, for their encouragement, unmemorable company, inspiration and ungrudging help.

I also extend my sincere thanks to Zakir Uncle, Ashi Bhai, Dishi Uncle for all the motivation and sincere help. Candid thanks to all my seniors and juniors, especially Yogender, Manish, Sudhanshu, Nitesh, Gourav Dhakad, Vaibhav Chittora.

I extend my heartfelt thanks to my classmates My cordial thanks are to Bhatia sir, Sarita maam Vinod Sir, Susheel sir, Ashok sir, Chaman sir, Sony sir, Vinod, Mangu, Sumair, Prem Pal, Davinder, Madan and also to the official staff of the Department of RHR&TS Dhaulakuan and Department of FLA for helping me during my research.

It is not possible to give a mention to everybody by words but I am gratified to everyone.

Place: Nauni, Solan
Date: **(ALI HAIDAR SHAH)**

CONTENTS

ABBREVIATIONS USED

%	:	Per cent
&	:	And
/	:	Per
ANOVA	:	Analysis of Variance
B:C	:	Benefit Cost Ratio
CD	:	Critical Difference
Cm	:	Centimeter
CRD	:	Completely Randomized Design
Cv.	:	Cultivar
Df	:	Degree of Freedom
e.g	:	for example
et al.	:	Co Worker
etc	:	*et cetera*
FYM	:	Farm Yard Manure
g	:	Gram
ha	:	hectare
HDPE	:	High Density Poly Ethylene
HP	:	Himachal Pradesh
i.e	:	that is
kg	:	Kilogram
ml	:	Milliliter
MOP	:	Muriate of Potash
MSL	:	Mean Sea Level
MSS	:	Mean sum of square
NPK	:	Nitrogen, Phosphorus, Potassium.
NS	:	Non Significant
PPF	:	Photosynthetic Photon Flux
ppm	:	Parts per million
w.r.t	:	with respect to

LIST OF TABLES

LIST OF PLATES

Chapter-1

INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora* Tzvelev.) is one of the most exquisite and possibly the oldest ornamental plant grown commercially all over the world. It belongs to the family Asteraceae (Jiangshuo et al 2019). It is native to Northern Hemisphere, primarily Europe and Asia (Anderson, 1987). In Hindi, it is commonly referred to as "*Guldaudi*", while in English, it is called as "*Queen of the East*". The Greek words '*chrysos*' which meaning golden and '*anthos*' meaning flower are the origin of the word 'chrysanthemum' (Gortzing and Gillow, 1964). It is one of the leading cut flowers in the international market and ranks 2nd position next to rose in global cut flower trade (NHB 2020).

Chrysanthemum cultivation has a long history; it was first cultivated as herb in China during the 15th century BC and was then successively carried to Japan, Europe, and the United States (Anderson, 1996). Although the origin of the modern chrysanthemum is unknown, it is believed that the plant evolved primarily as a result of long-term artificial selection of wild species such as *C. indicum* (2n = 18, 36), *C. lavandulifolium* (2n = 18), *C. nankingense* (2n = 18), *C. vestitum* (2n = 54), and *C. zawadskii* (2n = 54) (Yang et al 2007; Bhattacharjee and Chandra 2003; Liu et al., 2012; Jiangshuo et al 2019). The complex hexaploid cultivated chrysanthemum also displays aneuploidy, with chromosome number ranging from 47 to 67. Though, chromosome number 54 (2n = 6x = 54) is the most common and has steady conformation (Dowrick 1999; Roxas et al 1995). In addition to its ornamental and economic value, chrysanthemum holds special cultural importance. It has been acknowledged as one of the 'four gentlemen among flowers', together with plum blossom, orchid, and bamboo, in Chinese classic literature, and it is included in the heraldry of the Japanese Imperial Family as an emblem of courage (Jiangshuo et al 2019).

In India, chrysanthemum is being utilized as an important crop for loose flower and cut flower production. It is commercially cultivated in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, West Bengal, Assam, Haryana and Himachal Pradesh. In India, area covered under chrysanthemum cultivation is around 23.93 (Thousand ha) with the loose flower production of 454.20 (Thousand Tonnes) and cut flower production of 15.96 (Thousand Tonnes) (NHB, 2022). In Himachal Pradesh, total area of 0.11 (Thousand ha) is under chrysanthemum cultivation with the loose flower production of 0.52 (Thousand Tonnes) and cut flower production of 3.90 (Thousand Tonnes) (NHB 2022).

Chrysanthemum is commonly regarded as an autumn flower. However, by using simple lighting or black out system, day length (night length) can be altered and the flowering time precisely controlled. Photoperiodic control of the growth and flowering of chrysanthemum makes it feasible to cultivate this crop all-year-round. By lengthening a short day through additional lighting system or shortening a long one through shading/ blackout, one can keep the plants in the vegetative or the generative stage, and so delay or bring forward their flowering respectively (Machin and Scopes 1978).

Based on the number of weeks necessary from the start of the short days at a temperature of 15.5° C for the night, chrysanthemums are grouped into response subgroups that take 6 to 16 weeks (the number of short days required for flowering) (Larson, 1980). The essential photoperiod for vegetative growth and reproductive activity is 13.5 hours. Early flowering cultivars are short day plants exhibiting facultative flower initiation, qualitative flower bud development, and a 6–8week response subgroups (Cockskull and Kofranek 1985). The initiation and growth of flower buds are necessary for short days in the late flowering group (>8 response group).

Temperature also affects the growth and flowering of chrysanthemums. There are three classes of chrysanthemums and are separated based on how they respond to temperature. Thermo-zero cultivars are the ones that flower best between 10 and 27. At 15.5°C, flowering moves forward quickly. It was suggested that this group would be the most likely to display perennial flowering.

Second group is thermo-positive cultivars which include the cultivars that become incapable of flowering at temperatures below 15.5°C. Provided the temperature is properly managed, these varieties can be planted for year-round flower output.

The third group is thermo-negative cultivar, where temperatures above 15.5°C hinder flowering in certain cultivars. Lower temperatures (10°C) may delay commencement but may not prevent it. These cultivars can only be grown when overnight temperatures can be kept under control at 15.5°C or slightly below. Heat culture should be avoided. Group includes the late season varieties which belong to 13-16-week response group.

From September to November, chrysanthemums bloom naturally in the Himachal Pradesh state's hilly areas. However, chrysanthemum can be made to flower at any time of the year by adjusting the elements necessary for flowering. Successful flowering of chrysanthemum throughout the year by using thick dark coloured tarpaulin, have been obtained under Nauni, Solan conditions of Himachal Pradesh in selected cultivars as shown by research of Sita Ram (1991), Pathak (2002), Usha (2010) and Sangma et al (2016). Farmers in mid hills of Himachal Pradesh are producing chrysanthemum blooms for off season using tarpaulin as a covering material to create artificially short days. The same technology is required to be standardized in lower hills of Himachal Pradesh, where need and demand of off-season production of chrysanthemum is very high as per mid hill farmers.

Tarpaulin is an effective and most frequently used covering material and it excludes all the light from the plants but it has to be handled carefully as it tears very easily. Being heavy, several people are needed while covering and uncovering of the plants manually. Moreover, it is an expensive material, making it uneconomical in terms of production cost also. Therefore, cost-effective and light weight covering material is needed for large-scale production of chrysanthemum blooms outside of the growing season. Keeping this in view, the present investigation was undertaken to find out suitable covering material for off season flower production of chrysanthemum at RHR&TS, Dhaulakuan with the following objectives:-

Objectives

i) To find out suitable covering material(s) for off-season flower production of chrysanthemum cultivar(s) for low hills of HP

ii) To find out suitable chrysanthemum cultivar(s) for off season flower production for low hills of HP

Chapter-2

REVIEW OF LITERATURE

The literature pertaining to, chrysanthemum and various covering materials used for its off-season flower production, has been reviewed in this chapter under three broad categories.

A) Chrysanthemum-photoperiodic response and cultivation
B) Off season flower production and covering materials
C) Effect of temperature on growth and flowering of chrysanthemum.

A) Chrysanthemum-photoperiodic response and cultivation

Chrysanthemum (*Dendranthema grandiflora* Tzvelev), a member of the Compositae family, typically undergoes flowering during the short day conditions of winter, characterized by long nights and short days. Normally, this plant is unable to initiate flower buds when exposed to day lengths of either 14 hours or longer, as reported by Post in 1931, or 13.5 hours or longer, as indicated by Cockshull in 1976. Cockshull and Kofranek reported in 1992 that garden chrysanthemums display early flowering tendencies in September and October when cultivated outdoors, and this early flowering is closely associated with short day conditions. These early-flowering chrysanthemums are generally classified as quantitative short-day plants, which means that both the initiation and development of flowers occur more rapidly under short day conditions compared to long days. However, a few varieties are either day-neutral or exhibit near-day-neutral behavior, as identified by Kawata and Toyada in 1982, Langton in 1977, and Cockshull and Kofranek in 1992. It's important to note that the specific day length required to trigger rapid flower initiation varies among different chrysanthemum cultivars. Additionally, temperature and plant size interact with day length to determine the natural flowering season, as outlined by Langton in 1977.

Allard (1928) discovered that when plants were exposed to only 10 hours of light, from 5:30 am to 3:30 pm, starting in May and then placed in a dark chamber for the remainder of the day, they began flowering on July 15th. In contrast, plants growing under natural conditions didn't flower until mid-October. In 2004, Lee and colleagues reported that the most favorable photoperiod for progressing to anthesis was 10 hours for both the 'Envy' and 'Lady Time' cultivars. Plants subjected to a 10-hour photoperiod reached anthesis up to 7 days earlier than those exposed to 8 or 12-hour photoperiods. Furthermore, overall plant growth, including factors like dry weight, stem length, and leaf area, increased as photoperiods extended from 10 to 16 hours.

Light and temperature are two critical factors that significantly influence the growth and development of chrysanthemum plants. The number of leaves on these plants increases in response to elevated temperatures, both during the day and night. Notably, the increase in leaf number is more pronounced in response to higher daytime temperatures, as noted by Karlsson et al in 1989. Furthermore, when chrysanthemum plants experience higher temperatures during short days, they tend to develop more leaves below the flowering region, resulting in a delay in the initiation of morphological flower development. This observation aligns with findings from Karlsson et al. (1989), Cathey (1955), Cockshull (1979).

Furthermore, the rate of leaf emergence in chrysanthemum plants exhibits a linear relationship with rising temperatures, as demonstrated by Karlsson et al. in their 1990 study. Their research findings indicated that for every 1°C increase in the average daily temperature, chrysanthemum leaf development would accelerate by approximately 0.017 leaves per °C per day. Temperature emerges as the pivotal factor governing the length of chrysanthemum shoots. Elevated daytime temperatures, whether accompanied by low or high nighttime temperatures, tend to produce taller plants, as observed by Karlsson in 1989 and Lepage et al. in 1984. Conversely, increased nighttime temperatures have the opposite effect, reducing stem length and leaf weight, as noted by Lepage et al. in 1984. Furthermore, internode length decreases with rising temperatures, as reported by Khattak et al in 1997. High night time temperatures have the additional impact of delaying flowering, generating abnormal flowers, and retarding stem growth, as documented by Cockshull and Kofranek in 1992 and Bonaminio and Larson in 1980.

Temperatures can result in slower and erratic growth and development of plants temperatures have a delaying effect on both the initiation of flowering and the early formation of flower buds, as noted by Bonamino and Larson in 1980, Karlson and McIntyre in 1990, and Van Ruiten and Dejong in 1984. At a temperature of 10°C, both the initiation and progression of flower development experience delays, as indicated by Karlsson and Mc Intyre in 1990.

Adams and colleagues in their 1998 study also proposed that the reduced rate of development at lower temperatures results from a combination of delayed flower initiation and a slower pace of flower bud development. Additionally, it has been observed that lower nighttime temperatures can either hinder the formation of flower buds or postpone the flowering process. These lower temperatures also lead to a reduction in the number of leaves, stimulate basal resetting, shorten the internode length, and result in larger flower diameters. Furthermore, both a decrease in daytime and nighttime temperatures have been shown to diminish overall plant growth. However, it's worth noting that the impact of daytime temperature reduction is notably more pronounced than that of nighttime temperature reduction.

The ideal temperature conditions for both the initiation and development of flowers in chrysanthemum have been documented in scientific literature. Specifically, these conditions have been reported as: 16°C according to Cathey in 1955, and a day temperature of 22°C combined with a night temperature of 18°C, as outlined by Bonaminio and Larson in 1980. Furthermore, the temperature range considered optimal for flowering in chrysanthemum falls between 18 and 21°C, as supported by research conducted by De Jong in 1978 and 1989, Karlsson and colleagues in 1989, Hiden and Larson 1994 as well as Adams and colleagues in 1998.

The process of flower bud initiation and development exhibited an accelerated pace when subjected to short day conditions, as documented by Cockshull and Kofranek in 1992 and Langton in 1987. In contrast, for most chrysanthemum cultivars, the shoot apical meristem eventually triggers flower bud initiation under long day conditions, as illustrated by Cockshull in 1976 and Cockshull and Kofranek in 1985. Machin and Scopes inn 1978 conducted a study to investigate the impact of light quality, light intensity, and photoperiod on the stem elongation of chrysanthemum. They observed that stem and internode elongation occurred to a greater extent in darkness compared to light, and the growth of chrysanthemum was enhanced in the absence of light. Notably, the influence of light quality on chrysanthemum growth was more pronounced than the effects of light intensity and photoperiod. Additionally, higher light levels were associated with increased plant fresh and dry mass, greater stem strength, a higher number of flowers, and longer stem length. Moreover, it was determined that a shorter photoperiod is required for flower bud development compared to flower bud initiation. Varieties categorized within longer response groups necessitated a shorter photoperiod for both initiating flower buds and achieving the maximum rate of flower bud development. This finding aligns with the research of Cathey in 1954 and Furuta in 1954.

Nishio et al (1989) grew plants of chrysanthemum cultivars 'Jem' and 'Dramatic' under different photoperiods during different stages of development found that optimum day length for flower bud differentiation was 10 hours compared with 12 hours at optimum temperature (about 18°C) and for flower bud development it was 9 to 10 hours. However, photoperiod of 11 hours produced best quality cut flowers. They also reported that when the plants were subjected to a photoperiod longer than normal after appearance of flower color, flowering time was not affected, but elongation of lateral flowering shoots was promoted which resulted in improved plant shape.

When examining the impact of planting dates and foliar GA_3 spray on flowering and production of chrysanthemum, Deotale et al. (1994) discovered that planting chrysanthemum in late June is superior. When 150 ppm GA_3 was sprayed, it was preferable for higher yields. However, when crop was planted in mid-July and sprayed with GA_3 100 ppm, maximal flowering was achieved.

In 1994, Deotale et al. also noted that planting on June 4 was superior for obtaining the highest average height and number of leaves, June 24 was superior for obtaining the average leaf area, and July 14 was superior for obtaining the average number of primary and secondary acorns.

Meher et al. (1999) in their research on planting dates for chrysanthemums in Pune, Maharashtra, revealed that May planting is preferable to June and July plantings for a variety of growth metrics. Meher et al. stated that May planting again shown superiority for a number of blooming characteristics during 1999.

Depending on the dates, Przymeska and Lisiecka (2001) compared the flowering and quality of 8 spray chrysanthemum cultivars. They claimed that the cultivar had the biggest impact on plant quality, followed by the year of culture and the planting date.

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

B) Off season flower production and covering materials

Streck (2004) developmental models can help growers to decide management practices, and to predict flowering and harvest time. Currently, a double exponential function is proposed as a generalized temperature response function for chrysanthemum. This function is not the most appropriate because its parameters lack biological meaning. The objective of this study was to develop a nonlinear temperature response function of chrysanthemum development that has parameters with biological meaning. The proposed function is a beta function with three parameters, the cardinal temperatures (minimum, optimum, and maximum temperatures for development), which were defined as 0, 22, and 35°C. Published data of temperature response of development of three cultivars, which are independent data sets, were used to test the performance of the double exponential function and the beta function. Results showed that the beta function is better than the double exponential function to describe the temperature response of chrysanthemum development.

Taweesak et al. (2014) conducted an experiment to study the influence of irrigation frequency on the growth and flowering of chrysanthemum grown under restricted root volume. Chrysanthemum cuttings (*Chrysanthemum morifolium* “Reagan White”) were grown in seedling tray which contained coconut peat in volumes of 73 and 140 cm^3. Plants were irrigated with drip irrigation at irrigation frequencies of 4 (266 mL), 6 (400 mL), and 8 (533 mL) times/day to observe their growth and flowering performances. There was interaction between irrigation frequency and substrate volume on plant height of chrysanthemum. Plants grown in 140 cm^3 substrates and irrigated 6 times/day produced the tallest plant of 109.25

cm. Plants irrigated 6 and 8 times/day had significantly higher level of phosphorus content in their leaves than those plants irrigated 4 times/day. The total leaf area, number of internodes, leaf length, and leaf width of chrysanthemums grown in 140 cm^3 substrate were significantly higher than those grown in 73 cm^3 substrate. The numbers of flowers were affected by both irrigation frequencies and substrate volumes. Chrysanthemums irrigated 8 times/day had an average of 19.56 flowers while those irrigated 4 times/day had an average of 16.63 flowers. Increasing irrigation frequency can improve the growth and flowering of chrysanthemums in small substrate volumes.

Post (1931) utilized black satin cloth to simulate artificial short day conditions, imposing darkness from 6 pm to 7 am (with a 4-hour darkening period equally distributed between the beginning and end of the day). This was done to expedite early bloom production in chrysanthemum. The study concluded that forced flowers, which bloomed ahead of the normal schedule, exhibited shorter stems compared to those under standard conditions. Additionally, pompons subjected to continuous cultivation under tobacco cloth and darkened with stock satin bloomed simultaneously with those in the greenhouse, displaying superior quality. Across all standard and spray varieties, stem length was consistently shorter than the control group. Furthermore, the darkening process not only increased the number of stems per plant but also led to a reduction in the number of flowers per stem.

Poesch (1931) implemented full-covering white and black shades, applying them from 6 pm to 7 am. The investigation revealed that entirely white shades did not yield any significant advancements in early blooming. Both overhead black and overhead white shades failed to sufficiently reduce the duration of daylight to accelerate maturity. However, plots initially shaded with full-covering white shades, followed by subsequent application of full-covering black shades, exhibited a noticeable advantage in flowering time compared to the control group. Notably, the complete black shading method proved to be the most effective approach for achieving earlier blooms than those occurring in the normal season. Additionally, Poesch observed that frames covered with lath, which reduced light intensity by 60 to 75%, did not confer any beneficial effects on the timing of flowering.

Larson (1980) reported that chrysanthemum plants, subjected to 16 hours of darkness per day starting eight weeks after planting, exhibited flowering occurring 5 to 7 days earlier than those exposed to 12 hours of darkness per day and 10 to 14 days earlier than those kept under continuous light conditions. Additionally, Gloeckner (1985) recommended that during periods of the year when the natural dark period is insufficient for the formation of flower buds, it is advisable to employ black cloth coverings beginning at 7:00 pm and removing them at 7:00 am.

Post (1932) conducted a thorough examination of the impact of various types of black cloth on chrysanthemum growth, including black satin, 68 x 104 (previously used and washed twice), unused black satin, 68 x 104, unused black satin, 68 x 88, and new black cloth with a plain weave of 68 x 72. The results revealed that all satin cloths demonstrated an equal effectiveness in promoting early blooms. However, plants treated with the plain weave black cloth did not exhibit as early or as uniform blooming as those treated with black satin. Furthermore, when comparing black satin of 68 x 104 with a black costume cloth of 54 x 54, on six different varieties, it was determined that the satin cloth was significantly more effective in inducing early blooms than the black costume cloth.

Chrysanthemum blooming dates are primarily influenced by when suckers or cuttings first appear and when they quit. disbudding, according to Warup (1967). Clausen (1973) discovered that May planting, as opposed to June and July planting, resulted in the earliest blossoming in many chrysanthemum varieties.

When examining the effects of planting timings on 10 varieties of chrysanthemum, Plomacher (1980) found that planting early (May, June) produced flowering stems and a spread for the early September market. The best time to buy, however, was said to be in mid-June for the more lucrative late-September and October markets.

Langton et al. (1981) compiled a comprehensive catalogue detailing the leaf numbers required for the long-day treatment in numerous chrysanthemum cultivars. This approach has proven to be valuable for chrysanthemum growers and cutting producers, enabling them to identify cultivars that exhibit a tendency toward premature bud formation. As a result, they can take specific precautions and provide special care during the propagation of cuttings for these cultivars.

Jerzy (1981) highlights the potential for cost reduction in chrysanthemum production through the implementation of a direct short-day planting system for year-round cut flower chrysanthemums, which has been utilized in Poland since 1974. This system involves keeping vegetative plants separate for the entire long-day period, requiring only short-day treatment in the flowering area. Depending on the cultivar, it allows for 4 to 5 crops per year. The study examined this planting system in the context of Polish climatic conditions and investigated the growth and flowering patterns of 9 to 11-week cultivars under varying light conditions throughout the year. The findings indicated that the shortest period of generative development and the highest flower quality were observed in plants grown during the spring and summer seasons. In contrast, the duration of generative development reached its peak between November 1 and February 15, during which time many cultivars lost their capacity for flowering.

Chrysanthemums are grown commercially by digging the suckers that grow from the plants from the previous year. Plant to plant distances between 20 and 30 cm were set up and immediately on the ridges. There are two main planting seasons in Maharashtra. One is in March–April, while the other is in August. The planting season begins in Bangalore April to July (Kher, 1988).

Griffith and McIntyre (1989) documented that the duration for flowering initiation following the commencement of short-day treatment exhibited variation among cultivars, as well as in relation to specific growing conditions. 'Coronet' cultivar displayed the shortest time to flower (55-60 days), followed by 'Twilight', 'Free Spirit', and 'Spot Light'.

Nishio et al. (1989) conducted experiments with chrysanthemum cultivars 'Jem' and 'Dramatic', subjecting them to varying photoperiods during distinct developmental stages. They determined that the optimal day length for flower bud differentiation was 10 hours, as opposed to 12 hours, under ideal temperature conditions (approximately 18°C). For flower bud development, the optimal photoperiod ranged from 9 to 10 hours. Nevertheless, an 11-hour photoperiod yielded the highest quality cut flowers. Additionally, it was noted that if plants were exposed to a longer-than-normal photoperiod after flower coloration had begun, it did not impact the flowering time, but it did encourage the elongation of lateral flowering shoots, resulting in an enhanced plant structure.

In the case of chrysanthemums, continuous flowering could be obtained when the appropriate cultivars are chosen for flowering succession; it is possible to grow plants without a control over the photoperiod, or natural season, from early October to early January. Rooted cuttings are planted in this instance. 7 week cultivars were introduced in mid-June, and 15 week cultivars were introduced in mid-August (Kofranek, 1992).

In 1989, Kher proposed a method for cultivating specific crop varieties, typically with a growth period of 9-12 weeks, between Dussehra and Republic Day in Lucknow's natural conditions. To achieve this, Kher recommended the utilization of either black satin cloth or opaque polythene sheets. These materials would be used to create long nights or induce short-day conditions by completely blocking out light from 6 PM to 8 AM daily.

Sita Ram and Sehgal (1993[a]) achieved year-round flowering in chrysanthemum by employing dark tarpaulin to create artificial short days, lasting for 16 hours each day from 5 PM to 9 AM. They accomplished this by covering metallic frames shaped like mini tunnels with dark tarpaulin fabric. Their findings revealed that chrysanthemum plants exposed to these controlled photoperiods exhibited earlier flowering compared to those subjected to natural photoperiod conditions.

Hiden and Larsen (1994) employed black satin cloth to cover plants from 5:00 PM to 8:00 AM daily in a greenhouse setting, aiming to predict the development of chrysanthemum flowers. The results indicated that chrysanthemum plants exposed to temperatures between 18-22°C exhibited earlier flowering compared to those subjected to other temperature treatments. Flower development was notably delayed at temperatures of 12°C and 27°C. Specifically, at 12°C, the stage of "visible flower bud formation" experienced the most pronounced delay, while at 27°C, the phase when flower buds started to separate exhibited the greatest delay. Interestingly, higher temperatures ranging from 24.6°C to 25.1°C also caused delays in flower development, although these delays could be mitigated with increased light intensity. Furthermore, the study observed that as light intensity decreased, the delay in flower bud development increased. Notably, lower light levels not only resulted in smaller flower buds but also extended the time required for both visible flower bud formation and anthesis. Additionally, this delay was found to intensify as the temperature increased.

Cockshull and Kofranek (1994) employed black cloth for a duration of 14 hours each night, starting in July, to simulate artificial short days in the 'Polaris' and 'White Marble' varieties, maintaining a temperature of 32°C. Their findings revealed that temperatures exceeding 26°C were beyond the optimal range for flower bud initiation and development. Exposure to such high temperatures, whether during the day or night, led to alterations that postponed the onset of flowering. Importantly, these changes in the flower initiation process were irreversible. As a result, they emphasized the necessity of implementing measures to maintain temperatures below 26°C when covering crops during the summer. Their recommendations included using permeable covering materials (as suggested by Furuta and Nelson in 1954), employing covers with reflective outer surfaces (in line with Cotton and Wolfe's research from 1971), ensuring that covers are placed over the crops as late as possible in the afternoon and removed early the following morning, once the required hours of darkness have been provided (as proposed by Cockshull in 1987), or alternatively, automatically removing the covers after nightfall and replacing them before dawn (as demonstrated by Pearson et al. in 1993).

Datta et al. (1995) implemented artificially extended photoperiods of 14, 16, and 18 hours, commencing at 0, 1, and 2 months post-planting, lasting either 15 or 30 days, on the Co.1 cultivar. A control group was maintained under natural daylight conditions. It was observed that there was a delay of approximately 69.66 days in the onset of flowering compared to the control group. Additionally, when the plants were subjected to a 16-hour day length, starting one month after planting for a duration of 15 days, an extended flowering period was documented.

Benedetto and Porto (1996) conducted experiments within a commercial greenhouse involving cuttings of chrysanthemum cultivars 'Santini,' 'Shamrock,' and 'Seiko,' which were initially planted in November 1992. These cuttings were exposed to natural daylight for 30 days and then, until the first signs of flower color, were covered with black polyethylene from 18:00 to 10:00 hours. During the growth period of 15 days, the plants were either subjected to the removal of apical buds, with planting densities of either 40 or 80 plants/m_2, or they were grown without bud removal at a density of 80 plants/m^2. The results indicated that not removing the buds led to higher accumulation of dry matter in leaves, stems, and flowers, as well as greater stem length compared to the bud removal treatment. Furthermore, an increase in plant density resulted in improved commercial flower quality, an increased number of flower stems per unit area, and had no effect on the duration of the cropping cycle. Khattak et al. (1997) conducted research on the impact of light quality and temperature on the growth and flowering of chrysanthemum cultivars 'Bright Golden Anne' and 'Snowdon'. Their findings indicated a notable influence of light quality and temperature on plant height. As temperature rose, internodal length decreased, and heightened levels of blue light considerably expedited the flowering process.

In the study conducted by Stack (1998), black cloth was employed to induce short-day conditions in *Dendranthema grandiflora*, specifically within the cultivars 'Manatee Iceberg' and 'Naples.' Under these short-day conditions, the plants exhibited reduced height and had less vegetative growth.

Mc Mohan (1999) observed that proper floral primordial development only occurred under short photoperiods in the 'Bright Golden Anne' cultivar, when the experiment was conducted in April-May and repeated in May-June.

Willits and Bailey (1994) utilized dense black fabric to investigate the impact of night temperatures on the flowering of potted chrysanthemum cultivars, specifically examining heat-tolerant varieties ('Iridon' and 'Dark Bronze Charm') and heat-sensitive ones ('Yellow Mandalay' and 'Coral Charm'). Their aim was to understand the phenomenon of heat-related delays in flowering, which can pose significant challenges in warm climates during the summer months. To induce short-day conditions, they employed thick black cotton cloths, covering the plants from 17:00 hours to 7:30 hours. Their findings indicated that the normal flower diameter exhibited a more pronounced response to nighttime temperatures in the heat-sensitive cultivars compared to the heat-tolerant ones. Specifically, the normal flower diameter for the heat-sensitive cultivars was approximately 9% larger at 21°C compared to 25°C, while the heat-tolerant cultivars showed only about a 4% increase in normal diameter within the same temperature range.

Lee et al. (2001) noted that augmenting the duration of exposure to short days leads to a reduction in the ultimate leaf count and accelerates the onset of the floral phase, indicating an adaptable reaction to photoperiodic variations.

Pathak (2002) conducted an evaluation of thirty different cultivars for year-round flower production. The cultivation process involved planting of these cultivars at two-month intervals starting from April 26th. Successful flowering was achieved consistently under controlled photoperiod conditions in April, December, and February for all 30 cultivars. However, only 14 cultivars managed to flower in August, and merely 7 cultivars in October when subjected to controlled photoperiod conditions. To simulate artificial short days, semi-circular tunnel-shaped metallic frames measuring 3 x 1.5 x 1.65 meters were used, entirely covered with thick, dark-colored tarpaulin. This shading method was employed until approximately 60-70% of the flower buds on the plants displayed color. In terms of plant characteristics, such as height, spread, flower size, and flower numbers, better results were observed under natural photoperiod conditions compared to controlled photoperiod when planting took place in April, December, and February. The time it took for the first flower to open, the peak flowering period, and the total duration from planting to peak flowering varied, with controlled photoperiod consistently yielding earlier results than natural photoperiod. Overall, controlled photoperiod application was found to be more effective for promoting flowering in all plantings compared to natural conditions. Flowers tended to appear significantly earlier under controlled photoperiod conditions than under natural photoperiod conditions.

Velmurugal and Vadivel (2003) employed black cloth during the summer season to enhance the production of uniform and visually appealing flowers. They employed various shading techniques, including a control group and shades of 12 hours, 13 hours, 14 hours, and 15 hours of shade. Among these different short day treatments, the greatest number of flowers per plant and the highest flower yield per plant were consistently observed under the 14-hour shading condition in February, April, and June. Their research revealed that the increase in chlorophyll content played a significant role in augmenting flower yield across all months of flower production,

Jerzy (2003) noted that interrupting the short day period led to improved flower shape and quality, although it resulted in delayed flowering. The longest delay (21-26 days) occurred during the summer in a plastic tunnel.

When evaluating chrysanthemum cultivars for year-round production, Pathak (2002) found that planting in June produced the highest-quality blooms with the longest stems, better blossom size, and the longest flowering period. Nevertheless, in normal photoperiodic conditions. Early blossoming resulted from planting in August and October, but the quantity of flowers, side shoots, flower size, and plant height were observed.

According to Bres and Jery (2004), planting dates between October and January were deemed unsuitable for the initiation of controlled cultivation of chrysanthemum cultivars for pots.

According to Grawal et al (2004), planting chrysanthemum cv. "Flirt" in July performed better than planting it in August in the conditions of Punjab in terms of the quantity of blooms and stem length. On the other hand, late planting, i.e., 16 August, gave the flower with expanded diameter and maximum fresh and dry weight of flower. The earliest planting, i.e., 18 February, took more time to commence flowers with prolonged blooming duration, greater number of flower and extended vase life.

In a study by Lee et al. (2004), the impact of photoperiod on the floral development of Chrysanthemum cultivars 'Envy' and 'Lady Time' was investigated. It was observed that a 10-hour photoperiod was the most conducive for progressing towards anthesis. Additionally, overall plant growth, including parameters such as dry weight, stem length, and leaf area, exhibited an increase with extended photoperiods ranging from 10 to 16 hours.

Janakiram et al. (2004) subjected chrysanthemum cv to short days by using black polythene sheets. In order to examine the influence of photoperiod on the production of chrysanthemum cv. "Ravikiran" under low cost polyhouse from September 2003 to February 2004, "Ravikiran" was planted in the fifth week of the growing season and dark period treatments (i.e. 7 hours, 9 hours, 11 hours, 10 hours, and 11 hours) were provided. Among all of the treatments, 10 hours of darkness and 14 hours of light reported maximum plant height (77.73 cm), total number of flowers (37.58), flower diameter (3.81 cm), stem girth at bottom (0.62 cm), leaf area (102.30 cm^2), earliest flower initiation (124.67 days), and earliness to 50% flowering (137.33 days). The growth parameters, yield and quality of flowers were better in 10 hours dark and 14 hours light; the treatment of 11 hours dark and 13 hours light wasfound to be at par with the best treatment except in 50% flowering, they concluded that, this delay, can be used to catch off- season markets.

Anjum et al. (2007) conducted an experiment involving the planting of small and large-sized chrysanthemum suckers, with a height difference of at least 5 cm, on four distinct planting dates: February 18th, April 18th, June 17th and August 16th. The results demonstrated that small-sized suckers led to an extended blooming period and a higher flower count per plant. The earliest planting (February 18th) exhibited a prolonged initiation of flowers, resulting in an extended blooming period, a greater number of flowers, and an extended vase-life. Conversely, the late planting (August 16th) yielded flowers with an increased diameter and the highest fresh and dry weights per flower.

Usha (2010) used tarpaulin to induce artificially short days from 5 p.m. to 9 a.m. while examining 26 chrysanthemum cultivars for off-season flower production. They discovered that all 26 cultivars were suitable for off-season flower production. The adoption of controlled photoperiod was found to be superior to natural photoperiod for flowering in all plantings, and flowering occurred more rapidly under controlled photoperiod (165.83 days) with greater plant quality than natural photoperiod (240.51 days). Under a regulated photoperiod, flower bud production, bud opening, and maximum flowering occurred significantly earlier. In contrast to natural photoperiodic conditions, regulated photoperiod increased flowering length. In contrast to regulated photoperiod, however, natural photoperiod stimulated plant height and spread.

Black-polythene sheets were used by Nxumalo and Wahome (2010) to assess the impact of short-day treatments on the growth, flowering, and cut flower quality of chrysanthemums and to identify the most effective time of day for the application of the short day treatment. A randomized complete block design (RCBD) has been employed for setting up the experiment. There were four distinct treatments: providing the short day by covering the plants with a black polythene sheet from 5:00 AM to 7:00 AM, 11:00 AM to 2:00 PM, 4:00 PM to sunset, and control (no covering). Chrysanthemums were significantly impacted by short days in terms of growth and flowering. Uncovered (control) plants experienced the highest vegetative growth in terms of height of the plant, number of leaves, and leaf area. The number of cut flower stems obtained from chrysanthemums that were covered at 5.00-9.00 AM was more than double that obtained from control plants. It is recommended that chrysanthemum grown under similar environmental conditions beprovided with short-day from 5.00 pm to 9.00 am to induce higher yield and quality of cut flowers.

Basoli et al. (2016) conducted their research at the experimental farm of the Department of Floriculture and Landscape Architecture, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan. The study focused on four commercially cultivated spray varieties of chrysanthemum: 'Surf', 'Nanako', 'Ajay', and 'White Bouquet'. These cultivars were planted on nine different dates, spaced 15 days apart, ranging from April 9 to August 7. Significant variations were observed among the spray cultivars in terms of both vegetative and floral characteristics. Although successful flowering was achieved in all planting dates for the spray type chrysanthemum cultivars, later plantings resulted in shorter cut stems. Among the spray types, it is recommended to plant 'Surf' before July 8, 'Nanako' and 'White Bouquet' before June 8, and 'Ajay' before July in order to produce marketable cut stems. By adjusting the planting dates, flowering of these cultivars under Solan-Nauni conditions can be regulated from September 10 to November 1, spanning a period of 52 days.

Sangma et al. (2016) conducted a study focusing on the influence of covering materials on off-season cut flower production of chrysanthemum (*Dendranthema grandiflora* Tzvelev) at the experimental farm of the Department of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry in Nauni, Solan, Himachal Pradesh, during the year 2011. The experiment took place within a naturally ventilated polyhouse and involved the utilization of three types of covering materials: tarpaulin, high density polyethylene (HDPE), and black satin cloth. Four cultivars were selected from both standard (Purnima, Yellow Star, Tata Century, and White Star) and spray (Ajay, Birbal, Nanako, and White Bouquet) varieties. The results indicated that HDPE proved to be the most favorable alternative covering material in comparison to tarpaulin. Plants grown under HDPE exhibited optimal characteristics such as plant height (83.33 cm), plant spread (40.54 cm), the highest number of cut stems (4.21), duration of flowering (33.54 days), earliest flower bud formation (91.07 days), and earliest flowering. Notably, under controlled photoperiodic conditions, flowering occurred earlier compared to natural photoperiod conditions. Furthermore, peak flowering was observed at the earliest (140.36 days) in plants under HDPE cover, while plants under natural photoperiodic conditions took a maximum of 176.19 days to reach peak flowering. Under controlled photoperiodic conditions with HDPE, the tested varieties were categorized into different response groups. It was determined that all the varieties examined were suitable for off-season flower production.

Basoli et al. (2016) conducted their research at the experimental farm located in the Department of Floriculture and Landscape Architecture, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during the year 2008. The study focused on four commonly grown commercial chrysanthemum cultivars. These cultivars were planted on various dates with a 15-day interval between each planting, spanning from April 9 to August 7. Significant variations were observed among the cultivars concerning both their vegetative and floral characteristics. While all standard cultivars included in the study successfully flowered regardless of the planting date, later plantings resulted in shorter cut stems. Consequently, the optimal planting date for achieving marketable cut stems was found to vary depending on the cultivar, occurring on June 8 for Purnima, May 24 for White Star and Tata Century, and July 23 for Yellow Star among standard types. By strategically selecting planting dates, flowering could be regulated to occur between September 21 and November 25.

Dhiman et al. (2018) conducted a study in Solan to identify appropriate chrysanthemum cultivars for pot mum production under natural and controlled photoperiodic conditions. The experiment included 15 cultivars/selections of chrysanthemum arranged in a completely randomized design (factorial) with three replications. Off-season flowering was induced by applying artificial short days (16 hours of darkness from 5:00 pm to 9:00 am) starting from May 31, 2013, using high-density polyethylene covering material (white outside and black inside), until 60–70% of buds exhibited color. Among the various cultivars/selections examined, Pusa Anmol, Vijay, Vijay Kiran, and Anmol demonstrated suitability for pot mum production in both conditions. These cultivars exhibited desirable characteristics, including early flowering, optimal height, larger flower size, prolonged flowering duration, and compact growth, particularly under controlled photoperiodic conditions. Consequently, Pusa Anmol, Vijay, Vijay Kiran, and Anmol are recommended for pot mum production in the lower hills of Himachal Pradesh.

Dhiman 2018, conducted a study to investigate the impact of various blackout materials on the off-season potted chrysanthemum (*Dendranthema grandiflora* Tzevelev) production. The research was conducted at the experimental farm of the Department of Floriculture and Landscape Architecture, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during the year 2011. The study encompassed 10 selections/cultivars of chrysanthemum. Off-season flowering was induced by implementing artificial short days, entailing a 16-hour dark period commencing from 5.00 pm to 9.00 am, starting on June 9, 2011, and continuing until 60-70% of flower buds displayed color. Three different materials were employed to provide artificial short days: tarpaulin, high-density polyethylene with white on the outside and black on the inside, and black satin cloth. The findings unveiled that among the various covering materials, HDPE resulted in the shortest duration for visible flower bud formation in the cultivar 'UHFSChr -43' (60.67 days) and the largest flower diameter in 'UHFSChr -68' (4.22 cm). However, black satin cloth recorded the tallest plant height in the 'Ajay' cultivar (70.00 cm), along with the highest number of flowers per pot and per plant in 'UHFSChr -64' (367.30 and 123.00 respectively). In this experiment, all selections/cultivars subjected to off-season potted chrysanthemum production under different blackout materials achieved successful flowering. Among the various blackout materials used, HDPE demonstrated superior performance for the specific conditions of Solan-Nauni in Himachal Pradesh.

The research conducted by Sultanpuri et al. (2018) centered on the newly developed chrysanthemum selection 'UHFSChr-56.' These chrysanthemum plants were cultivated in pots filled with a mixture of sand, soil, and FYM (1:1:1 v/v). The pots were arranged with one, two, or three cuttings per pot, and they were spaced at varying distances of 9, 12, and 15 inches. The findings from the study demonstrated that 'UHFSChr-56' chrysanthemum selection can be successfully grown as potted mums under both natural and controlled photoperiodic conditions. The stage of visible bud formation occurred earlier in pots containing one plant per pot, spaced 9 inches apart, and grown under controlled photoperiodic conditions (94.02 days). In contrast, the visible bud formation stage took the longest time to reach when one plant per pot was spaced at 12 inches apart (158.50 days) under natural photoperiodic conditions. Among the 18 treatment combinations tested, eight treatments stood out. These included scenarios with one, two, or three plants per pot grown at a pot spacing of 9 inches under controlled photoperiodic conditions. Additionally, one plant at 9 inches pot spacing, one plant at 12 inches pot spacing, and two plants at 12 inches and 15 inches pot spacing, all under natural photoperiodic conditions, resulted in the production of the most visually appealing square-shaped plants in six-inch plastic pots.

C) Effect of temperature on growth and flowering of chrysanthemum.

Carvalho et al (2005) studied the sensitivity to temperature of the number of flowers per plant including flower buds, flower size, position and color in cut chrysanthemum (*Chrysanthemum morifolium* cv. ‘Reagan Improved’). Plants were grown either in a glasshouse at constant 24 h mean temperatures throughout cultivation (17°C or 21°C), or in growth chambers at 32 different temperature combinations (from 15°C to 24°C). The latter temperature combinations were applied by dividing the cultivation period into three sequential phases: long-day period (phase I), start of short-day period to visible terminal flower bud (phase II), and end of phase II to harvest stage (phase III). All flower characteristics were affected significantly by temperature, except for flower position within the plant. Higher temperatures increased NFPP, mainly by increasing the number of flower buds, but decreased individual flower size. The temperature effect was also dependent on the phase of the cultivation period. In general, flower characteristics were less sensitive to temperature applied during the long-day period. NFPP was affected positively by temperature, mainly during phase III, whereas individual flower size increased with temperature during phase II, but decreased with temperature during phase III. Lower temperatures during phase III significantly enhanced flower colour intensity. Interest in using a more dynamic heating strategy is discussed.

Nakano et al (2020) concluded that Heat-induced flowering delay of *Chrysanthemum morifolium* is a major problem affecting the production of cut flowers in Japan. Understanding the delay mechanism is indispensable to achieve stable production. Heat sensitivity has been shown to fluctuate throughout the day, as if it is regulated by a circadian clock. This paper studied the involvement of a circadian clock and photoperiod in the fluctuation of heat sensitivity throughout the day by applying pulses of heat at different times to *Chrysanthemum morifolium* under different regimens of light and dark. One experiment examined the elevation of heat sensitivity under different photoperiods in order to determine whether the transition from light to dark or vice versa serves as a signal for a clock-like regulation of heat sensitivity. Maximum heat sensitivity was frequently observed at a constant interval after light-off, but not after light-on, identifying the transition to darkness as the signal that initiates the elevation mechanism. Results of the three experiments suggest that the daily elevation in heat sensitivity is potentially controlled by an internal clock that is reset by a transition from light to dark. A subsequent transition to light appears to eliminate elevated sensitivity. From this, we conclude that heat sensitivity is maximized toward the end of the night, irrespective of photoperiod, in chrysanthemums

The effects of day temperature (DT), night temperature (NT) and photosynthetic photon flux (PPF), on rate of development and flower size were studied in chrysanthemum (*Dendranthema grandiflora* Tzvelev. cultivar 'Bright Golden Anne') by Karlsson et al (1989). DT and NT ranged from 10 to 30°C and PPF from 1.8 to 21.6 mol day/m^2. Flower initiation did not occur after 100 short days (SD) at low PPF levels (1.8 mol day/m^2) in combination with high DT or NT (30°C). The number of days to flower varied from 58 to 140 days among plants grown under environmental conditions allowing flower initiation within 100 SD. The time to flower from start of SD decreased nonlinearly as PPF increased. Increasing PPF by 9.9 mol day/m^2 at 20°C accelerated flowering 20 days when the initial PPF was 1.8 mol day^1 m^2, but only 10 days when the initial PPF was 11.7 mol day^1 m^2. The DT and NT for most rapid flower development were estimated from a model predicting time to flower. Independent of PPF in the range from 2 to 20 mol day^1 m^2, the optimum DT was 17°C and the optimum NT was 18°C. Total flower area per plant varied from 14 to 310 cm/^{2}. The flower size increased linearly as PPF increased from 1.8 to 21.6 mol day^1 m^2 at a constant temperature of 20°C. The optimum DT/NT combination for largest flower size changed from 21/14 ° to 20/18 °C as PPF increased from 5 to 20 mol day^1 m^2

Delayed flowering of chrysanthemum under high temperature conditions is a serious obstacle for all year round cut chrysanthemum flower production in southern temperate and subtropical zones. Nozaki and Fukai (2008) carried out a study to clarify the causes of flowering delay in spray chrysanthemum, two different genotypes of spray chrysanthemum (*Dendranthema grandiflorum* (Ramat.) Kitam were grown under high-temperature conditions: summer-to-autumn flowering type (SA type, high temperature tolerant) and autumn flowering type (A type, high temperature sensitive). Their flower-bud initiation and development were subsequently compared. Results clarify that two independent events caused by high temperatures occur in the shoot apex of spray chrysanthemum under short-day conditions. First, high temperatures slowed fl oral development in inflorescence, thereby increasing the number of florets in both SA and A chrysanthemum genotypes. Secondly, high temperatures slowed the developmental speed of inflorescence after the budding stage, and the time to reach the bud break stage was prolonged, thereby delaying flowering, especially in A chrysanthemum genotypes.

Adams et al (1998) studied the relationships between temperature and time to inflorescence initiation and subsequent development in chrysanthemum cv. "Snowdon" (*Chrysanthemum morifolium* Ramat.) were investigated. From pinching, flowering occurred most rapidly in plants grown at a mean temperature of 20.48°C, whilst those grown at 10.98°C had the lowest leaf number at flowering. The final leaf number, from the pinch to the inflorescence, increased with increasing temperature above 10.98°C. This could be attributed to a marked sigmoidal increase in the rate of leaf initiation with temperature, not delayed initiation. Above 20°C temperature had little effect on the time of floral initiation (plants initiating after 8±9 days), although temperatures below this led to a considerable delay in floral initiation (20.5 days at 9.6°C). Once initiated the inflorescences developed most rapidly at 20.28°C, however, unlike the process of flower initiation, subsequent flower development was delayed by both warmer and cooler temperature regimes.

According to Vince (1955), it was found that flowering in the chrysanthemum (Schwabe, 1950). A three-week period at 5-7°C. was effective in stimulating flowering. The varieties of *Chrysanthemum morifolium* Ramat. were "Sunbeam", " Godofrey's Gem", "Cossack" and" Blanche de Poitevine ", and in the absence of vernalization the flowering of each was delayed and the leaf number increased. In the variety "Sunbeam" there was a difference in leaf number of 86·1 between vernalized plants (28·6 leaves) and non-vernalized plants (114.7 leaves) grown in short days. When grown at high temperatures and with short days, all of these varieties exhibited a diageotropic habit of growth, except " Cossack", which produced short, abnormally thick stems. Another species, *C. rubellum* Sealy, behaved in the same manner as *C. morifolium*. No commercial mid-season or late-flowering decorative varieties of *C. morifolium* were included, and the response of one such variety was investigated in the experiments described here.

Hand et al (1996) in their study, four discrete and continuous humidity treatments (0.1, 0.4, 0.7 and 1.1 kPa vapour pressure deficit) were applied to plants of three chrysanthemum cultivars (Snowdon, Pink Gin and Snapper) growing in day light, controlled environment cabinets in autumn and spring experiments to determine effects on growth and flowering. There was some reduction in total leaf area and leaf dry weight in the highest humidity treatment but, overall, effects on stem and leaf growth were slight. Effects of high humidity on flowering were more marked, with estimated maximum delays of 4-5 d in flower development and reductions in flower dry weight at harvest. Visual appearance was not impaired in any of the treatments. It was concluded that the chrysanthemum is relatively insensitive to humidity within the range tested and that it is unlikely that this environmental variable is of major consequence in commercial growing during the winter period.

Whealy et al (1987) pinched the plants of *Chrysanthemum morifolium* Ramat. 'Orange Bowl' and 'Surf' grown in a chamber maintained 0at 22° day/18°C night were transferred to 30° day/26° nights at the beginning of week 1, 3, 5, or 7 after start of photo induction period (15-hr nyctoperiod). Plants remained at high temperatures for 2, 4, 6, 8, or 10 weeks and then were returned to the 22°/18° chamber. Exposure to high temperatures during the first 4 weeks of short days increased the number of nodes, leaf area, stem length, and dry weight of leaves and stems. Rate of floret initiation and perianth differentiation decreased when exposed to high temperatures during the first 4 weeks of short days in 'Orange Bowl' but not in 'Surf'. 'Orange Bowl' exposed to high temperatures for 10 weeks from the start of short days flowered 12 days later than plants grown at lower temperatures and formed bracteate buds. Flowering of 'Orange Bowl' grown at 22/18°C during the first 4 weeks of short days, then transferred to high temperatures, was not substantially delayed and flowers developed normally. Flowering was delayed 3 days when ‘Surf’ was exposed to high temperatures for 8 weeks from the start of short days. Exposure to high temperatures did not cause bracteate bud formation in ‘Surf’. With both cultivars, increasing the duration of high temperature exposure increased the time to flowering.

Chapter-3

MATERIALS AND METHODS

The present investigations on **"Effect of covering materials on off- season flower production of chrysanthemum (*Dendranthema* × *grandiflora* Tzvelev.) cultivars under low hills of HP"** was carried out at the Experimental Farm of the RHR&TS Dhaulakuan, Sirmour under Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during 2022 and 2023.

EXPERIMENTAL SITE

The experimental farm is located at an elevation of 438m above mean sea level at latitude 30◦30'20" North and longitude 77◦20'30" East. The area falls under the low hill zone of Himachal Pradesh. The climate of the area in general is sub-tropical characterized by hot summer with heavy rains and relatively cool winter. The meteorological data pertaining to the period of investigation are presented in Appendix-I.

3.1 PLANT MATERIAL

The studies were conducted on eight chrysanthemum cultivars viz 'White Star' ,'Yellow Star', 'Purnima' and 'Snowball' belongs to standard group, 'Surf', 'Well Spring White', 'Apricot Parasol' and 'Yellow Button', belong to spray group. For the experiment, plants were raised through shoot tip cuttings.

3.2 PROPAGATION

Cuttings of 8–10 cm long shoot tips were taken from healthy disease free mother plants in the early morning. These were dipped in a solution of Dithane M-45 (0.2 %) and Bavistin (0.1 %) for 30 minutes. Each cutting's basal leaves were taken off, and a sharp incision was made directly below the node. The cut end was then dipped in a solution of NAA (500 ppm) following quick dip method prior to planting. Cuttings were rooted in beds of damp sand and cocopeat (1:2) in the propagation room. Just after planting, beds were irrigated thoroughly. Optimum moisture was maintained in the propagation chamber by overhead misters/manually spraying the cuttings twice a day. The cuttings took 25-30 days to develop sufficient roots. For hardening, rooted cuttings were moved to a shade net house. After 8-10 days in the hardening chamber they were transplanted in the experimental field.

3.3 CULTIVATION PRACTICES

3.3.1 BED PREPARATION AND APPLICATION OF FERTILIZERS

With a motorized tiller, the soil was turned over and brought to a fine tilth. At the time of ploughing, well-rotted farmyard manure was mixed with the soil, at the rate of 5kg/m^2. For the planting of rooted cuttings, 1.5 m wide beds were made. At the time of bed preparation half dose of nitrogen (15g/m^2) and full dose of phosphorous and potassium (30g/m^2 each) was applied to the soil. Once beds are ready, metallic semicircular frames/ tunnels were positioned over the beds. Remaining half dose of nitrogen was applied after one month of planting. Along with basal application of N P K, plants were fertilized with a water soluble fertilizer having N P K in the ratio of 19:19:19 (1g/l). The application of this solution was done as drench at the rate of 200 ml per plant after pinching and continued till the time of flowering.

3.3.2 PLANTING

For normal season, planting under low hills is done in Aug- Sept as a common practice. However, in the present study, for off season flower production rooted cuttings of the selected cultivars for the study were planted in 1st week of February in both the years 2022 and 2023. The healthy cuttings were carefully removed from the propagation chamber. The planting was done on raised beds at a spacing of 30 x 20 cm. The plants were irrigated immediately after the planting. Planting was done late in the evening hours.

3.3.3 IRRIGATION AND OTHER INTERCULTURAL OPERATIONS

Irrigation was done manually in the experiment. Irrigation was given twice daily for the first three weeks of planting till the plants were established, thereafter irrigation was provided on alternate days or when required. Hoeing and weeding was done regularly to keep the soil porous, and free from weeds as and when required. The plants were pinched about 25 days after planting, by removing the apical growing portion leaving 6-10 leaves (depending upon the cultivar) below the pinch.

Disbudding was done at the stage when the plants started to form flower buds. In case of standard cultivars, leaving the apex or terminal flower bud all the axillary type of buds were removed and in case of spray cultivars the central apex bud was removed. Staking was done as needed for both the standard and spray varieties. Application of fungicides and insecticides was done as and when required. Fertigation was continued as described above.

3.3.4 INSECT-PEST AND DISEASE CONTROL

The crop was raised under naturally ventilated polyhouse and insect pests and diseases control measures were followed as and when needed. Among pests, appearance of aphids and whiteflies was noticed and controlled by spraying Thiamethoxam @ 1.5ml/l of water. Yellow sticky traps were installed to control the population of whiteflies. No severe disease incidence was noticed during the experiment.

PHOTOPERIOD

For induction of off season flowering, short days were provided to the crop. The experiment was carried out using three different kinds of covering materials, and also under natural photoperiodic conditions where plants were not covered.

3.4.1 CONTROLLED PHOTOPERIOD

The plants were given controlled photoperiodic treatments by subjecting them to artificial short days beginning when the plants have attained sufficient vegetative growth and the side branches had grown to one foot height after pinching. Artificial short days were provided using three different types of covering materials viz., tarpaulin, HPDE (one side black and other side silvery) and black satin cloth. To provide artificial short day semi-circular metallic tunnel frames (3x1.5x1.5m) completely covered with covering material were placed over the plants for 16 hours regularly from 5:00 pm till 9:00 am every day. The short days was continued till 60-75% flower buds on a plant showed color (Plate 1).

3.5 EXPERIMENTAL DETAILS

A. Number of cultivars = 8 (eight)

1) Purnima
2) Yellow Star
3) White Star
4) Snowball
5) Surf
6) Well Spring White
7) Apricot Parasol
8) Yellow Button

B. Treatments = 4 (four)

1) HDPE
2) Tarpaulin
3) Black Satin Cloth
4) Natural Photoperiod (control)

C. Total treatment combinations : 8x4= 32

D. Number of replication : Three

E. Number of plants per replication: Five

F. Design of experiment : Completely randomized design (Factorial)

3.6 OBSERVATIONS RECORDED:

1. **Plant height (cm):** Plant height was taken from the base of the plant till the tip of apical flower of the tallest shoot at the time of peak flowering or when 50-60% flower buds were fully opened.

2. **Plant spread (cm):** Plant spread was also recorded at the time of peak flowering as the average of distance between the outermost side shoot in East to West direction and the distance between the outermost side shoot in North to South direction.

3. **Number of shoots per plant:** Number of side shoots were counted at the time of peak flowering.

4. **Chlorophyll content (mg/g):** Chlorophyll content was estimated by spectrophotometry of samples prepared by 80% acetone extraction.

5. **Days taken for colored bud formation:** Days were counted from the date of planting till the stage when first colored flower bud became visible on the plants

6. **Days taken to flowering:** The number of days were counted from the date of planting to the stage when first flower became full bloomed.

7. **Number of short days required for flower bud formation:** The days were counted from the start of short days to the appearance of flower buds on plants.

8. **Flower size (cm):** Flower size was recorded at the time of peak flowering as average of the distance between apices of petals in East to West direction and distance between apices of petals in North to South direction.

9. **Number of flowers/cut stems per plant:** Number of flowers/cut stems were counted at the time of harvesting.

Plate 1. Use of different covering materials on off season flower production of chrysanthemum

10. **Flower weight/plant and cut stem weight (g):** Single cut stem was observed on weighing balance in grams and total number of flowers per plant were weighed in spray cultivars,

11. **Vase life/shelf life (days):** Number of days were counted from the time the cut flowers were kept in test tubes containing distilled water till they were presentable. Shelf life of loose flowers was counted by placing loose flowers at room temperature till they were fresh.

12. **Flower abnormalities, disease and insect- pest etc., if any:** Abnormal, malformed flower buds and flowers as well as the insect pest and diseases infesting the plants during the course of investigation were observed.

13. **B:C Ratio:** It was calculated on the sum total of cost of cultivation taken from the final earnings after selling of crop after harvest.

3.7 Statistical Analysis

The observations recorded on various growth and flowering parameters were subjected to analysis of variance (ANOVA) using Factorial CRD (Gomez and Gomez, 1984) and Tukey Test. Statistical analysis was done by using SPSS 22.0 & OPSTAT

Chapter-4

RESULTS AND DISCUSSION

The results of the experiment entitled **"Effect of covering materials on off season flower production of chrysanthemum (*Dendranthema* x *grandiflora* Tzvelev.) cultivars under low hills of HP"** carried out during the years 2022 and 2023 have been presented in this chapter.

Vegetative Parameters:

4.1 Plant Height (cm)

Data presented in Tables 4.1a and 4.1b shows the effect of different covering materials on plant height of different chrysanthemum cultivars in both the years of study i.e 2022 and 2023, respectively. Maximum plant height was observed in cv. White Star C_1 (89.33 cm and 91.87 cm) in the years 2022 and 2023, respectively. In contrast, minimum plant height was displayed by Well Spring White C_7 (31.82 cm and 32.66 cm) in the years 2022 and 2023, respectively.

Different covering materials have shown a significant difference in plant height in the year 2022. Data in Table 4.1 a depicts maximum plant height under natural photoperiod i.e M_4 (57.64 cm). Minimum plant height, on the other hand was displayed by plants under M_1 HDPE (54.75 cm). It was found to be at par with M_2 (Tarpaulin) i.e 54.77 cm. Non-significant results were obtained during second year (Table 4.1b).

Interaction data shows that maximum plant height was obtained when plants of cv. White Star were grown under natural photoperiod i.e C_1M_4 in both the years (92.37 cm and 92.39 cm respectively). In contrast, minimum plant height was shown by cv. Well Spring White grown under HDPE (28.76 cm) in the year 2022, it was found to be at par with cv. Well Spring White grown under Tarpaulin i.e C_7M_2 (29.55 cm) and Black Satin Cloth i.e (33.83 cm).

However, in the year 2023, minimum plant height was noted in C_7 M_2 (30.89cm) i.e Well Spring White grown under tarpaulin. Similar results were obtained in C_7 M_1 (31.25cm) and C_7 M_3 (31.93cm) i.e Well Spring White grown under HDPE and Black Satin cloth respectively.

Table 4.1c shows the pooled data for plant height. It is evident from the data that maximum plant height (90.60cm) was exhibited by C_1 i.e. White Star. Minimum height, on the other hand was observed in cv. Well Spring White (32.24 cm). Among covering materials, maximum plant height was noted in natural photoperiod (58.60cm), which was found to be at par with plants grown under Black Satin Cloth (57.50 cm). Minimum plant height, on the other hand was noted in plants grown under HDPE i.e 56.47cm.

Interaction between covering materials and cultivars shows that maximum plant height was observed in C_1 M_4 i.e plants of cv. White Star grown under natural photoperiod (92.38 cm). It was however found to be at par with White Star grown under all the covering materials C_1 M_1 (89.91cm), C_1M_2 (89.71cm) and C_1M_3 (90.41cm). Minimum plant height was however exhibited by C_1 M_1 i.e plants of cv. Well Spring White grown under HDPE (30.01cm). Similar results were however displayed by same cv. Well spring White grown under all covering materials i.e 30.22 cm under Tarpaulin and 32.88cm under Black Satin Cloth.

Variation in plant height among cultivars is attributed to the to the genotypic variation among them.

The variation in plant height among different cultivars of chrysanthemum is evident and could be attributed to different genetic constituents of genotypes under study. Covering materials have significantly affected plant height over natural photoperiod conditions. Lower plant height was noticed under controlled conditions in comparison to open conditions. Plant grown under open conditions received sunlight for longer duration per day and number of days as well. Longer exposure to sunlight has resulted in production of longer plant height over controlled conditions. Our findings are in close conformity with earlier findings of Sangma et al (2016), Sita Ram and Sehgal (1993) and Usha (2010). Where covering materials could induce less plant height because of less exposure to light under them. Among the covering materials, plant grown under black satin cloth produced longer plants which could be attributed to the stuff of covering material which is not 100% opaque to light and hence allowing longer exposure to the sunlight. Plants grown under HDPE were the shortest. The effectiveness of HDPE to cut the light inside the covering seems to be the reason for allowing limited vegetative growth.

Table 4.1a: Effect of covering materials on plant height (cm) of chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	88.63	86.81	89.53	92.37	**89.33**
C_2 : Yellow Star	65.06	64.84	76.11	71.90	**69.48**
C_3 : Purnima	61.98	62.48	64.82	65.86	**63.78**
C_4 : Snow Ball	60.33	59.54	54.31	56.71	**57.72**
C_5 : Surf	42.01	43.77	48.56	43.99	**44.58**
C_6 : Apricot Parasol	42.22	42.49	41.74	43.52	**42.49**
C_7 : Well Spring White	28.76	29.55	33.83	35.13	**31.82**
C_8 : Yellow Button	49.05	48.68	42.80	51.64	**48.04**
Mean	**54.75**	**54.77**	**56.46**	**57.64**	
C.D.$_{0.05}$ for					
Cultivars	**=**	**2.69**			
Covering materials	**=**	**1.90**			
Cultivars × Covering materials	**=**	**5.39**			

Table 4.1.b: Effect of covering materials on plant height (cm) of chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	91.19	92.60	91.29	92.39	**91.87**
C_2 : Yellow Star	70.44	76.53	72.93	74.81	**73.68**
C_3 : Purnima	66.64	65.34	67.50	65.39	**66.22**
C_4 : Snow Ball	72.37	72.93	71.95	70.45	**71.92**
C_5 : Surf	40.50	40.76	36.77	39.75	**39.44**
C_6 : Apricot Parasol	42.30	44.24	45.17	45.90	**44.40**
C_7 : Well Spring White	31.25	30.89	31.93	36.58	**32.66**
C_8 : Yellow Button	50.68	50.29	50.67	51.12	**50.69**
Mean	**58.17**	**59.20**	**58.53**	**59.55**	
C.D.$_{0.05}$ for					
Cultivars	**=**	**1.54**			
Covering materials	**=**	**NS**			
Cultivars × Covering materials	**=**	**3.08**			

Table 4.1c: Effect of covering materials on plant height (cm) of chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	89.91	89.71	90.41	92.38	**90.60**
C_2 : Yellow Star	67.75	70.68	74.53	73.36	**71.58**
C_3 : Purnima	64.31	63.91	66.16	65.63	**65.00**
C_4 : Snow Ball	66.35	66.24	63.13	63.58	**64.82**
C_5 : Surf	41.26	42.27	42.67	41.87	**42.02**
C_6 : Apricot Parasol	42.26	43.37	43.46	44.71	**43.45**
C_7 : Well Spring White	30.01	30.22	32.88	35.86	**32.24**
C_8 : Yellow Button	49.87	49.49	46.74	51.38	**49.37**
Mean	**56.47**	**56.99**	**57.50**	**58.60**	
$C.D._{0.05}$ for					
Cultivars	**=**	**1.63**			
Covering materials	**=**	**1.15**			
Cultivars × Covering materials	**=**	**3.27**			

4.2. Plant Spread (cm):

Data presented in Tables 4.2a and 4.2 b shows that plant spread varied significantly among the cultivars in both the years i.e 2022 and 2023.

It is evident that maximum plant spread was observed in cv. Purnima C_3 (49.12cm and 50.79cm) in the years 2022 and 2023, respectively. In contrast, least plant spread was displayed by cv. C_7 Well Spring White (29.43 cm and 27.71 cm) in the years 2022 and 2023, respectively.

Different covering materials did not induce significant results on plant spread in the year 2022. However, during 2023 (Table 4.2 b) maximum plant spread was recorded under natural photoperiod (38.26 cm). It was however found to be at par with M_1 i.e plants grown under HDPE (37.33 cm). Minimum plant spread was however noted in plants under tarpaulin (36.94 cm) which was at par with black satin cloth i.e 36.96 cm.

The interaction between cultivars and covering materials showed significant effect on plant spread in both years of study. During the year 2022 (Table 4.2b), maximum plant spread was noted in C_3 M_2 i.e Purnima grown under tarpaulin (51.56cm). It was found to be at par with C_3M_3 (51.27cm) i.e Purnima under black satin cloth and C_3M_4 (48.02cm) i.e Yellow Button under Black satin cloth.

During the year 2023 cv. Purnima grown under natural photoperiod exhibited maximum plant spread i.e 52.68cm, which was found to be at par with C_3M_1 (51.06 cm) i.e Purnima under HDPE and C_8M_1 (51.33 cm) i.e Yellow Button under HDPE. Whereas minimum plant spread was observed in C_7M_2 (27.01cm) i.e Well Spring White grown under tarpaulin which was found to be at par with Well Spring White grown under all covering conditions i.e C_7M_1 (27.71 cm), C_7M_3 (27.29 cm) and C_7M_4 (28.85 cm) and C_5M_1 i.e cv. Surf grown under HDPE (27.91 cm).

Table 4.2c depicts the pooled data for plant spread. Among cultivars, maximum spread was attained by Purnima (49.96 cm). In contrast minimum spread was noted by C_7 i.e Well Spring White (28.57 cm). Covering materials does not show any significant results on plant spread.

Interaction data shows that maximum plant spread was noted in C_3M_2 i.e Purnima grown under tarpaulin 50.68 cm. It was, however found to be at par with Purnima grown under all covering materails i.e C_3M_1 (48.35 cm), C_3M_3 (50.44 cm) and C_3M_4 (50.35 cm).

Minimum plant spread was, however noted in C_7M_3 i.e Well Spring White grown under balck satin cloth (27.82 cm). It was, however found to be at par with Well Spring White grown under all covering materials i.e C_7M_1 (28.54 cm) C_7M_2 and C_7M_4 (29.45 cm).

The genotypic difference among the cultivars are reflected in the plant spread also. Plants exposed to short day conditions received less light for vegetative growth. The results are in conformity with findings of Sangma (2016) and Yang et al (2007). Least plant spread obtained in plants grown under HDPE could be attributed to the less light hours received which did not allow even a single ray of light to enter the tunnel, once blackout started.

Table 4.2a: Effect of covering materials on plant spread (cm) of chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	36.31	36.96	36.15	36.26	**36.42**
C_2 : Yellow Star	36.77	38.45	38.13	36.58	**37.48**
C_3 : Purnima	45.65	51.56	51.27	48.02	**49.12**
C_4 : Snow Ball	33.50	34.01	37.74	36.34	**35.40**
C_5 : Surf	35.97	33.07	29.89	37.11	**34.01**
C_6 : Apricot Parasol	36.30	37.24	37.45	33.52	**36.13**
C_7 : Well Spring White	29.37	29.93	28.35	30.06	**29.43**
C_8 : Yellow Button	44.88	46.83	50.48	42.51	**46.17**
Mean	**37.34**	**38.51**	**38.68**	**37.55**	
C.D.$_{0.05}$ for					
Cultivars	**=**	**1.97**			
Covering materials	**=**	**NS**			
Cultivars × Covering materials	**=**	**3.95**			

Table 4.2b: Effect of covering materials on plant spread (cm) of chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	36.18	37.89	37.27	36.21	**36.89**
C_2 : Yellow Star	34.85	34.83	34.57	37.41	**35.42**
C_3 : Purnima	51.06	49.79	49.62	52.68	**50.79**
C_4 : Snow Ball	33.17	32.49	34.55	34.19	**33.60**
C_5 : Surf	27.91	29.74	29.26	33.21	**30.03**
C_6 : Apricot Parasol	36.42	36.42	35.38	38.50	**36.68**
C_7 : Well Spring White	27.71	27.01	27.29	28.85	**27.71**
C_8 : Yellow Button	51.33	47.37	47.75	45.01	**47.87**
Mean	**37.33**	**36.94**	**36.96**	**38.26**	
C.D.$_{0.05}$ for					
Cultivars	**=**	**1.29**			
Covering materials	**=**	**0.91**			
Cultivars × Covering materials	**=**	**2.58**			

Table 4.2c: Effect of covering materials on plant spread (cm) of chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	36.24	37.42	36.71	36.23	**36.65**
C_2 : Yellow Star	35.81	36.64	36.35	37.00	**36.45**
C_3 : Purnima	48.35	50.68	50.44	50.35	**49.96**
C_4 : Snow Ball	33.33	33.25	36.15	35.27	**34.50**
C_5 : Surf	31.94	31.41	29.58	35.16	**32.02**
C_6 : Apricot Parasol	36.36	36.83	36.41	36.01	**36.40**
C_7 : Well Spring White	28.54	28.47	27.82	29.45	**28.57**
C_8 : Yellow Button	48.10	47.10	49.12	43.76	**47.02**
Mean	**37.34**	**37.73**	**37.82**	**37.90**	
C.D.$_{0.05}$ for					
Cultivars	**=**	**1.18**			
Covering materials	**=**	**NS**			
Cultivars × Covering materials	**=**	**2.36**			

4.3. Number of side shoots per plant:

Data presented in Table 4.3a and 4.3b shows that number of side shoots per plant varied significantly among the cultivars in both the years i.e. 2022 and 2023.

It is evident that maximum number of side shoots per plant was observed in cv. Surf C_5(4.62) and 4.44 in cv Well Spring White in the years 2022 and 2023, respectively. In contrast, least number of side shoots per plant were observed in cv. C_1 White Star and C_4 Snow Ball (3.10 and 3.57) in the year 2022 and 2023, respectively.

A non-significant variation was observed in number of side shoots per plant due to different covering materials in both the years of study.

Interaction data in year 2022 reveals that maximum number of side shoots per plant was achieved, when plants of cv. Surf were grown in Tarpaulin i.e C_5M_2 (4.93). It was at par with C_8 M_3 and C_8 M_4 i.e. (4.80 and 4.60), respectively. In contrast, minimum number of side shoots per plant was observed in C_1 M_2 i.e White Star grown under tarpaulin (2.87). On the other hand, during the second year i.e. 2023 the interaction effects of cultivars under covering materials were found to be non-significant.

A wide variation in number of side shoots per plant was noticed among cultivars in pooled data also (Table 4.3 c). Maximum number of side shoots per plant was noted in cv. Surf i.e 4.43, whereas minimum number of side shoots per plant i.e 3.41 was observed in cv. White Star and Purnima.

Covering materials as well as the interaction effects between cultivars and covering materials did not show any significant effect on number of side shoots in the pooled analysis

From the findings of the study it was noted that maximum number of side shoots per plants were observed in natural photoperiod followed by black satin cloth which was not total opaque in nature, such results are found to be similar with the earlier findings of Post (1931), Usha (2010). Whereas minimum number of side shoots were observed in HDPE and Tarpaulin due to their complete opaque nature offering less photoperiod for vegetative growth. These findings are in conformity with Post (1931), Usha (2010) and Sangma (2016) where vegetative growth of chrysanthemum was less under covering materials in comparison to natural photoperiod.

Table 4.3a: Effect of covering materials on number of side shoots of chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	3.33	2.87	3.13	3.07	**3.10**
C_2 : Yellow Star	3.60	3.13	3.07	2.93	**3.18**
C_3 : Purnima	3.27	3.07	3.07	3.20	**3.15**
C_4 : Snow Ball	3.93	3.93	3.53	3.20	**3.65**
C_5 : Surf	4.73	4.93	4.07	4.73	**4.62**
C_6 : Apricot Parasol	3.20	3.00	4.27	4.20	**3.67**
C_7 : Well Spring White	3.13	3.33	4.07	4.13	**3.67**
C_8 : Yellow Button	3.60	3.67	4.80	4.60	**4.17**
Mean	**3.60**	**3.49**	**3.75**	**3.76**	

C.D.$_{0.05}$ for
Cultivars = 0.67
Covering materials = NS
Cultivars × Covering materials = 1.34

Table 4.3b: Effect of covering materials on number of side shoots of chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	3.80	3.80	3.67	3.60	**3.72**
C_2 : Yellow Star	4.13	3.80	3.73	3.80	**3.87**
C_3 : Purnima	4.00	3.60	3.47	3.60	**3.67**
C_4 : Snow Ball	3.13	3.27	3.47	4.40	**3.57**
C_5 : Surf	3.27	4.27	4.60	4.80	**4.24**
C_6 : Apricot Parasol	3.47	3.27	4.87	4.67	**4.07**
C_7 : Well Spring White	4.47	3.53	4.90	4.87	**4.44**
C_8 : Yellow Button	3.87	4.40	4.47	4.80	**4.39**
Mean	**3.77**	**3.74**	**4.15**	**4.32**	
C.D.$_{0.05}$ for					
Cultivars	**=**	**0.55**			
Covering materials	**=**	**NS**			
Cultivars × Covering materials	**=**	**NS**			

Table 4.3c: Effect of covering materials on number of side shoots of chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	3.57	3.34	3.40	3.34	**3.41**
C_2 : Yellow Star	3.87	3.47	3.40	3.37	**3.53**
C_3 : Purnima	3.64	3.34	3.27	3.40	**3.41**
C_4 : Snow Ball	3.53	3.60	3.50	3.80	**3.61**
C_5 : Surf	4.00	4.60	4.34	4.77	**4.43**
C_6 : Apricot Parasol	3.34	3.14	4.57	4.44	**3.87**
C_7 : Well Spring White	3.80	3.43	4.49	4.50	**4.06**
C_8 : Yellow Button	3.74	4.04	4.64	4.70	**4.28**
Mean	**3.69**	**3.62**	**3.95**	**4.04**	
C.D.$_{0.05}$ for					
Cultivars	**=**	**0.64**			
Covering materials	**=**	**NS**			
Cultivars × Covering materials	**=**	**NS**			

4.4. Chlorophyll content (mg/g):

Data presented in Table 4.4 a and 4.4 b shows that Chlorophyll content of leaves varied significantly among the cultivars in both the years i.e. 2022 and 2023.

It is evident that maximum Chlorophyll content was observed in cv. Apricot Parasol C_6 (1.44 mg/g and 1.51mg/g) in the years 2022 and 2023, respectively. In contrast, least Chlorophyll content was observed in cv. C_1 White Star (0.56 mg/g and 0.60 mg/g) in the years 2022 and 2023, respectively.

A non-significant variation was observed in Chlorophyll content due to different covering materials also.

Interaction data Table 4.4a reveals that maximum Chlorophyll content per plant was achieved, when plants of cv. Apricot Parasol were grown under Natural photoperiod i.e C_6M_4 (1.58). In contrast, minimum Chlorophyll content was observed in C_1 M_3 i.e White Star grown under Black Satin Cloth (0.52) in year 2022.

On the other hand, during the second year 2023 maximum Chlorophyll content was displayed by cv. Apricot Parasol grown under Black Satin Cloth and open (C_6 M_3) and C_6M_4 i.e 1.58. Whereas Minimum Chlorophyll content was noted in C_1 M_1 and C_1 M_2 i.e 0.58.

A wide variation in Chlorophyll content was noticed among cultivars in pooled data also (Table 4.4 c). Maximum Chlorophyll content was noted in cv. Apricot Parasol i.e 1.47, whereas minimum i.e 0.58 was observed in cv. White Star.

Covering materials have shown non-significant effects on Chlorophyll content.
Interaction data showed non-significant results. However, plants of cv. Apricot Parasol grown under Natural Photoperiod displayed maximum Chlorophyll content i.e 1.58 (C_6/M^4). In contrast minimum Chlorophyll content per plant i.e 0.57 was observed in cv. White star under black Satin Cloth (C_1 M_3).

Chlorophyll content varied from cultivars to cultivars and it was also non-significant among the different covering materials, it could be due to genetic variability of different cultivars of chrysanthemum. Findings of this study are very similar to the study of Uddin et al (2015).

Table 4.4a: Effect of covering materials on Chlorophyll content (mg/g) of chrysanthemum cultivars in year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	0.58	0.58	0.52	0.55	**0.56**
C_2 : Yellow Star	0.73	0.73	0.79	0.69	**0.74**
C_3 : Purnima	1.14	1.14	1.17	1.12	**1.14**
C_4 : Snow Ball	0.71	0.71	0.72	0.68	**0.70**
C_5 : Surf	1.11	1.11	0.98	1.07	**1.07**
C_6 : Apricot Parasol	1.43	1.45	1.31	1.58	**1.44**
C_7 : Well Spring White	1.33	1.33	1.28	1.29	**1.31**
C_8 : Yellow Button	0.83	0.83	0.89	0.70	**0.81**
Mean	**0.98**	**0.98**	**0.96**	**0.96**	
C.D.$_{0.05}$ for					
Cultivars	=	**0.12**			
Covering materials	=	**NS**			
Cultivars × Covering materials	=	**NS**			

Table 4.4b: Effect of covering materials on Chlorophyll content (mg/g) of chrysanthemum cultivars in 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	0.58	0.58	0.62	0.63	**0.60**
C_2 : Yellow Star	0.73	0.73	0.67	0.67	**0.70**
C_3 : Purnima	1.15	1.13	1.13	1.08	**1.13**
C_4 : Snow Ball	0.71	0.71	0.69	0.69	**0.70**
C_5 : Surf	1.13	1.11	1.24	1.25	**1.18**
C_6 : Apricot Parasol	1.44	1.43	1.58	1.58	**1.51**
C_7 : Well Spring White	1.33	1.33	1.40	1.35	**1.35**
C_8 : Yellow Button	0.84	0.83	0.77	0.79	**0.81**
Mean	**0.98**	**0.98**	**0.96**	**0.96**	
C.D.$_{0.05}$ for					
Cultivars	=	**0.13**			
Covering materials	=	**NS**			
Cultivars × Covering materials	=	**NS**			

Table 4.4c: Effect of covering materials on Chlorophyll content (mg/g) of chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	OPEN (M_4)	Mean
C_1 : White Star	0.58	0.58	0.57	0.59	**0.58**
C_2 : Yellow Star	0.73	0.73	0.73	0.68	**0.72**
C_3 : Purnima	1.15	1.13	1.15	1.10	**1.13**
C_4 : Snow Ball	0.71	0.71	0.71	0.68	**0.70**
C_5 : Surf	1.12	1.11	1.11	1.16	**1.13**
C_6 : Apricot Parasol	1.44	1.44	1.44	1.58	**1.47**
C_7 : Well Spring White	1.33	1.33	1.34	1.32	**1.33**
C_8 : Yellow Button	0.84	0.83	0.83	0.75	**0.81**
Mean	**0.99**	**0.98**	**0.99**	**0.98**	
C.D.$_{0.05}$ for					
Cultivars	**=**	**0.08**			
Covering materials	**=**	**NS**			
Cultivars × Covering materials	**=**	**NS**			

Flowering parameters:

Two cultivars namely Snowball and Yellow Button among the eight selected cultivars have not responded to any of the covering materials and did not flower and due to extreme metrological conditions **(Appendix I)** of the area i.e. extreme temperature and heavy rainfall during the period from July to September. Further none of the cultivars flowered in natural photoperiod that was long days throughout the growing season. So the data for these two cultivars and for all these cvs under natural photoperiod was not taken for further analyses.

As available data under different photoperiod produces significant results under for CD 0.05, there if the missing values would have been be included in the analysis the shape of experiment would have become imbalanced. So, statistically the treatments having value 7 SD both zero has been excluded in the analysis. Since SPSS software can handle Missing Value Model 3, hence following parameters have been analysed accordingly, this study is supported by many of the earlier research work conducted in similar metrological conditions (Streck 2004, Taweesak 2014, Carvalho et al.2005, Nakanoet al. 2020 Karlsson et al. 1989, Nozaki and Fukai 2008, Adams et al.1998, Vince 1955, Hand, et al. 1996, Turan et al. 2015, Whealy et al. 1987.

4.5: Number of short days required for coloured bud formation:

Data presented in Table 4.5 a and 4.5 b shows that number of short days required for coloured bud formation varied significantly among the cultivars in both the years i.e. 2022 and 2023.

It is evident from the data that minimum number of short days were required for coloured bud formation in cv. Surf C_4 in both the years i.e. 39.16 days and 38.49days, respectively. In contrast, maximum number of short days required for coloured bud formation was observed in cv. Apricot Parasol in both the years 2022 and 2023 i.e. 64.60 days and 64.33 days which was found to be at par with cv. Well Spring White in both the years i.e. 62.82 days and 62.90 days.

Significant results were seen w.r.t. covering materials in both the years i.e. 2022 and 2023.It was observed that minimum number of short days were required for coloured bud formation when plants were grown under HDPE M_1 (50.20 and 48.62 days). In contrast, whereas maximum number of short days required for coloured bud formation was shown by plants grown under black satin cloth (M_3) i.e. (59.86 and 59.73 days) in both the years, respectively. Further, it was observed that no coloured bud formation was observed in cvs Purnima, Apricot Parasol and Well Spring White grown under black satin cloth and did not flower.

Interaction data of 2022 and 2023 also revealed that minimum number of short days required for coloured bud formation was achieved, when plants of cv. Surf were grown under HDPE i.e. C_4M_1 (30.80 and 29.47 days). In contrast, maximum number of short days required for coloured bud formation was observed in C_5M_2 i.e. Apricot Parasol grown under Tarpaulin in both the years i.e. (66.87 days and 67.47 days). It was found to be at par with C_2M_3 cv. Yellow Star grown under black satin cloth (66.67 days and 66.27 days) in both the years of study.

Table 4.5c depicts the pooled data of number of short days required for coloured bud formation. Among the cultivars, minimum number of short days required for coloured bud formation was noted in cv. Surf C_4 i.e 38.82 days. On the other hand, maximum number of short days required for coloured bud formation was observed in cv. Apricot Parasol i.e (64.46 days) which was found to be at par with cv. Well Spring White i.e. 62.86 days.

Covering materials also significantly affected number of short days required for coloured bud formation. Minimum number of short days required for coloured bud formation was observed under HDPE i.e. (49.41 days), whereas maximum number of short days required for coloured bud formation was found in plants grown under black satin cloth i.e. 59.80 days. Simultaneously it was noted that black satin cloth could not induce flower bud formation in cvs Purnima, Apricot Parasol and Well Spring White.

Interaction data reveals that C_4M_1 i.e plants of cv. Surf grown under HDPE displayed earliest coloured bud formation i.e. (30.13days). In contrast, maximum number of short days required for coloured bud formation i.e. 67.17 days was observed in cv. C_5M_3 Apricot Parasol under black Satin cloth it was found to be at par with cv. Yellow Star (66.47) grown under black satin cloth i.e. C_2 M_3.

Number of short days required for colored bud formation was found to be minimum in plants where artificial short day treatments was provided under HDPE and Tarpaulin and it was seen to be late or no flowering response was attained where cultivars were grown under black satin cloth. The efficiency and superiority of covering materials HDPE and Tarpaulin is clear from the results. Black satin cloth on the hand had allowed light rays to pass through it and was not effective in producing true blackout conditions resulting in poor or no flower at all in some of the cultivars. Our studies find a support from earlier work done by Sita Ram (1991), Sangma (2015), Usha (2010), Velmurugan and Vadivel (2003), Sita Ram and Shegal (1993[a]), Pathak (2002), Cockshull and Kofranek (1992).

Table 4.5a. Effect of covering materials on number of short days required for coloured bud formation in chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	40.87	45.47	61.87	**49.40**
C_2 : Yellow Star	46.33	48.93	66.67	**53.98**
C_3 : Purnima	60.27	64.87	-	**62.57**
C_4 : Surf	30.80	35.60	51.07	**39.16**
C_5 : Apricot Parasol	62.33	66.87	-	**64.60**
C_6 : Well Spring White	60.60	65.05	-	**62.82**
Mean	**50.20**	**54.46**	**59.86**	

Cultivars	**(CD)**	**Cultivars**	**(CD)**	**Covering material**	**(CD)**
WS x YS	0.60	**YS x WSW**	0.67	**HDPE x TP**	0.43
WS x PU	0.67	**PU x SU**	0.67	**HDPE X BSC**	0.52
WS x S	0.60	**PU x AP**	1.80	**TP x BSC**	0.52
WS x AP	0.67	**PU x WSW**	1.80	**INTERACTION**	1.28
WS x WSW	0.67	**SU x AP**	0.67		
YS x PU	0.67	**SU x WSW**	0.67		
YS x SU	0.60	**AP x WSW**	1.80		
YS x AP	0.67				

Table 4.5b. Effect of covering materials on number of short days required for coloured bud formation in chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	38.60	45.33	62.07	**48.67**
C_2 : Yellow Star	44.20	48.53	66.27	**53.00**
C_3 : Purnima	58.13	63.80	-	**60.97**
C_4 : Surf	29.47	35.13	50.87	**38.49**
C_5 : Apricot Parasol	61.20	67.47	-	**64.33**
C_6 : Well Spring White	60.13	65.67	-	**62.90**
Mean	**48.62**	**54.32**	**59.73**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	0.88	YS x WSW	0.98	HDPE x TP	0.62
WS x PU	0.98	PU x SU	0.07	HDPE X BSC	0.76
WS x S	0.88	PU x AP	0.43	TP x BSC	0.76
WS x AP	0.98	PU x WSW	0.43	INTERACTION	1.52
WS x WSW	0.98	SU x AP	0.98		
YS x PU	0.98	SU x WSW	0.98		
YS x SU	0.88	AP x WSW	0.43		
YS x AP	0.98				

Table 4.5c. Effect of covering materials on number of short days required for coloured bud formation in chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	39.73	45.40	61.97	**49.03**
C_2 : Yellow Star	45.27	48.73	66.47	**53.49**
C_3 : Purnima	59.20	64.33	-	**61.77**
C_4 : Surf	30.13	35.37	50.97	**38.82**
C_5 : Apricot Parasol	61.77	67.17	-	**64.46**
C_6 : Well Spring White	60.37	65.36	-	**62.86**
Mean	**49.41**	**54.39**	**59.80**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	0.66	YS x WSW	0.73	HDPE x TP	0.46
WS x PU	0.73	PU x SU	0.73	HDPE X BSC	0.57
WS x S	0.66	PU x AP	1.76	TP x BSC	0.57
WS x AP	0.73	PU x WSW	1.76	INTERACTION	1.52
WS x WSW	0.73	SU x AP	0.73		
YS x PU	0.73	SU x WSW	0.73		
YS x SU	0.66	AP x WSW	1.76		
YS x AP	0.73				

4.6: Days taken to coloured flower bud formation:

Data presented in Table 4.6 a and 4.6 b shows that days taken to visible colour flower bud formation varied significantly among the cultivars in both the years i.e. 2022 and 2023.

It is evident that in years 2022 and 2023, minimum number of days taken to coloured flower bud formation was seen in cv. Surf C_4 (99.60days and 99.65 days). In contrast, number of days taken to coloured bud formation was observed in cv. Apricot Parasol in both the years of study i.e (124.93 days and 125.36 days) it was found be to statistically at par with cv. Well Spring White in both years i.e 123.03 days and 123.26 days.

Number of days required for coloured bud formation showed significant results in both the years of study i.e 2022 and 2023. During course of study, minimum number of days required for coloured bud formation was observed by plants grown under HDPE (M_1) in both the years of study i.e. (110.42 and 111.07 days). On the other hand, plants grown under black satin cloth M_3 has shown maximum days required for visible coloured bud formation in both year of study i.e. (120.11 and 121.15 days) irrespective of cultivars. Simultaneously cvs Purnima, Apricot Parasol and Well Spring White did not induce flower bud formation under black satin cloth.

Interaction data reveals that minimum days required to visible coloured bud formation was achieved, when plants of cv. Surf were grown under HDPE i.e. C_4M_1 for both the years of study i.e (91.33 days and 91.47 days). In contrast, maximum days taken to visible colour flower bud formation in year 2022 was observed in C_5M_2 i.e. Apricot Parasol grown under Tarpaulin i.e (127.07 days), which was at par with cv Yellow Star grown under black satin cloth i.e 126.67 days, whereas in the year 2023 the maximum number of days to coloured bud formation was observed in cv. Yellow Star under black satin cloth i.e 127.93 days which was found to be at par with cv Apricot Parasol grown under Tarpaulin i.e 126.20 days.

Pooled data (Table 4.6c) also expressed significant results w.r.t. days to coloured bud formation. Minimum days taken to visible coloured bud formation was noted in cv. Surf i.e. 99.62 days, whereas maximum i.e. 125.15 days was observed in cv. Apricot Parasol, which was statistically at par with cv. Well Spring White i.e 123.15 days.

Covering materials also significantly affected number of days required to visible coloured bud formation. Minimum number of days required to visible coloured flower bud formation was observed under HDPE i.e. (110.74 days) in comparison maximum days required to visible coloured flower bud formation under black satin cloth i.e. 129.63 days.

Interaction data reveals that C_4M_1 i.e. plants of cv. Surf grown under HDPE displayed minimum days to visible coloured flower bud formation i.e. 91.40 days. In contrast maximum days to visible coloured flower bud formation i.e. 127.30 was observed in C_2M_3 cv. Yellow Star grown under black satin cloth, it was found to be at par with cv. Apricot Parasol grown under Tarpaulin i.e 126.63 days. C_5M_2.

Number of days required for coloured bud formation was found to be very earlier in plants under HDPE as compared to tarpaulin and black satin cloth. HDPE is a highly opaque material and did not allow even a single ray of light to reach plants during black out period and hence produced blackout effects similar to natural short day conditions inducing flower bud formation. Tarpaulin also is a good covering material but it is cloth based and hence same short day conditions were created under this also but with a delay. On the contrast, black satin cloth knit is not opaque and allow some light to enter inside as a result prohibiting true short day conditions. Under the present studies black satin cloth could not induce flowerings stimulus in cvs Purnima, Apricot Parasol and Well Spring White and hence flowering was not observed at all in these cvs. On the other hand, HDPE was found to be most effective material and induced earlier formation in all cultivars under study where artificial short day treatments were given which is in conformity with the findings of Sita Ram (1991), Sangma (2015), Usha (2010), Velmurugan and Vadivel (2003), Sita Ram and Shegal (1993[b]), Pathak (2002), Cockshull and Kofranek (1992).

Table 4.6a. Effect of covering materials on days taken to coloured bud formation of chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	100.87	105.60	121.87	**109.45**
C_2 : Yellow Star	106.27	108.93	126.67	**113.96**
C_3 : Purnima	120.40	124.87	-	**122.63**
C_4 : Surf	91.33	95.67	111.80	**99.60**
C_5 : Apricot Parasol	122.80	127.07	-	**124.93**
C_6 : Well Spring White	120.87	125.20	-	**123.03**
Mean	**110.42**	**114.56**	**120.11**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	0.59	YS x WSW	0.66	HDPE x TP	0.42
WS x PU	0.66	PU x SU	0.66	HDPE X BSC	0.51
WS x S	0.59	PU x AP	1.93	TP x BSC	0.51
WS x AP	0.66	PU x WSW	1.93	INTERACTION	1.02
WS x WSW	0.66	SU x AP	0.66		
YS x PU	0.66	SU x WSW	0.66		
YS x SU	0.59	AP x WSW	1.93		
YS x AP	0.66				

Table 4.6b. Effect of covering materials on days taken to coloured bud formation of chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	101.40	105.40	122.13	**109.64**
C_2 : Yellow Star	106.87	109.13	127.93	**114.64**
C_3 : Purnima	120.53	122.73	-	**121.63**
C_4 : Surf	91.47	94.07	113.40	**99.65**
C_5 : Apricot Parasol	124.53	126.20	-	**125.36**
C_6 : Well Spring White	121.60	124.93	-	**123.26**
Mean	**111.07**	**113.74**	**121.15**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	0.57	YS x WSW	0.59	HDPE x TP	0.40
WS x PU	0.56	PU x SU	0.49	HDPE X BSC	0.59
WS x S	0.64	PU x AP	2.11	TP x BSC	0.50
WS x AP	0.66	PU x WSW	2.11	INTERACTION	1.80
WS x WSW	0.63	SU x AP	0.64		
YS x PU	0.62	SU x WSW	0.66		
YS x SU	0.58	AP x WSW	2.11		
YS x AP	0.60				

Table 4.6c. Effect of covering materials on days taken to coloured bud formation of chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	101.13	105.50	122.00	**109.54**
C_2 : Yellow Star	106.57	109.03	127.30	**114.30**
C_3 : Purnima	120.47	123.80	-	**122.13**
C_4 : Surf	91.40	94.87	112.60	**99.62**
C_5 : Apricot Parasol	123.67	126.63	-	**125.15**
C_6 : Well Spring White	121.23	125.07	-	**123.15**
Mean	**110.74**	**114.15**	**120.63**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	0.56	YS x WSW	0.56	HDPE x TP	0.42
WS x PU	0.59	PU x SU	0.48	HDPE X BSC	0.57
WS x S	0.67	PU x AP	2.01	TP x BSC	0.48
WS x AP	0.68	PU x WSW	2.01	INTERACTION	1.04
WS x WSW	0.64	SU x AP	0.63		
YS x PU	0.60	SU x WSW	0.64		
YS x SU	0.57	AP x WSW	2.01		
YS x AP	0.65				

4.7. Days taken to harvesting:

Data presented in Table 4.7a and 4.7b shows that Days taken to harvesting of cut/loose flower of different chrysanthemum cultivars varied significantly among cultivars in both the years i.e. 2022 and 2023.

It is observed that in year 2022 and 2023 minimum days taken to harvesting was seen in cv. Surf C_4 (109.89 days and 109.11 days) On the other hand maximum days taken to harvesting was observed in cv. Well Spring white i.e 139.33 and 138.86 days for both years of investigation.

In the year 2022 and 2023 various disparity was observed in days taken to harvesting by different covering materials. Minimum days taken to harvesting was observed by plants grown under HDPE (M_1) i.e (123.62 days and 121.81 days) for both the years of investigation, whereas maximum days taken to harvesting was observed in black satin cloth i.e 131.33 days and 131.93 days for both years of study (Plate 2).

Interaction data of 2022 reveals that minimum days taken to harvesting was achieved, when plants of cv. Surf were grown under HDPE i.e. C_4M_1 (102.13 days). In contrast, maximum days taken to harvesting was observed in C_6M_2 i.e. Well Spring White grown under Tarpaulin (141.33 days) which was found to be at par with cv. White Star under black satin cloth C_1M_3 i.e (136.20 days). On the other hand, in year 2023, Interaction data reveals that minimum days taken to harvesting was again displayed by cv. Surf grown under HDPE (C_4 M_1) i.e. (100.40 days) whereas maximum days taken to harvesting was observed in C_6M_2 i.e. Well spring White grown under tarpaulin i.e (141.00 days).

Table 4.7c represented pooled data of days taken to harvesting. Minimum days taken to harvesting was noted in cv. Surf i.e. (109.50 days), whereas maximum i.e. 139.10 days was observed in cv. Well Spring White. Covering materials also significantly affected days taken to harvesting, minimum days taken to harvesting was observed under HDPE i.e. 122.72 days, whereas maximum days taken to harvesting was seen under black satin cloth M_3 i.e. (131.63 days).

Interaction data reveals that plants of cv. Surf grown under HDPE displayed minimum days taken to harvesting i.e. 101.27 days. In contrast maximum days taken to harvesting i.e. 141.17 was observed in cv. Well Spring White under HDPE.

The time needed for the harvesting of flowers was observed to be significantly shorter in plants grown under HDPE compared to those under tarpaulin and black satin cloth. This observation held true even when artificial short day treatments were applied, aligning with the findings of previous studies by Sita Ram (1991), Sangma (2015), Usha (2010), Velmurugan and Vadivel (2003), Sita Ram and Shegal (1993[b]), Pathak (2002), and Cockshull and Kofranek (1992).

Table 4.7a. Effect of covering materials on days taken to harvesting of chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	113.53	116.00	136.20	**121.91**
C_2 : Yellow Star	122.07	126.33	135.07	**127.82**
C_3 : Purnima	132.13	135.33	-	**133.73**
C_4 : Surf	102.13	104.80	122.73	**109.89**
C_5 : Apricot Parasol	134.53	135.80	-	**135.16**
C_6 : Well Spring White	137.33	141.33	-	**139.33**
Mean	**123.62**	**126.60**	**131.33**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	1.64	**YS x WSW**	1.83	**HDPE x TP**	1.16
WS x PU	1.83	**PU x SU**	1.83	**HDPE X BSC**	1.42
WS x S	1.64	**PU x AP**	2.01	**TP x BSC**	1.42
WS x AP	1.83	**PU x WSW**	2.01	**INTERACTION**	2.84
WS x WSW	1.83	**SU x AP**	1.83		
YS x PU	1.83	**SU x WSW**	1.83		
YS x SU	1.64	**AP x WSW**	2.01		
YS x AP	1.83				

Table 4.7b. Effect of covering materials on days taken to harvesting of chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	112.13	115.60	136.73	**121.49**
C_2 : Yellow Star	119.33	125.93	135.33	**126.86**
C_3 : Purnima	129.87	135.20	-	**132.53**
C_4 : Surf	100.40	103.20	123.73	**109.11**
C_5 : Apricot Parasol	132.40	135.67	-	**134.03**
C_6 : Well Spring White	136.73	141.00	-	**138.86**
Mean	**121.81**	**126.10**	**131.93**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	1.72	**YS x WSW**	1.92	**HDPE x TP**	1.22
WS x PU	1.92	**PU x SU**	1.92	**HDPE X BSC**	1.49
WS x S	1.72	**PU x AP**	2.11	**TP x BSC**	1.49
WS x AP	1.92	**PU x WSW**	2.11	**INTERACTION**	2.98
WS x WSW	1.92	**SU x AP**	1.92		
YS x PU	1.92	**SU x WSW**	1.92		
YS x SU	1.72	**AP x WSW**	2.11		
YS x AP	1.92				

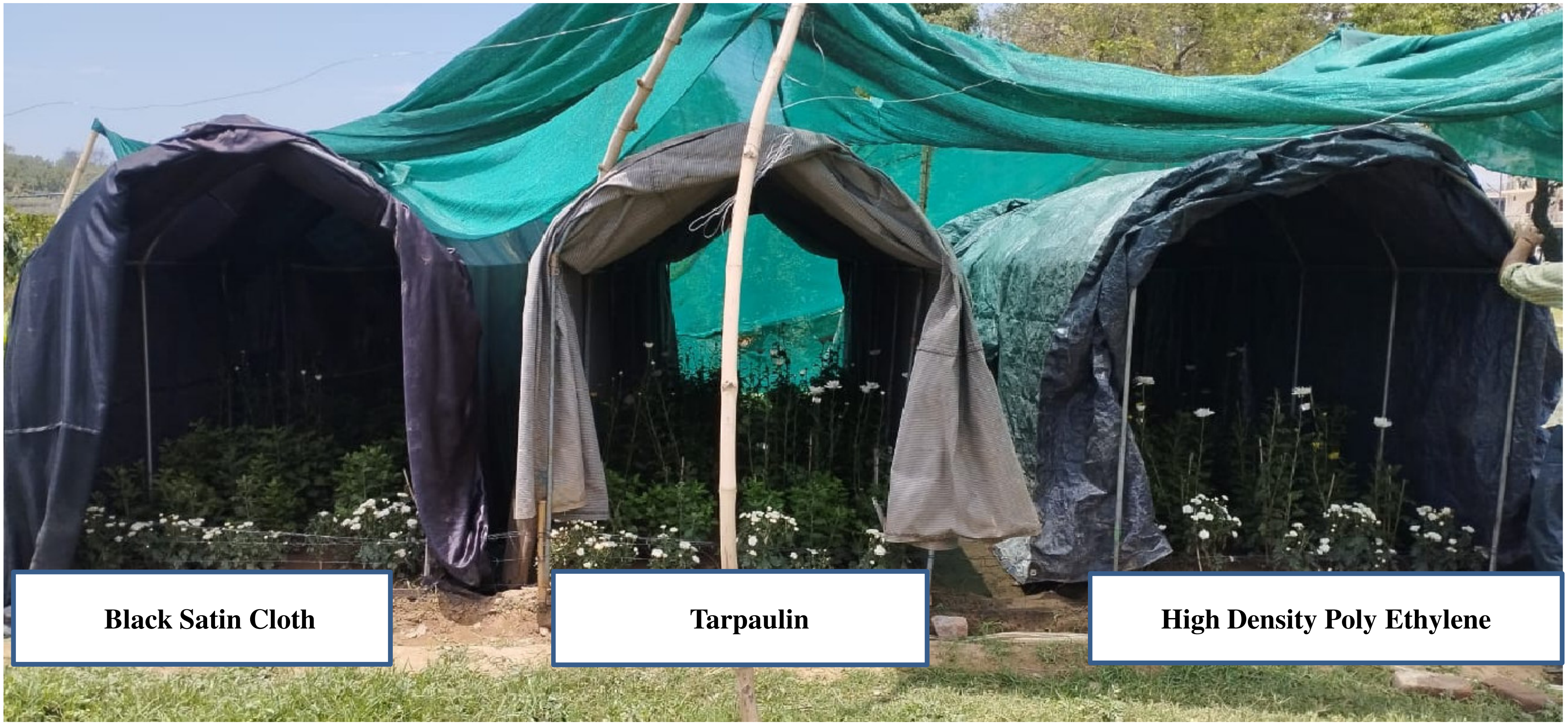

Plate 2. Variation in days to harvesting under different covering materials in chrysanthemum

Table 4.7c. Effect of covering materials on days taken to harvesting of chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	112.83	115.80	136.47	**121.70**
C_2 : Yellow Star	120.70	126.13	135.20	**127.34**
C_3 : Purnima	131.00	135.27	-	**133.13**
C_4 : Surf	101.27	104.00	123.23	**109.50**
C_5 : Apricot Parasol	133.47	135.83	-	**134.60**
C_6 : Well Spring White	137.03	141.17	-	**139.1**
Mean	**122.72**	**126.37**	**131.63**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	2.32	**YS x WSW**	2.59	**HDPE x TP**	1.64
WS x PU	2.59	**PU x SU**	2.59	**HDPE X BSC**	2.01
WS x S	2.32	**PU x AP**	2.84	**TP x BSC**	2.01
WS x AP	2.59	**PU x WSW**	2.84	**INTERACTION**	4.02
WS x WSW	2.59	**SU x AP**	2.59		
YS x PU	2.49	**SU x WSW**	2.59		
YS x SU	2.32	**AP x WSW**	2.84		
YS x AP	2.59				

4.8a: Number of flowers per plant in standard chrysanthemum:

Data presented in Table 4.8.1 a and 4.8.2 a shows that number of flower per plant varied significantly among the standard chrysanthemum cultivars in both the years i.e. 2022 and 2023.

In the years 2022 and 2023 maximum number of flowers per plant was observed in cv. Yellow Star C_2 i.e (3.00 and2.91). In contrast minimum numbers of flowers per plants was observed in cv. Purnima C_3 for both years of study i.e. (2.35 and 2.17).

Variation in the year 2022 and 2023 was observed in number of flowers per plant under different covering materials. Maximum number of flowers was observed by plants grown under HDPE (M_1) for both the years of study i.e. (3.07 and 3.20). On the other hand, in year 2022 plants grown under black satin cloth M_3 has shown minimum number of flowers per plant i.e. (2.12), whereas in the year 2023 minimum number of flowers per plant was observed in plants grown under Tarpaulin M_2 i.e. (2.50) (Plate 3).

Interaction data of 2022 and 2023 shows significant response and it reveals that maximum number of flowers per plant was achieved, when plants of cv. Yellow Star were grown under HDPE i.e. C_2M_1 for both the years of study i.e. (3.60 and 3.60). In contrast, minimum number of flowers per plant was observed in C_3M_2 i.e. Purnima grown under black satin cloth for both years of study i.e. (2.07 and 2.10).

A variation in number of flowers per plant was noticed among cultivars in pooled data also (Table 4.8 c). Maximum number of flowers per plant was noted in cv Yellow Star. i.e. 2.96, whereas minimum number of flowers per plant were seen in cv. Purnima i.e. 2.27.

Covering materials also significantly affected number of flowers per plant. Maximum number of flowers per plants was observed under HDPE i.e. (3.14) in comparison to minimum number of flowers per plant under black satin cloth i.e. 2.31. Flowering was not observed in Purnima under black satin cloth

Interaction data reveals C_2M_1 that plants of cv. Yellow Star grown under HDPE displayed maximum number of flowers per plant i.e. 3.60. In contrast minimum number of flowers per plant i.e. 2.09 was observed in cv. Purnima under black satin cloth.

The controlled photoperiod resulted in a higher number of flowers per plant, while the natural photoperiod led to a lower count, consistent with the findings of Talent et al. (1979) and Post (1931). In the controlled photoperiod, plants were subjected to consistent light treatments, promoting the proper development of buds and uniform early flowering. Some chrysanthemum cultivars tend to form flower buds prematurely under long-day conditions (Langton et al., 1981; Lee et al., 2004), possibly contributing to the occurrence of abnormal flowers in plants exposed to natural photoperiodic conditions. This phenomenon ultimately resulted in a reduced number of flowers per plant.

Table 4.8.1a. Effect of covering materials on number of flowers per plant of standard chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	3.33	2.67	2.10	**2.70**
C_2 : Yellow Star	3.60	3.27	2.13	**3.00**
C_3 : Purnima	2.27	2.07	-	**2.17**
Mean	**3.07**	**2.67**	**2.12**	-
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.72	**HDPE x TP**		0.72
WS x PU	0.81	**HDPE X BSC**		0.81
YS x PU	0.81	**TP x BSC**		0.81
Interaction	1.24			

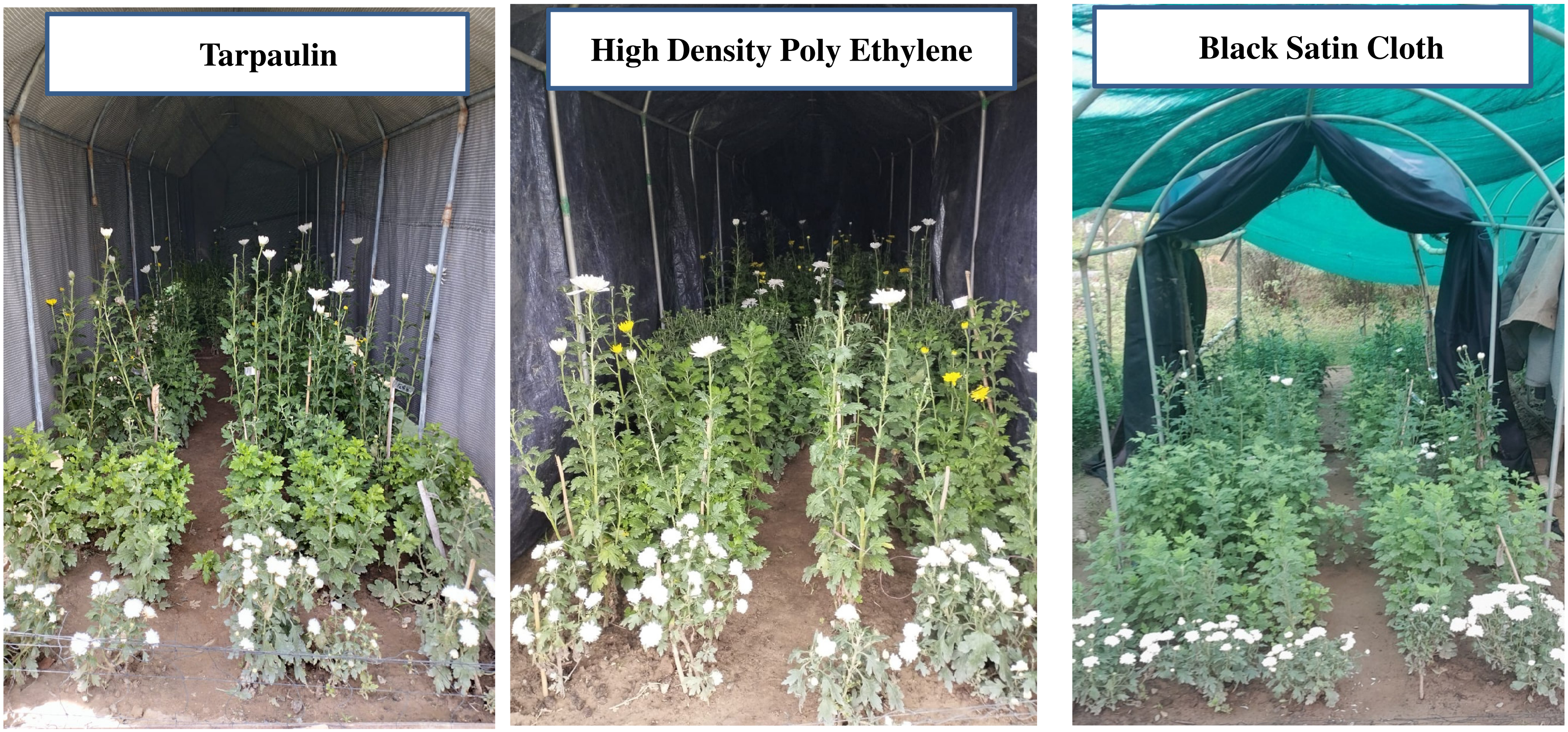

Plate 3. Variation in number of flowers per plant under different covering materials in chrysanthemum

Table 4.8.2a. Effect of covering materials on number of flowers per plant of standard chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	3.40	2.47	2.80	**2.89**
C_2 : Yellow Star	3.60	2.93	2.21	**2.91**
C_3 : Purnima	2.60	2.10	-	**2.35**
Mean	**3.20**	**2.50**	**2.51**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.66	**HDPE x TP**		0.66
WS x PU	0.74	**HDPE X BSC**		0.68
YS x PU	0.74	**TP x BSC**		0.68
Interaction	1.14			

Table 4.8.3a. Effect of covering materials on number of flowers per plant of standard chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	3.37	2.57	2.45	**2.80**
C_2 : Yellow Star	3.60	3.10	2.17	**2.96**
C_3 : Purnima	2.44	2.09	-	**2.27**
Mean	**3.14**	**2.59**	**2.31**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.68	**HDPE x TP**		0.68
WS x PU	0.83	**HDPE X BSC**		0.83
YS x PU	0.83	**TP x BSC**		0.83
Interaction	1.17			

4.8b: Number of flowers per plant in spray chrysanthemum:

Data presented in Table 4.8.1 b and 4.8.2 b shows that number of flower per plant varied significantly among the spray chrysanthemum cultivars in both the years i.e. 2022 and 2023.

In the year 2022 and 2023 maximum number of flowers per plant was observed in cv. Well Spring White C_6 in both the years i.e. (51.40 and 48.83). In contrast minimum number of flowers per plant in 2022 was observed in cv. Apricot Parasol C_5 i.e. (36.43), whereas for the year 2023 the minimum number of flowers per plant was observed in cv. Surf i.e 39.73.

Variation in the year 2022 and 2023 was observed in number of flowers per plant under covering materials also. Maximum number of flowers per plant was observed by plants grown under HDPE M_1 for both years of study i.e. (44.29 and 45.13). On the other hand, in both years of study the minimum number of flowers per plant was observed in plants grown under Black satin cloth M_3 i.e. (37.33 and 36.67).In case of cvs Apricot Parasol and Well Spring White flowering was observed under HDPE and tarpaulin. Black satin cloth could not induce flowering in theses cvs.

Interaction data of 2022 and 2023 shows significant responses and it exhibits that maximum number of flowers per plant was achieved, when plants of cv. Well Spring White were grown under HDPE i.e. C_6M_1 for both year of study i.e. (53.60 and 52.00). In contrast to this for the year 2023 the minimum number of flowers per plant was observed in C_5M_1 i.e. Apricot Parasol grown under HDPE i.e. (36.27), whereas in year 2023 the minimum number of flowers per plant were seen in C_4M_3 i.e cv. Surf grown under black satin cloth (36.67).

A wide variation in number of flowers per plant was noticed among cultivars in pooled data also (Table 4.8 c). Maximum number of flowers per plant was noted in cv Well Spring White. i.e. 50.12, whereas minimum number of flowers per plant were seen in cv. Apricot Parasol i.e. 38.32.

Covering materials also significantly affected number of flower per plant. Maximum number of flowers per plants was observed under HDPE i.e. (44.71) in comparison to minimum number of flower per plant under black satin cloth i.e. 37.00.

Interaction data reveals that plants of cv. Well Spring White grown under HDPE C_6M_1 displayed maximum number of flowers per plant i.e. 52.80. On the other hand, minimum number of flowers per plant i.e. 37.00 was observed in cv. Surf under black satin cloth. (C_6M_3).

The controlled photoperiod resulted in a higher number of flowers per plant, contrasting with the lower count observed in plants exposed to natural photoperiod. This aligns with the findings of Talent et al. (1979) and Post (1931). Plants subjected to controlled photoperiod experienced consistent exposure to uniform light conditions, facilitating proper bud development and achieving uniform early flowering. Certain chrysanthemum cultivars exhibit premature flower bud formation in extended daylight conditions (Langton et al., 1981; Lee et al., 2004). This tendency might contribute to the occurrence of numerous abnormal flowers in plants under natural photoperiod, consequently leading to a reduced overall flower count per plant.

Table 4.8.1b. Effect of covering materials on number of flowers per plant of spray chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	43.00	42.47	37.33	**40.93**
C_5 : Apricot Parasol	36.27	36.60	-	**36.43**
C_6 : Well Spring White	53.60	49.20	-	**51.40**
Mean	**44.29**	**42.76**	**37.33**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
SU x AP	1.14	**HDPE x TP**		1.02
SU x WSW	1.14	**HDPE X BSC**		1.45
AP x WSW	1.25	**TP x BSC**		1.45
Interaction	1.77			

Table 4.8.2b. Effect of covering materials on number of flowers per plant of spray chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	41.00	41.53	36.67	**39.73**
C_5 : Apricot Parasol	42.40	38.00	-	**40.20**
C_6 : Well Spring White	52.00	45.67	-	**48.83**
Mean	**45.13**	**41.73**	**36.67**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
SU x AP	1.63	**HDPE x TP**		1.49
SU x WSW	1.63	**HDPE X BSC**		1.99
AP x WSW	1.82	**TP x BSC**		1.99
Interaction	2.30			

Table 4.8.3b. Effect of covering materials on number of flowers per plant of spray chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	42.00	42.00	37.00	**40.33**
C_5 : Apricot Parasol	39.34	37.30	-	**38.32**
C_6 : Well Spring White	52.80	47.44	-	**50.12**
Mean	**44.71**	**42.25**	**37.00**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
SU x AP	1.47	**HDPE x TP**		1.34
SU x WSW	1.47	**HDPE X BSC**		1.80
AP x WSW	1.64	**TP x BSC**		1.80
Interaction	2.08			

4.9: Flower size (cm)

Data presented in Table 4.9a and 4.9b shows that flowers size varied significantly among the cultivars in both the years i.e. 2022 and 2023.

Among the cultivars the results were significant in both the year 2022 and 2023 maximum flower Size was seen in cv. White Star C_1 (7.22 cm and 6.76 cm) which was found to be at par with yellow Star C_2 i.e (6.90 cm and 6.75 cm) respectively. In contrast, minimum flower size was observed in cv. Well Spring White C_6 (2.80 cm and 3.07 cm).

Variation in the year 2022 and 2023 was observed in flower size to different covering materials. Maximum flower size was observed by plants grown under black satin (M_3) i.e. (5.48cm and 5.39 cm) for both years of study. On the other hand, plants grown under Tarpaulin M_2 has shown minimum flower size i.e. (5.21 cm and 5.00 cm) for both years of study.

Interaction data of 2022 and 2023 reveals that maximum flower size was achieved, when plants of cv. White Star were grown under HDPE i.e. C_1M_1 (7.63 cm and 7.49 cm). In contrast, minimum flower size was observed in C_6M_1 i.e. Well Spring White grown under HDPE (2.49 cm and 2.99 cm) during both the year of study.

A wide variation in flower size was noticed among cultivars in pooled data (Table 4.9.c). Maximum flower size was noted in cv White Star. i.e.6.99cm, whereas minimum i.e. 2.94 cm was observed in cv. Well Spring white

Covering materials also significantly affected flower size. Maximum flower size was observed under Black satin cloth i.e. (5.44 cm) in comparison to minimum flower size under Tarpaulin i.e. 5.11 cm.

Interaction data reveals that plants of cv. White Star grown under HDPE displayed maximum flower size i.e. 7.56 cm, in contrast minimum flower size i.e. 2.74 cm was observed in cv. Well Spring White under HDPE.

Studies show that due to less exposure to light and with increase in temperature in night hours under covering materials causes smaller size of flowers, it is in conformity to the earlier studies conducted by Carvalho et al. 2005, Nakano et al, 2020 Karlsson et al. 1989, Nozaki & Fukai 2008.

Table 4.9a. Effect of covering materials on flower size (cm) of chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	7.63	7.41	6.63	**7.22**
C_2 : Yellow Star	7.13	6.89	6.69	**6.90**
C_3 : Purnima	5.70	5.57	-	**5.64**
C_4 : Surf	4.34	4.15	3.13	**3.87**
C_5 : Apricot Parasol	4.22	4.11	-	**4.17**
C_6 : Well Spring White	2.49	3.11	-	**2.80**
Mean	**5.25**	**5.21**	**5.48**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	0.25	YS x WSW	2.59	HDPE x TP	0.18
WS x PU	0.28	PU x SU	2.59	HDPE X BSC	0.21
WS x S	0.25	PU x AP	2.84	TP x BSC	0.21
WS x AP	0.28	PU x WSW	2.84	INTERACTION	0.39
WS x WSW	0.28	SU x AP	2.59		
YS x PU	0.28	SU x WSW	2.59		
YS x SU	0.25	AP x WSW	2.84		
YS x AP	0.28				

Table 4.9b. Effect of covering materials on flower size(cm) of chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	7.49	6.97	5.83	**6.76**
C_2 : Yellow Star	7.25	6.28	6.72	**6.75**
C_3 : Purnima	5.50	5.63	-	**5.57**
C_4 : Surf	4.97	4.09	3.61	**4.22**
C_5 : Apricot Parasol	3.98	3.88	-	**3.93**
C_6 : Well Spring White	2.99	3.15	-	**3.07**
Mean	**5.36**	**5.00**	**5 .39**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	0.22	YS x WSW	0.24	HDPE x TP	0.16
WS x PU	0.24	PU x SU	0.24	HDPE X BSC	0.19
WS x S	0.22	PU x AP	0.27	TP x BSC	0.19
WS x AP	0.24	PU x WSW	0.27	INTERACTION	0.34
WS x WSW	0.24	SU x AP	0.24		
YS x PU	0.24	SU x WSW	0.24		
YS x SU	0.22	AP x WSW	0.27		
YS x AP	0.24				

Table 4.9c. Effect of covering materials on flower size (cm) of chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	7.56	7.19	6.23	**6.99**
C_2 : Yellow Star	7.19	6.59	6.71	**6.83**
C_3 : Purnima	5.60	5.60	-	**5.60**
C_4 : Surf	4.66	4.12	3.37	**4.05**
C_5 : Apricot Parasol	4.10	4.00	-	**4.05**
C_6 : Well Spring White	2.74	3.13	-	**2.94**
Mean	**5.31**	**5.11**	**5.44**	

Cultivars	(CD)	Cultivars	(CD)	Covering material	(CD)
WS x YS	0.16	YS x WSW	0.18	HDPE x TP	0.11
WS x PU	0.18	PU x SU	0.18	HDPE X BSC	0.14
WS x S	0.16	PU x AP	0.20	TP x BSC	0.14
WS x AP	0.18	PU x WSW	0.20	INTERACTION	0.28
WS x WSW	0.18	SU x AP	0.18		
YS x PU	0.18	SU x WSW	0.18		
YS x SU	0.16	AP x WSW	0.20		
YS x AP	0.18				

4.10a: Cut stem weight(g) of standard chrysanthemum

Data presented in Table 4.10.1 a and 4.10.2.a shows that cut stem weight varied significantly among the cultivars in both the years i.e. 2022 and 2023.

In year 2022 and 2023, maximum cut stem weight was observed in cv. White Star C_1 i.e (24.87g and 23.44g) which was found to be at par with Yellow Star C_2 i.e (23.71g and 23.06g) respectively. In contrast, minimum cut stem weight was observed in cv. Purnima C_6 i.e (21.72g and 22.12 g) during both the years of study.

Variation in the years 2022 and 2023 was observed in cut stem weight due to different covering materials. Maximum cut stem weight was observed by plants grown under HDPE (M_1) i.e. (24.12g and 24.02g). On the other hand, plants grown under black satin cloth M_3 has shown minimum cut stem weight i.e. (22.80g and 21.59g) during both the years of study.

Interaction data of 2022 and 2023 reveals that heaviest cut stems were obtained, when plants of cv. White Star were grown under HDPE i.e. C_1M_1 (26.22g and 25.14g). It was found to be at par with C_1M_2 White Star grown under tarpaulin i.e. 24.93 g and C_2M_2(24.02) and C_2M_2(24.95) i.e Yellow Star under HDPE and black satin cloth, respectively for the year

2023. In contrast, minimum cut stem weight in year 2022 was displayed in C_3M_2 i.e. Purnima grown under tarpaulin i.e. (21.32 g), whereas it was found to be minimum in 2023 by C_1M_3 White Star under Black satin cloth (21.50 g)

A wide variation in cut stem weight was noticed among cultivars in pooled data (Table 4.10.3a). Maximum cut stem weight was noted in cv White Star. i.e.24.16, which was found to be at par with cv. Yellow Star i.e. 23.39g, whereas minimum cut stem weight i.e.21.92 g was observed in cv. Purnima.

Covering materials also affected cut stem weight. Maximum cut stem weight was observed under HDPE i.e. (24.07g) in comparison to minimum cut stem weight under black satin cloth i.e. 22.19 g.

Interaction data reveals that plants of cv. White Star grown under HDPE displayed maximum cut stem weight i.e. 25.68 g in contrast minimum cut stem weight i.e. 21.50g was observed in cv. Purnima under Tarpaulin.

Variation in cut stem weight among standard cultivars could be attributed to the genotypic difference amongst them. Among covering materials, maximum cut stem weight was noted in the plants grown under HDPE. In the present study, HDPE was found to induce maximum vegetative growth in comparison to others covering materials. Optimum vegetative growth under the treatment has resulted in production of healthy shoots that terminated into flowers as it received short days' inductive treatments. The results of the research align with previous studies on the same subject of Sita Ram and Sehgal (1993[b]) ,Sangma (2015)

Table 4.10.1a. Effect of covering materials on cut stem weight (g) of standard chrysanthemum cultivars in the year 2022

Covering materials / Cultivars	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	26.22	24.93	23.45	**24.87**
C_2 : Yellow Star	24.02	24.95	22.15	**23.71**
C_3 : Purnima	22.12	21.32	-	**21.72**
Mean	**24.12**	**23.73**	**22.80**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.57	**HDPE x TP**		0.57
WS x PU	0.64	**HDPE X BSC**		0.64
YS x PU	0.64	**TP x BSC**		0.64
Interaction	0.99			

Table 4.10.2a. Effect of covering materials on cut stem weight (g) of standard chrysanthemum cultivars in the year 2023

Covering materials / Cultivars	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	25.14	23.68	21.50	**23.44**
C_2 : Yellow Star	24.37	23.15	21.67	**23.06**
C_3 : Purnima	22.56	21.67	-	**22.12**
Mean	**24.02**	**22.83**	**21.59**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.65	**HDPE x TP**		0.65
WS x PU	0.72	**HDPE X BSC**		0.72
YS x PU	0.72	**TP x BSC**		0.72
Interaction	1.12			

Table 4.10.3a. Effect of covering materials on cut stem weight (g) of standard chrysanthemum cultivars (pooled)

Covering materials / Cultivars	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	25.68	24.31	22.48	**24.16**
C_2 : Yellow Star	24.20	24.05	21.91	**23.39**
C_3 : Purnima	22.34	21.50	-	**21.92**
Mean	**24.07**	**23.28**	**22.19**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.61	**HDPE x TP**		0.61
WS x PU	0.68	**HDPE X BSC**		0.68
YS x PU	0.68	**TP x BSC**		0.68
Interaction	1.12			

4.10b Flower weight/plant (g) of spray chrysanthemum

Data presented in Table 4.10.1 b and 4.10.2.b shows that flower weight/plant varied significantly among the cultivars in both the years i.e. 2022 and 2023.

In years 2022 and 2023, maximum flower weight/plant was observed in cv. Apricot Parasol C_4 i.e. (101.97 g and 105.20g respectively). In contrast, minimum flower weight/plant was observed in cv. Well Spring White C_6 i.e (87.54g and 82.97g) during both years of study.

Variation in the year 2022 and 2023 was observed in flower weight/plant due to different covering materials. Maximum flower weight/plant was observed by plants grown under HDPE (M_1) i.e. (123.18g and 122.78g). On the other hand, plants grown under black satin cloth M_3 has shown minimum flower weight/plant i.e. (64.95g and 63.80g) during both the years of study.

Interaction data of 2022 and 2023 reveals that maximum flower weight/plant was achieved, when plants of cv. Surf were grown under HDPE i.e. C_4M_1 (141.9g and 139.45g). In contrast, minimum flower weight/plant in year 2022 was displayed in C_4M_3 i.e. Surf grown under black satin cloth i.e. (64.95g), and in 2023 it was displayed by C_6M_2 Well Spring White under Tarpaulin i.e 63.43g.

A variation in flower weight/plant was noticed among cultivars in pooled data (Table 4.10.3b). Maximum flower weight/plant was noted in cv Apricot Parasol. i.e.103.58g, whereas minimum flower weight/plant i.e.86.01g was observed in cv. Well Spring White.

Data also shows that maximum flower weight/plant was observed under HDPE i.e. (122.98g) in comparison to minimum flower weight/plant under black satin cloth i.e. 64.38 g.

Interaction data reveals that plants of cv. Surf grown under HDPE C_4M_1 displayed maximum flower weight/plant i.e. 140.68g, in contrast minimum flower weight/plant i.e. 64.38g was observed in cv. Surf under black satin cloth (C_4M_3).

Variation in flower weight/plant in spray cultivars seems to be due to genetic constitution of different cultivars. Superiority of cv Surf for loose flower production is an established fact in studies of Usha (2010) As for as growing conditions are concerned, HDPE was found most effective material for producing healthy plants as it is evident from previous results. Therefore, maximum flower weight /plant was found in plants grown under HDPE irrespective of cultivars.

Table 4.10.1b Effect of covering materials on flower weight/plant (g) of spray chrysanthemum cultivars in the year 2022

Covering materials / Cultivars	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	141.90	93.43	64.95	**100.09**
C_5 : Apricot Parasol	120.12	83.81	-	**101.97**
C_6 : Well Spring White	107.53	67.56	-	**87.54**
Mean	**123.18**	**81.60**	**64.95**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
SU x AP	0.87	**HDPE x TP**		0.78
SU x WSW	0.87	**HDPE X BSC**		1.10
AP x WSW	0.95	**TP x BSC**		1.10
Interaction	1.34			

Table 4.10.2b. Effect of covering materials on flower weight/plant(g) of spray chrysanthemum cultivars in the year 2023

Covering materials / Cultivars	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	139.45	91.36	63.80	**98.20**
C_5 : Apricot Parasol	123.38	87.02	-	**105.20**
C_6 : Well Spring White	105.52	63.43	-	**82.97**
Mean	**122.78**	**80.60**	**63.80**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
SU x AP	0.83	**HDPE x TP**		0.75
SU x WSW	0.83	**HDPE X BSC**		1.06
AP x WSW	0.91	**TP x BSC**		1.06
Interaction	1.29			

Table 4.10.3b. Effect of covering materials on flower weight/plant (g) of spray chrysanthemum cultivars (pooled)

Covering materials / Cultivars	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	140.68	92.40	64.38	**99.15**
C_5 : Apricot Parasol	121.75	85.42	-	**103.58**
C_6 : Well Spring White	106.52	65.50	-	**86.01**
Mean	**122.98**	**81.06**	**64.38**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
SU x AP	0.72	**HDPE x TP**		0.65
SU x WSW	0.72	**HDPE X BSC**		0.92
AP x WSW	0.79	**TP x BSC**		0.92
Interaction	1.12			

4.11a: Vase life (days) of standard chrysanthemum cultivars.

Data presented in Table 4.11.1 a and 4.11.2 a shows that vase life varied significantly among the cultivars in both the years i.e. 2022 and 2023 (Plate 4).

In years 2022 and 2023, maximum vase life was observed in cv. White Star C_1 (5.57 days and 4.93 days) respectively. In contrast, minimum vase life was observed in cv. Purnima C_3 (3.70 days and 3.64 days)

Variation in the years 2022 and 2023 was observed vase life to different covering materials also. Maximum vase life was observed by plants grown under HDPE (M_1) i.e. (4.98 days and 4.71 days) for both the years of study. On the other hand, plants grown under black satin cloth M_3 has shown minimum vase life i.e. (3.60 days and 3.87days)

Plate 4. A view of experiment on vase life of chrysanthemum grown under different covering materials

Interaction data of 2022 and 2023 reveals that maximum vase life was achieved, when plants of cv. White Star were grown under tarpaulin i.e. C_1M_2 (6.0 days and 5.53 days). It was found to be at par with Yellow Star grown under HDPE (C_2M_1) i.e. (5.23 days and 5.20 days) for both the years of study. In contrast, minimum vase life was displayed in C_3M_2 i.e. Purnima under Tarpaulin (2.80 days and 3.47 days) for both the years of investigation.

A wide variation in vase life was noticed among cultivars in pooled data also (Table 4.11.3a). Maximum vase life was noted in cv White Star. i.e. (5.07 days), whereas minimum vase life i.e.3.67 days was observed in cv. Purnima.

Covering materials also affected vase life. Maximum vase life was observed under HDPE i.e. (4.84 days), which was found to be at par with M_2 4.30. It was however minimum under black satin cloth i.e. (3.95 days).

Interaction data reveals that plants of cv. White Star grown under Tarpaulin C_1M_2 displayed maximum vase life i.e. (5.77 days), which was found to be at par with cv. Yellow star under tarpaulin i.e 5.22 days C_2M_1. In contrast minimum vase life i.e. 3.14 days was observed in cv. Purnima under black satin cloth C_3M_2.

Vase life is a function of healthy stems and cut flower quality. The heaviest cut stems with ample of carbohydrate levels produced under HDPE irrespective of cultivars. The healthy stems ensured consistent supply of carbohydrates to the stem when in vases resulting in longer vase life. The findings of the study are in conformity to earlier studies of Pathak (2002) and Sangma (2015)

Table 4.11.1a. Effect of covering materials on vase life of standard chrysanthemum cultivars in the year 2022

Covering materials / Cultivars	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	5.13	6.00	4.46`	**5.57**
C_2 : Yellow Star	5.20	3.73	3.60	**4.18**
C_3 : Purnima	4.60	2.80	-	**3.70**
Mean	**4.98**	**4.18**	**3.60**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.28	**HDPE x TP**		0.28
WS x PU	0.31	**HDPE X BSC**		0.31
YS x PU	0.31	**TP x BSC**		0.31
Interaction	0.49			

Table 4.11.2a. Effect of covering materials on vase life of standard chrysanthemum cultivars in year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	5.10	5.53	4.17	**4.93**
C_2 : Yellow Star	5.23	4.26	3.57	**4.35**
C_3 : Purnima	3.80	3.47	-	**3.64**
Mean	**4.71**	**4.42**	**3.87**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.26	**HDPE x TP**		0.26
WS x PU	0.29	**HDPE X BSC**		0.29
YS x PU	0.29	**TP x BSC**		0.29
Interaction	0.45			

Table 4.11.3a. Effect of covering materials on vase life of standard chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_1 : White Star	5.12	5.77	4.32	**5.07**
C_2 : Yellow Star	5.22	4.00	3.59	**4.27**
C_3 : Purnima	4.20	3.14	-	**3.67**
Mean	**4.84**	**4.30**	**3.95**	
Cultivars	**(CD)**	**Covering Material**		**(CD)**
WS x YS	0.21	**HDPE x TP**		0.21
WS x PU	0.24	**HDPE X BSC**		0.24
YS x PU	0.24	**TP x BSC**		0.24
Interaction	0.37			

4.11b Shelf life days of spray chrysanthemum cultivars

Data presented in Table 4.11.1b and 4.11.2b shows that shelf life varied significantly among the cultivars in both the years i.e. 2022 and 2023 (Plate 5).

In year 2022 maximum shelf life was observed in cv. Surf C_4 (2.55 days), which was found to be at par with cv. Well Spring White C_6i.e 2.53 days. In contrast, minimum shelf life was observed in cv. Apricot Parasol C_5 (2.43 days).

In year 2023, maximum shelf life was observed in cv. Well Spring White C_6 (2.49 days), which was found to be at par with cv. Apricot Parasol C_4 i.e 2.46 days. In contrast, minimum shelf life was observed in cv. Surf C_4 i.e (2.42 days)

Variation in the year 2022 was observed in shelf life to different covering materials. Maximum shelf Life was observed by plants grown under HDPE (M_1) i.e. (2.60 days), which was found to be at par with Tarpaulin i.e 2.55 days. On the other hand, plants grown under black satin cloth M_3 has shown minimum Shelf life i.e. (2.13 days)

Plate 5. Shelf life studies

Variation was also observed in the year 2023 in shelf life due to different covering materials. Maximum was shelf life observed by plants grown under Tarpaulin (M_2) i.e. (2.69 days), which was found to be at par with HDPE i.e 2.51 days. On the other hand, plants grown under black satin cloth M_3 has shown minimum shelf life i.e. (1.58 days)

Interaction data of 2022 reveals that maximum shelf life was achieved, when plants of cv. Surf were grown under tarpaulin i.e. C_4M_2 (2.80 days), which was found to be at par with C_4M_1 i.e cv. Surf grown under HDPE (2.73 days). In contrast, minimum shelf life was displayed in C_4M_3 i.e. cv. Surf under black satin cloth (2.13 days).

Interaction data of 2023 reveals that maximum shelf life was achieved, when plants of cv. Surf were grown under HDPE i.e. C_4M_1 (2.89 days), which was found to be at par with C_4M_2 i.e cv. Surf grown under Tarpaulin (2.80 days). In contrast, minimum shelf life was displayed in C_4M_3 i.e. cv. Surf under black satin cloth (1.58 days).

A wide variation in shelf life was noticed among cultivars in pooled data also (Table 4.11.3a). Maximum shelf life was noted in cv Well Spring White. i.e. (2.51 days), which was found to be at par with cv. Surf i.e (2.49 days).In contrast minimum shelf life i.e.2.45 days was observed in cv. Apricot Parasol.

Covering materials also affected shelf life. Maximum shelf life was observed under tarpaulin i.e. (2.62 days), which was found to be at par with HDPE M_1 i.e.2.55days. Minimum shelf life was observed under black satin cloth i.e. (1.86 days).

Interaction data reveals that plants of cv. Surf grown under HDPE C_4M_1 displayed maximum shelf life i.e. (2.81 days), which was found to be at par with cv. Surf under tarpaulin C_4M_2 i.e 2.80 days. In contrast minimum shelf life i.e. 1.86 days was observed in cv. Surf under black satin cloth. C_4M_3

Genotypic variations among spray chrysanthemum cultivars is reflected in shelf life also plants grown under HDPE attained best vegetative growth which in turn resulted in best quality flower production in terms of flower size and weight as it is evident in the present study. Availability of larger amounts of carbohydrates ensures continuous supply of food to flowers after harvesting resulting into longer shelf life. The study's results align with those of previous research of Pathak (2002), and Cockshull and Kofranek (1992).

Table 4.11.1b. Effect of covering materials on shelf life of spray chrysanthemum cultivars in the year 2022

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	2.73	2.80	2.13	**2.55**
C_5 : Apricot Parasol	2.53	2.33	-	**2.43**
C_6 : Well Spring white	2.53	2.53	-	**2.53**
Mean	**2.60**	**2.55**	**2.13**	
Cultivars	(CD)	Covering Material		(CD)
SU x AP	0.29	HDPE x TP		0.26
SU x WSW	0.29	HDPE X BSC		0.37
AP x WSW	0.32	TP x BSC		0.37
Interaction	0.45			

Table 4.11.2b. Effect of covering materials on shelf life of spray chrysanthemum cultivars in the year 2023

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	2.89	2.80	1.58	**2.42**
C_5 : Apricot Parasol	2.19	2.73	-	**2.46**
C_6 : Well Spring white	2.45	2.53	-	**2.49**
Mean	**2.51**	**2.69**	**1.58**	
Cultivars	(CD)	Covering Material		(CD)
SU x AP	0.28	HDPE x TP		0.25
SU x WSW	0.28	HDPE X BSC		0.36
AP x WSW	0.31	TP x BSC		0.36
Interaction	0.43			

Table 4.11.3b. Effect of covering materials on shelf life of spray chrysanthemum cultivars (pooled)

Cultivars \ Covering materials	HDPE (M_1)	TP (M_2)	BSC (M_3)	Mean
C_4: Surf	2.81	2.80	1.86	**2.49**
C_5 : Apricot Parasol	2.36	2.53	-	**2.45**
C_6 : Well Spring white	2.49	2.53	-	**2.51**
Mean	**2.55**	**2.62**	**1.86**	
Cultivars	(CD)	Covering Material		(CD)
SU x AP	0.21	HDPE x TP		0.19
SU x WSW	0.21	HDPE X BSC		0.21
AP x WSW	0.23	TP x BSC		0.21
Interaction	0.32			

Chapter-5

SUMMARY AND CONCLUSION

The present investigation entitled "**Effect of covering materials on off season flower production of chrysanthemum (*Dendranthema* x *grandiflora* Tzvelev.) cultivars under low hills of HP**" was carried out at Experimental Farm of RHR&TS Dhaulaukuan, Simour of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2022 and 2023. The experiment was laid out in CRD with 4 treatments, replicated thrice. One week before planting vermicompost, full doses of P and K and half dose of N were incorporated into the beds. The remaining half dose of nitrogen was applied after 30 days of planting. After the plants attained height of more than one to one and half feet with sufficient vegetative growth the blackout treatment was started with different covering materials i.e. HDPE, Black Satin Cloth and Tarpaulin. The findings and conclusions of the study are summarized below:

Maximum plant height (cm) was observed under natural photoperiod (58.60 cm) and minimum plant height in HDPE (56.47.cm). Among different cultivars, maximum plant height was recorded in 'White Star' (90.60. cm) and minimum height was recorded in 'Well Spring White' (32.24 cm).

Plant spread was found to be maximum in the different cultivars belonging to spray and standard groups, cultivar 'Purnima' (49.96 cm) exhibited maximum plant spread and minimum was observed in 'Well Spring White'(28.57cm).

Maximum number of shoots per plant was recorded in plants under natural photoperiod (4.04) and minimum number of shoots per plant was recorded in plants under tarpaulin (3.62). Among different cultivars, maximum number of shoots per plant was observed in cultivar 'Surf' (4.43) whereas minimum was observed in cultivar 'White Star and Purnima' (3.41).

Maximum chlorophyll content was recorded in cultivar 'Apricot Parasol'(1.47mg/g) whereas minimum was recorded in cultivar 'White Star'(0.58mg/g).

Number of short days taken for visible flower bud formation was minimum in plants covered with HDPE (high density polyethylene) (49.41. days) while maximum number of days were taken by plants grown under black satin cloth (59.80 days). Among the different cultivars, 'Surf' (38.82 days) took least number of short days taken for visible coloured flower bud formation, while 'Well Spring White' (59.80 days) took maximum number of short days for visible colour flower bud formation.

Days taken to colored flower bud formation was observed to be minimum in plants covered with HDPE (high density polyethylene) (110.74 days) while maximum number of days were taken by plants under black satin cloth (129.63. days). Among the different cultivars, 'Surf' (99.62 days) took least number of days taken for visible colored bud formation, while 'Well Spring White' (123.15 days) took maximum number of days taken for visible colored bud formation

Minimum days to reach harvesting stage was recorded in plants under high density polyethylene (122.72 days) and in comparison, plant grown under black satin cloth (131.63 days) took maximum number of days to reach at this stage. Among the different cultivars 'Surf' (109.50 days) took minimum number of days to reach at this stage and 'Well Spring White' (139.10 days) took maximum number of days to reach harvesting

Among the standard cultivars, plants under HDPE cover (3.14) had maximum number of flowers per plant and minimum number of flowers per plant was recorded under black satin cloth (2.21). Among the different standard cultivars, maximum number of flowers per plant was recorded in 'Yellow Star' (2.96). In contrast, minimum number of flowers per plant was recorded in 'Purnima' (2.27).

In spray cultivars, plants grown under HDPE (44.71) produced maximum number of flowers per plant and minimum number of flowers per plant was produced in plants under black satin cloth (37.00). Among the cultivars, maximum number of flowers per plant recorded in 'Well Spring White'(50.12) and minimum number of flowers per plant was seen in 'Apricot Parasol'(38.32).

Maximum flower size of 5.44 cm diameter was recorded in plants under black satin cloth, whereas minimum flower size was recorded in plants under tarpaulin (5.11 cm). Among the cultivars, maximum flower size was recorded in 'White Star' (6.99 cm), whereas minimum flower size was observed in 'Well Spring White' (2.94 cm).

Maximum cut stem weight was obtained from plants covered with HDPE (high density polyethylene) (24.07 g) while minimum stems weight was recorded in case of plants under black satin cloth (22.19 g). Among the cultivars maximum cut stem weight was observed in 'White Star' (24.16 g), whereas minimum stem weight was seen in 'Purnima' (21.92 g).

Maximum flower weight per plant was obtained from plants covered with HDPE (high density polyethylene) (122.98 g) while minimum flower weight was recorded in case of plants under black satin cloth (64.38 g). Among the cultivars maximum flower weight was observed in 'Apricot Parasol' (103.58 g), whereas minimum flower weight was seen in 'Well Spring White' (86.01 g).

Maximum vase life (4.84 days) was recorded in cut stems produced from plants where HDPE was used as covering material. In contrast, minimum vase life was recorded under black satin cloth (3.95 days). Among the different cultivars belonging to standard groups, cultivar 'White Star' (5.07 days) recorded maximum vase life. In contrast, minimum vase life of 3.67 days was recorded in 'Purnima'.

Maximum shelf life of loose flowers (2.62 days) was recorded in plants where tarpaulin was used as covering material. In contrast, minimum duration of shelf life was recorded under black satin cloth (1.86 days). Among the different cultivars belonging to spray groups, flower of cultivar 'Well Spring White' (2.51 days) recorded maximum shelf life. In contrast, minimum shelf life of 2.45 days was recorded in 'Apricot Parasol'.

CONCLUSION:

Out of three covering materials studied, the utilization of High-Density Polyethylene (HDPE) covering for chrysanthemum cultivars demonstrated optimal outcomes in terms of plant height (56.47 cm), plant spread (37.34 cm), the highest number of cut stems (3.69), earliest flower bud formation (49.41 days), and flowering initiation (110.74 days). Consequently, based on the present study, it can be inferred that HDPE serves as a superior alternative to tarpaulin for off-season chrysanthemum flower production, applicable to both standard and spray cultivars. Among the eight cultivars evaluated—'White Star,' 'Yellow Star,' and 'Purnima' in the standard group, and 'Surf,' 'Apricot Parasol,' and 'Well Spring White' in the spray group were found suitable for off season flower production under low hills conditions of H.P. Cultivars 'Snow Ball' and 'Yellow Button' did not flower. Black satin cloth produced ineffective in inducing off season flower production in almost all of the cultivars. Whereas further studies can be done to identify better performing cultivars for off season flower production in low hills of H.P by using HDPE.

LITERATURE CITED

Abou Dahab and AM. 1967. Effects of light and temperature on growth and flowering of carnation *(Dianthus caryophyllus* L.) (Doctoral dissertation, Veenman).

Adams SR, Pearson S and Hadley P. 1998. An appraisal of the use of reciprocal transfer experiments assessing the stages of photoperiod sensitivity in chrysanthemum cv. Snowdon (*Chrysanthemum morifolium* Ramat). *Journal of Experimental Botany*. 49: (325):1404-1411.

Allard HA. 1928. Chrysanthemum flowering season varied according to daily exposure to light. Year Book USDA. 194p.

Andersen A and Klougart A. 1996. The control of carnation flowering. *Gartner Tidende*. 82: 751-53.

Andersen H and Aabrandt Z. 1989. Artificial lighting for Dianthus cv. Fancy. *Gartner Tidende*. 105(38):941-43.

Anderson RL. 1987. Reclassification of genus chrysanthemum. *HortScience*. 123(12): 34-42.

Anderson, N. O. 1987. Reclassifications of the genus Chrysanthemum L. *HortScience* 22(2), 313-313.

Anjum, M. A., Nawaz, A., Gul, S., and Naveed, F. 2007. Effect of various sucker sizes and planting times on flowering and vase life of chrysanthemum. *Pak. J. Agric. Sci*, *44*(3), 475-480.

Atherton JG and Harris GP. 1980. Effects of photoperiod on shoot elongation and endogenous gibberellins in the glasshouse carnation. *Scientia Hortic*. 12(1): 83- 88.

Basoli, M., Dhiman, S. R., Gupta, Y. C., and Gupta, R. K. 2016. Flower regulation in standard chrysanthemum (*Dendranthema grandiflora* Tzvelev) by staggered planting. *International Journal of Farm Sciences* 6(3), 137-145.

Benedetto, G. and Porto, M. 1996. Commercial Greenhouse Experiments with Chrysanthemum Cultivars 'Santini,' 'Shamrock,' and 'Seiko': Planting and Growth Observations from November 1992. *Horticultural Science Journal*, 21(3), 127-134.

Benjamin Wolf. 1971. The determination of boron in soil extracts, plant materials, composts, manures, water and nutrient solutions, Communications in Soil Science and Plant Analysis, 2:5, 363-374.

Bhattacharjee. S.K. and Chandra De.L. 2003. Advanced Commercial Floriculture, Jaipur Publications. Jaipur, 302003 (Rajasthan), India.

Blake J and Whitehead T. 196 l. The influence of extended daylength on flower production of carnations. Exp. Hort., 5: 1-8. Blandford Press, Dorset, UK. 233p

Blake SJ. 1955. Photoperiodism in perpetual flowering carnation. Rep. XIV lntn. Hort Congress, Netherlands, 1:331-36.

Bonaminio VP and Larson RS. 1980. Influence of reduced night temperature on growth and flowering of 'May Shoesmith' chrysanthemum. *Journal of American Society for Horticultural Science.* 105(1):9-11.

Bres W and Jery M. 2004. Effect of the planting dates on the quality of pgt · chrysanthemums from the time group in all year round culture. *Folia Horticulture*. 16(2):119-126.

Bunt AC and Powell MC. 1983. Quantitative response of carnation to solar radiation, long day and supplementary light source. *Acta Hortic.* 141:139-50.

Bunt AC and Sheard GF. 1967. Observations on the effect of time of planting and to - plant density on the yield and flower quality of the carnation (*Dianthus caryophyllus* L.). *J Hort. Sci.* 43:263-67.

Butters RE. 1974. Effect of spacing and dusk to dawn lighting on carnations. *Grower*. 81(20):965-66.

Bylov BN, Voroncbikhina ZN and Forrrin EM. 1976. Regulating the flowering dates in perpetual carnations. *Glavnogo Botanicheskogo Sada*. 99:60-66.

Bylov VN and Srnimova ZI. 1984. Improving the quality of perpetual flowering in carnation during winter forcing. *Glavnogo Boranicheskogo Sada*. 130:55-58.

Byrne TG. 1982. Lighting carnations. Flower and Nursery Report. Summer. 3-4. California, University, USA.

Chaffey, S.R. and Bastion, P. 1968. Dusk to dawn lighting increases blooms. boosts returns. *Grower*. 69:412.

Cairol D. 1982. Reaction of the chrysanthemum cv. 'Super White' to soil heating in relation to photoperiod. *Acta Horticulturae.* 125:159-165.

Carvalho SMP, Abi-Tarabay H and Heuvelink E. 2005. Temperature affects chrysanthemum flower characteristics differently during three phases of the cultivation period. *The Journal of Horticultural Science and Biotechnology*. 80(2): 209-216.

Cathey HM. 1954. Temperature classification of chrysanthemum. *New York State Flower Growers Bull* 104. 1p.

Cathey HM. 1955. Temperature guide chrysanthemum varieties. *New York State Flower Growers Bul* 119. 1p.

Cathey, HM. 1954. Chrysanthemum temperature study. B. Thermal modification of photoperiods pre and after flower bud initiation. In *Proc. Amer. Soc. Hort. Sci.* 64, pp. 492-498.

Chan AP. 1960. Floriculture research. Prog. Rep. Hort. Div. Centre Exp. Farm Ottawa (1954-58). pp.71-78.

Clausen G. 1973 Intermittent illumination and the photoperiodic control of Flowering in chrysanthemum. *Annt journel*. 16:146-52.

Clausen, C.1973. Effect of planting time on blooming dates of chrysanthemum varieties. *Miscellaneous Findings in Horticulture*. 18(2): 45-52

Cockshull KE and Kofranek AM. 1985. Long day flower initiation by chrysanthemum. *HortScience.* 20(2):296-298.

Cockshull KE and Kofranek AM. 1992. Responses of garden chrysanthemums to day length. *HortScience.* 27(2):113-115.

Cockshull KE and Kofranek AM. 1994. High night temperatures delay flowering produce abnormal flowers and retard stem growth of cut flower chrysanthemums. *Scientia Horticulturae.* 51:217-234.

Cockshull KE. 1975. Premature budding in year round chrysanthemum. *Report of Glasshouse Crops Research Institute.* 1874:128-136.

Cockshull KE. 1976. Flower and leaf initiation by *Chrysanthemum morifolium* Ramat in long days. *Journal of Horticultural Science.* 51:441- 450.

Cockshull KE. 1979. Effect of irradiance and temperature on flowering of *Chrysanthemum morifolium* in continuous light. *Annals of Botany.* 44: 451-460.

Cockshull KE. The integration of plant physiology with physical changes in the greenhouse climate. In Symposium on Biological Aspects of Energy Saving in Protected Cultivation 229 1987 Sep 8 (pp. 113-124).

Crater GD. 1980. In**:** *Introduction to Floriculture*, RA Larson (ed.). Academic Press, Inc., London, England. 607p.

Crater GD. 1992. Potted chrysanthemums, In: *Introduction to Floriculture*, RA Larson (ed.). Academic Press, Inc., London, England. 636p.

Datta JP, Seemanthini R and Ramdas S. 1995. Regulation of flowering in chrysanthemum cv. co.l through Supplementary illumination. *Journal of Agricultural Science Society North-East- India.* 8(1): 29-32.

De Jong, J. (1978). Selection for wide temperature adaptation in *Chrysanthemum morifolium* (Ramat.) Hemsl. *Netherlands Journal of Agricultural Science* 26(1), 110-118

De Jong, J. Analysis of components controlling early flowering of chrysanthemum at low temperature. *Euphytica* **40** 121–126 (1989).

De Lint PJAL and Heij G. 1987. Effects of day and night temperature on growth and flowering of chrysanthemum. *Acta Horticulturae.* 197:53-61.

Demmink JF and Koehorst-Van Putten HJJ. 1981. Factors influencing the response to photoperiod (long day treatment) during the winter in an autumn carnation. *Acta Horticulture* 216:303-11.

Deotale AB, Belarkarp V, Patil SR, Zode-V N and Kecbe B. 1994. Effect of date of planting and foliar spray of GA_3 on flowering and yield of chrysanthemum. *Journal of Soils and Crops* 4(2):148-151.

Dhiman SR, Gupta YC, Thakur P, Kashyap B, Sharma M and Sharma K. 2018. Effect of different black-out materials on off-season pot mum production of chrysanthemum (*Dendranthema grandiflora*). *Indian Journal of Agricultural Sciences*, 88(4):601-605.

Dhiman S R. 2018. Impact of blackout materials on off-season potted chrysanthemum (*Dendranthema grandiflora* Tzevelev) production. *Journal of floriculture and landscape architecture research*. 5(2), 45-53.

Dowrick, G. J. 1999. The chromosomes of chrysanthemum. II. Garden varieties. Heredity **7** (1953): 59–72.

Furuta T and Nelson KS. 1954. The effect of high night temperature on development of chrysanthemum flower buds. *Proceedings of American Society for Horticultural Science*. 61:548p.

Furuta T. 1954. Photoperiod and flowering of *Chrysanthemum morifolium.*

Garner WW and Allard HA. 1920. Effect of relative length of day and night and other factors of the environment on growth and reproduction in plant. *Journal of Agricultural Research.* 18:553-606.

Grawal, H.S., Kumar, R. and Singh, H., 2004. Effect of nitrogen, planting time and pinching on flower production in chrysanthemum *(Dendrenthema Grandiflora* Ramat.) cv. Flirt. *Journal of Ornamental Horticulture*, *7*(2), pp.196-199.

Glockner FC. 1985-86. Chrysanthemum manual. 15 East 26th St, New York.

Gomez KA and Gomez AA. 1984. Statistical Procedures for Agricultural Research. 2nd ed. John Willey and Sons, New York.680p.

Gonz H. 1966. Positive effects of extended day length on carnations. DCK inf. 14:4-6.

Gortzing, C. and Gillow, I. 1964. Chrysanthemum: a manual of the culture. The New York State, Extension Bulletin, pp: 9-17.

Gloeckner, R. E. (1985). Photoperiodic Flower Induction in Camellia. *HortScience*, 20(6), 1129-1130.

Griesbach RJ and Berberich SM. 1995. The early history of research on ornamental plants at the U.S Department of Agriculture from 1840 to 1862. *HortScience.* 30(3):421-425.

Griffith M and McIntyre HCH. 1989. Use of low night temperature and supplemental light to produce potted chrysanthemum in Alaska. *Agrobarealis* 21(1):12-17.

Gupta YC and Bhattacharjee SK. 2002. Carnation. Technical Bulletin Number 1 S of All India Coordinated Research Project on Floriculture (ICAR), New Delhi, India.

Hanan JJ. 1987. Pilot scale study on use of photoperiod to enhance yield and influence timing of standard carnations. *Acta Horticulture*. 216:321-29.

Hand DW, Langton FA, Hannah MA and Cockshull KE. 1996. Effects of humidity on the growth and flowering of cut-flower chrysanthemums (*Dendranthema grandiflora* Tzvelev). *Journal of Horticultural Science*. *71*(2):227-234.

Harris GP. 1967. Studies on photoperiodism in carnations: an application to commerc ial flower production. *Hort Res*. 7:76-77.

Harris GP. 1968b. Photoperiodism in a glasshouse carnation: tbe effectiveness of different light sources in promoting flower initiation. *Ann Bot*. 32:187-97.

Harris GP. 1972. Intermittent illumination and the photoperiodic control of Flowering in carnation. *Ann Bot*. 36:345-52.

Healy W and Wilkins HF. 1983. Photoperiod control of lateral branching and flower production in carnations. *Acta Hortic.* 141:151-156.

Healy WE, Heins RD and Wilkins HF. 1980. Influence of photoperiod and light quality on lateral branching and flowering of selected vegetative-propagated plants. *Journal of the American Society for Horticultural Science*. 105(6):812-816.

Hiden C and Larsen RU. 1994 Predicting flower development in greenhouse grown chrysanthemum. *Scientia horticulturae*. Jun 1;58(1-2):123-38.

Hoeven AP. 1980. The culture of short-stemmed (micro) chrysanthemums. Vakblad voor de Bloemisterij.;35(1):24-5.

Hoeven, A.P. 1987. Chrysanthemum production in the netherlands. *ActaHortic.* 197,11-20

Horridge JS, Cockshull KE. The effect of the timing of a night-break on flower initiation in *Chrysanthemum morifolium* Ramat. *Journal of Horticultural Science*. 1989 Jan 1;64(2):183-8.

Ito K, Hukuda M and Ito S. 1996. Factors in the occurrence of proliferated flowers on chrysanthemum cv. 'Seiun'. *Research Bulletin of Aichi Ken Agricultural Research Center.* 28:233-239.

Jerzy M. 1981 Longday glasshouse-shortday glasshouse system in the year-round chrysanthemum production. InSymposium on Chrysanthemum 125 1981 Aug 10 (pp. 143-148).

Jerzy M. 2003. Effect of short day interruption on flowering of spray chrysanthemum cultivars under protection. *Acta Scientiarum Polonorum Hortorum Cultus.* 2(1):47-54.

Janakiram, T., Anandakumar, C. R., Sathiamurthy, S., & Chinnusamy, C. (2004). Influence of photoperiod on the production of chrysanthemum cv. "Ravikiran" under low cost polyhouse. +, 52(1/6), 192-194.

Jiangshuo Su, Jiafu Jiang, Fei Zhang, Ye Liu, Lian Ding, Sumei Chen and Fadi Chen 2019. Current achievements and future prospects in the genetic breeding of chrysanthemum: a review, *Horticulture Research*, Volume 6, 109

Karlsson KG and Mc Intyre HCH. 1990. Evaluation of low temperature flower formation in chrysanthemum using several microsopy techniques. *Acta Horticulturae.* 272:273-277.

Karlsson MG, Heins RD, Erwin JE, Berghage RD, Carlson WH and Biernbaum JA. 1989. Irradiance and temperature effects on time of development and flower size in chrysanthemum. *Scientia Horticulturae. 39*(3):257-267.

Kawata J and Toyada T. 1982. The response of photoperiod and temperature in Japanese July to September flowering chrysanthemum. *Acta Horticulturae.* 125:93-99.

Khattak AM, Pearson S, Cockshull KE (ed.), Langton FA (ed.) and Lumsden PJ. 1997. The effect of light quality and temperature on the growth and development of chrysanthemum cvs., 'Bright Golden Anne' and 'Snowdon'. *Acta Horticulturae.* 435:113-121.

Khattak, A.M., Pearson, S and Spectral Filters. Temperature effects on the growth and development of chrysanthemums under low light integral. *Plant Growth Regul* **49**, 61–68 (2006).

Kher MA. 1988. Chrysanthemum in India, Associate Publishing House, New Delhi, ~dia. 80p.

Kher MA. 1989. Chrysanthemum, pp. 417-486. **In**: *Commercial Flowers*, TK Bose and LP Yadav (eds.). Naya Prakash, Calcutta, India. 874p.

Kher MA. 1993. Chrysanthemums spot cropping in North Indian plains without temperature control. *Proceedings of the American Society for Horticultural Science. 2*0**:**123p

Kofranek AM and Halevy AH. 1974. Minimum number of short days for production of high-quality standard chrysanthemums. *HortScience.* 9(6):543-546.

Kofranek AM. 1980. Cut chrysanthemums, pp. 1-42. In: *Introduction to Floriculture*, RA Larson (ed.). Academic Press, New York. 607p.

Kofranek AM. 1983. The minimum number of short day exposure for producing high quality spary chrysanthemum. *Acta Horticulturae* **147**:199-210.

Kofranek AM. 1992. Cut chrysanthemum: An introduction of floriculture, R A Earson{ed.). Academic Press New York. 36p.

Langton FA 1987. Breeding for improved ornamental plants. *Annals of Applied Biology.* 103(4):87-101.

Langton FA, Royce H and Cockshull KE. 1981. Leaf number of chrysanthemum cultivars grown in long days. Tests of agrochemicals and cultivars. *Annals of Applied Biology.* 100(3):110-111.

Langton FA. 1977. The response of early flowering chrysanthemum to daylength.

Larson RA. 1980. The effect of three darkening regimes ion development of *Chrysanthemum morifolium* Ramat grown during spring. *Swedish Journal of Agriculture Research.* 11(1):35-39.

Laurie A. 1930. Photoperiodism – practical application to green house culture.

Lee B, Won M, Choi W, Yang E, Lee J and Atherton JG. 2004. Floral development of chrysanthemum influenced by photoperiod. *Journal of the Korean Society for Horticultural Science.* 45(3):149-153.

Lee B, Won M, Lee D and Shin D. 2001. Flowering responses to sequential short day/ long day exposure in chrysanthemum (*Dendranthema grandiflora* Tzvelev*). Korean Journal of Horticultural Science and Technology* 19(4):560-563.

Lepage I, Jong J De and Smeets L. 1984. Effect of day and night temperatures during short photoperiods on growth and flowering of *Chrysanthemum morifolium*. *Scientia Horticulturae* **22**(4): 373-381.

Liu P L, Wan Q, Guo Y P, Yang J, Rao G Y. 2012. Phylogeny of the Genus *Chrysanthemum* L.: Evidence from Single-Copy Nuclear Gene and Chloroplast DNA Sequences. PLoS ONE 7(11): e48970.

Machin BJ and Scopes N. 1978. Chrysanthemum- Year Round Growing. pp80

Machin BJ. 1977. New pot mums to fit Princess Anne regime. *Horticulture Industry*. 622-624.

Mc Mohan M. 1999. Development of chrysanthemum meristems grown under far-red absorbing filters and long and short photoperiods. *Proceedings of American Society for Horticutural Science.* 124(5):483-487.

Meher SP, Jiotode DJ, Lurkhede AB, Daiange SO, Dhawad CS and Thorat KAW. 1999. Effect of planting time and growth regulators on growth of chrysanthemum. *Crop Research.* 8(3):486-48.9.

Mildenberge F and Hendriks L. 1996. Spacing as a quality factor, TOSPO-

Nakano Y, Takase T, Sumitomo K, Suzuki S, Tsuda-Kawamura K and Hisamatsu T. 2020. Delay of flowering at high temperature in chrysanthemum: Duration of darkness and transitions in lighting determine daily peak heat sensitivity. *The Horticulture Journal. 89*(5):602-608.

National Horticulture Board 2020: Floricultural Crops summary https://www.nhb.gov.in {accessed 24 Nov 2023}.

National Horticulture Board 2022: Floricultural Crops summary https://www.nhb.gov.in {accessed 24 Nov 2023}.

Nishio J, Yamaguchi T and Yonemura K. 1989. Effects of day length on flowering of chrysanthemum in shade culture. *Bulletin of Aichi Ken AgriculturalResearch Centre.* 21:211-216.

Nozaki K and Fukai S. 2008. Effects of high temperature on floral development and flowering in spray chrysanthemum. *Journal of Applied Horticulture*. 10(1):8-14.

Nxumalo SS and Wahome PK. 2010. Effects of application of short-days at different periods of the day on growth and flowering in chrysanthemum. *Journal of Agriculture and Social Sciences.* 6:39-42.

Okada M. 1959. On the resetting of suckers and measures for breaking resetting in chrysanthemums. (Japanese). *J. Hort. Ass. Japan* 28:209.

Pathak N. 2002. Screening of chrysanthemum cultivars for year round flower production. Ph,D. Thesis, Dr. Y.S. Parmar University ·of Horticulture and Forestry, Nauni, Solan (H.P.), India.

Pearson, J., Smith, R. and Brown, K. (1993). Automated cover management for enhancing flower development in greenhouse settings: a demonstration. *Journal of Agricultural Engineering Research,* 56(4), 321-328.

Pearson, P. Hadley and A. E. Wheldon (1993) A reanalysis of the effects of temperature and irradiance on time to flowering in chrysanthemum *(Dendranthema grandiflora)*, *Journal of Horticultural Science,* 68:1, 89-97.

Plomacher H. 1980. Experiments on growing chrysanthemum in the open in 1 919. Zie1pflarize1ib.au 20(7):347.

Poesch GH. 1931. Studies on photoperiodism of chrysanthemum. *Proceedings of the American Society for Horticultural Science.* 28**:**389p.

Post K. 1931. Reducing the day length of chrysanthemum for the production of early blooms by the use of black satin cloth. *Proceedings of the American Society for Horticultural Science.* 28:382-388.

Post K. 1932. Further results with black cloth for the production of early blooms of the chrysanthemum. *Proceedings of the American Society for Horticultural Science.* 29:545-547.

Przymeska J and Lisiecka A. 2001. Flowering of spray chrysanthemum cultivars (*Dendranthema grandiflora* Tzevelev) in year round cultivation depending on the date of planting. *Pntce-Z-Zakresu-Nauk-Ralniczyc*. 9l:163-174.

Renetka V and Kodytek K. 1992. The reponses of LTT mutant of *Dendranthema grandiflora* Tzvelev to lower level of light and temperature. *Zahradnictvi* 19(3):231-238.

Roberts RH and Struckmeyer BE. 1938. The effect of temperature and some other environmental factors upon the photoperiodic responses of some of higher plants. *Journal of Horticultural Science* 56:633.

Roxas, N. J., Tashiro, Y., Miyazaki, S., Isshiki, S., and Takeshita, A. 1995. Meiosis and pollen fertility in Higo chrysanthemum (*Dendranthema* × *grandiflorum* (Ramat.) Kitam.). *Journal of the Japanese Society for Horticultural Science* 64(1), 161-168.

S. R. Adams, V. M. Valdés and D. Fuller. 2009. The effects of day and night temperature on *Chrysanthemum morifolium*: investigating the safe limits for temperature integration, *The Journal of Horticultural Science and Biotechnology*, 84:6, 604-608.

Sangma P, Dhiman SR, Thakur P and Gupta YC. 2016. Effect of covering materials on off-season cut flower production in chrysanthemum (*Dendrathema grandiflora*). *Indian J Agric Sci*. *86*:522-526.

Schwabe WW. 1950. Factors controlling flowering in the chrysanthemum. I. The effects of photoperiod and temporary chilling. *Journal of ExperimentalBotany* 1:329.

Schwabe WW. 1951. Factors controlling flowering in chrysanthemum. II. Daylength effects and their experimental reversal and modification. *Journal of Experimental Botany* 2:233-237.

Schwabe WW. 1953. Effect of temperature, day length and light intensity in thecontrol of flowering in the chrysanthemum. *Proceedings of 13th International Horticultural Congress*. 952p.

Schwabe WW. 1959. Some effects of environments on reproductive morphogenesis in the chrysanthemum. *J. Linn. Soc.* (Bot.) 56:254.

Seeley JG and Weise AH. 1965. Photoperiodic response of garden and greenhouse chrysanthemums. *Proceedings of American Society for Horticultural Science.* 87:464-471.

Shibata M. 1997. Studies on responses to temperature and photoperiod and breeding of spray type chrysanthemums with summer to autumn flowering. *Bulletin of the National Research Institute of Vegetables. Ornamental plants and Tea series A: Vegetables and Ornamental plants.* 12:1-71.

Shin H, Kim J, Choi S and Woo S. 1999. Effect of temperature and light on axillary bud initiation in branchless chrysanthemum. *Journal of Korean Society for Horticultural Science.* 40(3):368-370.

Sita Ram and Sehgal OP. 1993a. Studies on year round flower production in pot chrysanthemum. I Effect of controlled photoperiod and growth retardant on vegetative growth. *Journal of Ornamental Horticulture.* 1(2):21-27.

Sita Ram and Sehgal OP. 1993b. Studies on year round flower production in pot chrysanthemum. II. Effect of controlled photoperiod and growth retardant on flowering. *Journal of Ornamental Horticulture.* 1(2):28-35.

Sita Ram. 1991. Studies on year round flower production in chrysanthemum. MSc. Thesis, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauru, Solan (H.P.), lndia.

Stack PA, Drummond FA and Stack LB. Chrysanthemum flowering in a blue light—supplemented long day maintained for biocontrol of thrips. *HortScience.* 1998 Jul 1;33(4):710-5.

Statens P. 1970. Long day treatment of carnations. *Gartner Tidende,* 86: 220-22.

Van der Hoeven, A.P. 1987. The influence of day length on flowering of carnation. *Acta Hortic*. 216:315-19.

Streck NA. 2004. A temperature response function for development of the chrysanthemum (*Chrysanthemum* x *morifolium* Ramat.). *Ciência Rural*. 34:49-54.

Sultanpuri, A., Dhiman, S. R., Gupta, Y. C., Kakar, R., Thakur, P., Kashyap, B., and Sharma, M. (2018). Effect of number of plants per pot, pot spacing and photoperiod on production of pot mum chrysanthemum. *Journal of Hill Agriculture* 9(2),149-152.

Talent M , Sukmar P and Jigmat R 1979. Supplementary lighting for carnations economic or not? *Gartenwelr*. 64:45-47.

Tangeras H. 1979. The effect of different shading (short day) materials on light and temperature at the plant level. *Meldinger fra Norges Landbrukshgskole.* 58(43):1-10.

Tanigawa T, Kobayashi Y and Matsui H. 1997. Effect of CO_2 enrichment and day temperature on growth, flowering and cut flower quality in *Dendranthema grandiflorum* (Ramat.) Kitamura. *Environmental Control of Biology.* 35(2):107-115.

Taweesak V, Lee Abdullah T, Hassan SA, Kamarulzaman NH and Wan Yusoff WA. 2014. Growth and flowering responses of cut chrysanthemum grown under restricted root volume to irrigation frequency. *The Scientific World Journal*. 26(4):156-67.

Turan A, Ucar Y and Kazaz S., 2015. Effects of different irrigation treatments on quality parameters of cut chrysanthemum. *Sci Pap Ser B Hortic*. 59:419-426.

Uddin AFMJ, Taufique T, Ona AF, Shahrin S and Mehraj H. 2015. Growth and flowering performance evaluation of thirty-two chrysanthemum cultivars. *Journal of Bioscience and Agriculture Research*. 4(1):40-51.

Usha. 2010. Screening of newly evolved selection of chrysanthemum for off season flower production. M.Sc. Thesis. Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni-Solan, H.P.

Van Ruiten JE and DeJong J. Speed of flower induction in *Chrysanthemum morifolium* depends on cultivar and temperature. *Scientia horticulturae*. 1984 Aug 1;23(3):287-94.

Velmurugan S and Vadivel E. 2003. Effect of photoperiod and paclobutrazol on year round flower production in chrysanthemum. *South Indian Horticulture.* 51(1/6):51-59.

Vince D. 1953. Delayed bloom of mid-season and late-flowering chrysanthemums. *Agriculturae London.* 60:68.

Vince D. 1955. Some effects of temperature and day length on flowering in the chrysanthemum. *Journal of Horticultural Science.* 30:34-42.

Votruba R. 1982. Premature budding in *Chrysanthemum morifolium* in relation to the age of the stock plants. *Acta Horticulturae.* 125:111-117.

Warup, A.1967. Chrysanthemum blooming dates: Influence of sucker appearance and cessation. *Journal of Horticultural Science*. 42(3): 217-224.

Watson DP and Andrews PS. 1953. The effect of light intensity on the flowering of chrysanthemum variety 'Gold Coast'. *Proceedings of American Society for Horticultural Science.* 61:551.

Whealy CA, Nell TA, Barrett JE and Larson RA. 1987. High temperature effects on growth and floral development of chrysanthemum. *Journal of American Society for Horticultural Science.* 112(3):464-468.

White HE. 1960. The effect of supplementary light on growth and flowering of carnations (*Dianthus caryophyllus*). *Proc. Amer. Soc. Hort. Sci*. 76:594-598.

Wilfret GJ and Harbaugh BK. 1979. Mini pot garden chrysanthemum cultivar characteristics and consumer preferences. *Proceedings of the Florida State Horticulture Society.* 92:317-319.

Wilfret GJ. 1985. Evaluation of chrysanthemum cultivars grown as centre disbudded plants in containers. *Proceedings of the Florida State Horticulture Society.* 98:124-127.

Wilkins HF, Healy WF and Grueber KL. 1990. Temperature regimes at various stages of production influences growth and flowering of *Dendranthema x grandiflorum. Journal of American Society for Horticultural Science.* 115(5):732-736.

Willits DH and Bailey DA. 1994. Night cooling as a mean of improving warm weather chrysanthemum production the effect of night temperature on growth and flower development in mums. *American Society for Agricultural Engineering.* 944070:12.

Yang N, Guo W, Chen F and Fang W. 2007. Effects of photoperiod on floral bud differentiation and flowering of *Chrysanthemum morifolium* Ramat. 'Jinba'. *Acta Horticulturae Sinica* 34(4):965-972.

Yonemura K, Ohishi K and Osuga M. 1981. Effect of planting time and long day treatment on the growth and flowering of spray carnations. Research Bulletin uf the Aichi-Ken Agriculrural Research Centre. 13:235-42.

Zhiyu M, Shimizu H, Moriizumi S, Miyata M, Douzono M and Tazawa S. 2007. Effect of light intensity, quality and photoperiod on stem elongation of chrysanthemum cv. 'Reagon'. *Japanese Society of Agricultural, Biological and Environmental Engineers and Scientists* 45(1):19-25.

APPENDIX I

Meteorological data on monthly basis for the period January 2022 to July 2022 and January 2023 to July 2023 of RHR&TS Dhaulakaun

Months	Temperature (°C)			Rainfall (mm)	RH (%)
	Maximum	Minimum	Mean		
January, 2022	15.8	11.0	13.49	71.0	85.9
February, 2022	21.2	13.0	14.16	87.0	72.9
March, 2022	30.4	20.8	16.61	0.0	59.5
April, 2022	37.6	19.0	22.39	0.0	46.3
May, 2022	36.2	21.0	25.34	37.3	62.0
June, 2022	37.0	23.7	17.51	267.4	59.0
July, 2022	31.7	22.3	16.94	452.0	83.4
January, 2023	16.51	7.50	13.61	2.37	98.42
February, 2023	24.19	10.03	13.54	0.13	98.43
March, 2023	26.61	13.59	17.16	3.03	98.39
April, 2023	32.55	16.22	20.00	1.13	79.13
May, 2023	35.15	20.27	24.68	3.06	70.52
June, 2023	36.30	24.12	17.73	7.02	84.60
July, 2023	33.37	25.17	17.68	1100.3	95.48

APPENDIX II

Analysis of Variance Table 2022

Source of Variation	Degree of Freedom	Mean Sum of Square			
		Plant height	Plant spread	Side Shoots	Chlorophyll
Factor A	**3**	47.386	10.811	1.429	0.005
Factor B	**7**	3,972.274	502.275	571.252	1.186
Interaction A X B	**21**	27.048	14.991	2.411	0.011
Error	**64**	10.880	5.861	0.673	0.024

Analysis of Variance Table 2022

Source of Variation	Degree of Freedom	Mean Sum of Square						
		Days to coloured flower bud	Days to Harvest	No of short days to colour bud	Flower Size	Flower weight	Number of flowers	Vase life/shelf life
Factor A	**5**	1173.311	1358.897	1180.077	23.859	170.427	3841.609	24.295
Factor B	**3**	1453.930	1059.429	1466.916	.304	.952	49.210	2.942
Interaction A X B	**9**	3.758	6.972	3.905	.469	1.085	20.833	1.145
Error	**36**	.381	2.945	.396	.056	.359	1.146	.086

Analysis of Variance Table 2023

Source of Variation	Degree of Freedom	Mean Sum of Square			
		Plant height	Plant spread	Side Shoots	Chlorophyll
Factor A	**3**	9.415	9.099	2.390	0.005
Factor B	**7**	4,924.651	781.961	343.004	1.382
Interaction A X B	**21**	8.287	7.127	1.207	0.007
Error	**64**	3.551	2.502	1.456	0.026

Analysis of Variance Table 2023

Source of Variation	Degree of Freedom	Mean Sum of Square						
		Days to coloured flower bud	Days to Harvest	No of short days to colour bud	Flower Size	Flower weight	Number of flowers	Vase life/shelf life
Factor A	5	1194.612	1165.228	1212.873	25.907	140.647	3732.952	18.577
Factor B	3	1528.358	1178.290	1651.501	.083	.247	58.200	.296
Interaction A X B	9	5.618	49.495	3.645	.183	.088	28.802	0.56
Error	36	3.361	27.238	.842	.043	.419	2.910	0.87

Analysis of Variance Table pooled

Source of Variation	Degree of Freedom	Mean Sum of Square			
		Plant height	Plant spread	Side Shoots	Chlorophyll
Factor A	3	19.858	1.532	1.250	0.000
Factor B	7	4,362.932	629.616	443.521	1.276
Interaction A X B	21	8.845	6.282	0.743	0.004
Error	64	4.013	2.088	0.628	0.011

Analysis of Variance Table pooled

Source of Variation	Degree of Freedom	Mean Sum of Square						
		Days to coloured flower bud	Days to Harvest	No of short days to colour bud	Flower Size	Flower weight	Number of flowers	Vase life/shelf life
Factor A	5	1183.508	1251.583	1195.809	26.429	155.059	3155.735	23.740
Factor B	3	1488.916	1115.604	1557.185	.087	.504	317.746	.325
Interaction A X B	9	4.323	17.754	3.705	.100	.371	237.094	.103
Error	36	1.129	7.885	.472	.028	.215	1.124	.048

APPENDIX III

1. Cost of cultivation of different chrysanthemum cultivars for off season flower production under low Hills of HP on an area of 200m² Covered with HDPE

Sr. No.	Particulars/Items	Quantity required	Cost/unit (Rs)	Total cost (Rs)
A.	**Fixed cost**			
1.	Rental value of poly house	200m²for6 months	Rs 5000/100m²/year	5,000.0
2.	Farm Yard Manure	750 kg	1.5/kg	1125.0
3.	Urea	9.75 kg	Rs380/50kg	74.1
4.	Single Super Phosphate	28.1 kg	Rs556/50kg	312.0
5.	Muriate of Potash	7.5 kg	Rs780/50kg	147.00
	Plant protection materials			
	i.Spike	50 g(Twice)	Rs200/100g	200
	ii.Bavistan/(SAAF)	250g	Rs 190/250g	190
6.	**Staking material**			
	Bamboo sticks	-	-	500.0
	Cladding materials (HDPE) Considering total life span of 10 years	974m²	Rs75/m²	3652.0
	Total			**11,199**
B.	**Variable cost**			
Sr.No	**Particulars**	**Quantity required**	**Cost/unit(Rs)**	**Total cost(Rs)**
1.	**Planting material**			
	Cultivars	2040	Rs2.5/cutting	5,100.00
2.	**Labour cost**			
	i.Land preparation (Ploughing through power tiller)	1 hour	200/hour	200.00
	ii. Layout, preparation of beds, incorporation of FYM, Basal application of fertilizers, planting, irrigation and staking	2man-days	420/man-day	840.0
	iii. Labour cost for irrigation, pinching, weeding, hoeing, disbudding and deshooting			
		10 man-days	420/man-day	4200.0
	Total			**10,340**
C.	**Transportation cost (400 cut stems/box)**	**Number of boxes**	**Cost/box(Rs)**	**Totalcost**
	White Star	17 box	300/box	5100.0
	Yellow Star	18 box	300/box	54,00.00
	Purnima	12 box	300/box	3600.0
	Surf	6 gunny bags	300/bag	1800.0

	Apricot Parasol	5 gunny bags	300/bag	1500.0
	Wellspring White	3 gunny bags	300/bag	900.0
D.	**Cost of box**	**No of boxes**	**Rate/box(Rs)**	**Total cost(Rs)**
	White Star	17	80/box	1360.0
	Yellow Star	18	80/box	1440.0
	Purnima	12	80/box	960.0
	Surf	6 gunny bags	30/bag	180.0
	Apricot Parasol	5 gunny bags	30/bag	150.0
	Wellspring White	3 gunny bags	30/bag	90.0
	Total cost of boxes/bags and transportation			
	White Star	5100.0	1360.0	6460.0
	Yellow Star	54,00.00	1440.0	6840.0
	Purnima	3600.0	960.0	4560.0
	Surf	1800.0	180.0	1980.0
	Apricot Parasol	1500.0	150.0	1650.0
	Wellspring White	900.0	90.0	990.0
E	**Total cost of expenditure(A+B)**			
		Fixed cost and Variable cost	**Transportation cost and cost of boxes/bags**	**Total cost (Rs)**
	White Star	21539	6460.0	27999.0
	Yellow Star	21539	6840.0	28379.0
	Purnima	21539	4560.0	26099.0
	Surf	21539	1980.0	23519.0
	Apricot Parasol	21539	1650.0	23189.0
	Wellspring White	21539	990.0	22529.0
F	**Gross returns**			
	Cultivars	**Cut flower yield (Number of cut stems)**	**Cost/cut stem (Rs)**	**Gross returns (Rs)**
	White Star	6824	Rs12/cut stem	81888.0
	Yellow Star	7290	Rs12/cut stem	87480.0
	Purnima	4941	Rs12/cut stem	59292.0
	Surf	284kg	Rs250/kg	71000.0
	Apricot Parasol	246kg	Rs250/kg	61500.0
	Wellspring White	215kg	Rs250/kg	53750.0
G.	**Net return**			
	White Star	81888.0	27999.0	81888-27999=53889
	Yellow Star	87480.0	28379.0	87480-28379=59101
	Purnima	59292.0	26099.0	59292-26099=33193
	Surf	71000.0	23519.0	71000-23519=47481
	Apricot Parasol	61500.0	23189.0	61500-23189=38311
	Wellspring White	53750.0	22529.0	53750-22529=31221

	Benefit cost ratio (Cost of Cultivation Gross returns/Total cost) for HDPE			
CV	**Cost of Cultivation**	**Gross Return**	**Net Return**	**B:C Ratio**
White Star	27999.0	Rs 81888.0	Rs 53889.0	1.92
Yellow Star	28379.0	Rs 87480.0	Rs 59101.0	2.08
Purnima	26099.0	Rs 59292.0	Rs 33193.0	1.27
Surf	23519.0	Rs 42600.0	Rs 47481.0	2.01
Apricot Parasol	23189.0	Rs 36900.0	Rs 38311.0	1.65
Well Spring White	22529.0	Rs 32250.0	Rs 31221.0	1.38

2. Cost of cultivation of different chrysanthemum cultivars for off season flower production under low Hills of HP on an area of 200 m^2 Covered with Tarpulin

Sr.No	Particulars/Items	Quantity required	Cost/unit (Rs)	Total cost (Rs)
A.	**Fixed cost**			
1.	Rental value of poly house	200m^2for6 months	Rs 5000/100m^2/year	5,000.0
2.	Farm Yard Manure	750 kg	1.5/kg	1125.0
3.	Urea	9.75 kg	Rs380/50kg	74.1
4.	Single Super Phosphate	28.1 kg	Rs556/50kg	312.0
5.	Muriate of Potash	7.5 kg	Rs780/50kg	147.00
	Plant protection materials			
	i.Spike	50 g(Twice)	Rs200/100g	200
	ii.Bavistan/(SAAF)	250g	Rs 190/250g	190
6.	**Staking material**			
	Bamboo sticks	-	-	500.0
	Cladding materials (Tarpaulin) Considering total life span of 10 years	974m^2	Rs100/m^2	4850.0
	Total			**12398**
B.	**Variable cost**			
Sr.No	**Particulars**	**Quantity required**	**Cost/unit(Rs)**	**Total cost(Rs)**
1.	**Planting material**			
	Cultivars	2040	Rs2.5/cutting	5,100.00
2.	**Labour cost**			
	i.Land preparation (Ploughing through power tiller)	1 hour	200/hour	200.00
	ii. Layout, preparation of beds, incorporation of FYM, Basal application of fertilizers, planting, irrigation and staking	2 man-days	420/man-day	840.0

	iii. Labour cost for irrigation, pinching, weeding, hoeing, disbudding and de shooting			
		10 man-days	420/man-day	4200.0
	Total			**10,340**
C.	**Transportation cost (400cutstems/box)50kg gunny bag**	**Number of boxes**	**Cost/box(Rs)**	**Total cost**
	White Star	13 box	300/box	3900
	Yellow Star	15 box	300/box	4500
	Purnima	11 box	300/box	3300
	Surf	4 gunny bags	300/bag	1200
	Apricot Parasol	3 gunny bags	300/bag	900
	Wellspring White	3 gunny bags	300/bag	900
D.	**Cost of box**	**No of boxes**	**Rate/box(Rs)**	**Total cost(Rs)**
	White Star	13 box	80/box	1040
	Yellow Star	15 box	80/box	1200
	Purnima	11 box	80/box	880
	Surf	4 gunny bags	30/bag	120
	Apricot Parasol	3 gunny bags	30/bag	90
	Wellspring White	3 gunny bags	30/bag	90
	Total cost of boxes/bags and transportation			
	White Star	3900	1040	4940
	Yellow Star	4500	1200	5700
	Purnima	3300	880	4180
	Surf	1200	120	1320
	Apricot Parasol	900	90	990
	Wellspring White	900	90	990
E.	**Total cost of expenditure(A+B)**			
		Fixed cost and Variable cost	**Transportation cost and cost of boxes/bags**	**Total cost (Rs)**
	White Star	22738	4940	27678
	Yellow Star	22738	5700	28438
	Purnima	22738	4180	26918
	Surf	22738	1320	24058
	Apricot Parasol	22738	990	23728
	Wellspring White	22738	990	23728
F.	**Gross returns**			
	Cultivars	**Cut flower yield (Number of cut stems)**	**Cost/cut stem (Rs)**	**Gross returns (Rs)**
	White Star	5204	Rs12/cut stem	62448.0
	Yellow Star	6277	Rs12/cut stem	75324.0
	Purnima	4232	Rs12/cut stem	50784.0
	Surf	187kg	Rs250/kg	46750.0
	Apricot Parasol	172kg	Rs250/kg	43000.0
	Wellspring White	165kg	Rs250/kg	41250.0

G.	Net return			
	White Star	62448.0	27678	34770
	Yellow Star	75324.0	28438	46886
	Purnima	50784.0	26918	23866
	Surf	46750.0	24058	22692
	Apricot Parasol	43000.0	23728	19272
	Wellspring White	41250.0	23728	17522

Benefit cost ratio(Cost of Cultivation Gross returns/Total cost) for Tarpaulin

CV	Cost of Cultivation	Gross Return	Net Return	B:C Ratio
White Star	27678	62448.0	34770	1.25
Yellow Star	28438	75324.0	46886	1.64
Purnima	26918	50784.0	23866	0.88
Surf	24058	28050.0	22692	0.94
Apricot Parasol	23728	25800.0	19272	0.81
Wellspring White	23728	24750.0	17522	0.73

Department of Floriculture and Landscape Architecture
Dr. Yashwant Singh Parmar University of Horticulture & Forestry
(Nauni) Solan (HP)-173 230 India

Title of the thesis	**:**	**"Effect of covering materials on off season flower production of chrysanthemum (*Dendranthema* x *grandiflora* Tzevelev.) cultivars under low hills of HP"**
Name of the student	**:**	**Mr. Ali Haidar Shah**
Admission number	**:**	H-2020-11-D
Major Discipline	**:**	Floriculture and Landscape Architecture
Minor Discipline	**:**	Soil science and water management & Plant Physiology
Date of Thesis submission	**:**	
No. of pages in thesis	**:**	80+viii
Major Advisor	**:**	**Dr. Priyanka Thak**ur

ABSTRACT

"Effect of covering materials on off season flower production of chrysanthemum (*Dendranthema* x *grandiflora* Tzevelev.) cultivars under low hills of HP" were carried out at the experimental farm of the RHR&TS Dhaulakuan, Sirmour under Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during 2022 and 2023 under naturally ventilated poly tunnels. The experiment was carried out using three types of covering materials (viz. tarpaulin, HDPE* and black satin cloth) and four cultivars each of standard and spray varieties. Findings revealed that HDPE* was the best alternative covering material to tarpaulin as optimum plant height (56.47 cm), plant spread (37.34 cm), maximum number of cut stems (3.14), and earliest coloured flower bud was recorded. Flowering was earlier under HDPE photoperiod than black satin cloth. Flower harvest was earliest (122.72 days) in plants under HDPE* cover as compared to plants under Black satin cloth conditions which took maximum number of days (131.63 days) to reach flowering. The varieties were categorized to different response group under controlled photoperiodic conditions with HDPE*. Out of eight varieties, only six varieties ('Yellow Star', 'White Star', 'Purnima' and 'Surf', 'Apricot Parasol', 'Well Spring White') were found suitable for off- season flower production for low hills of HP.

*HDPE-High Density Polyethylene

Signature of Student	**Signature of Major Advisor**
Name	**Name**
Date	**Date**

Head of Department

BRIEF BIO-DATA

Name	**:**	Ali Haidar Shah
Father's Name	**:**	Sh. Khadim Hussain Shah
Mother's Name	**:**	Smt. Shamim Akhter
Date of Birth	**:**	01.11.1995
Parmanent Address	**:**	R/O Shergargi, Tehsil Chassana, District Reasi (J&K)

Academic Qualifications **:**

Examination Passed	**Year of Passing**	**University/Board**	**Marks (%)**	**Division**
10th	2/2011	JKBOSE	71.9	Ist
10 +2	2/2013	JKBOSE	71.6	Ist
B.Sc. (Hons)Agriculture	8/2018	SKUAST Jammu	68.9	Ist
Msc Floriculture and Landscaping	10/2020	SKUAST Jammu	74.0	Ist

Title of Thesis in M Sc: "Effect of mycorrhiza on growth and flowering of chrysanthemum (*Chrysanthemum coronarium* L.) in soil supplemented with vermicompost"

Fellowship Scholarship/Gold Medal/Awards/ Any other Distinction received	No
Publications:	5
Research	4
Scientific Popular Articles:	2
Others: Newspaper articles	11
Visit abroad alongwith duration and purpose of visit:	Nil

(Ali Haidar Shah)