EVALUATION OF *Bellis perennis* L. CULTIVARS UNDER DIFFERENT ALTITUDINAL GRADIENTS IN HIMACHAL PRADESH

Thesis

by

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(H-2019-24-M)

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CERTIFICATE – I

This is to certify that the thesis titled **"Evaluation of *Bellis perennis* L. cultivars under different altitudinal gradients in Himachal Pradesh"**, submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE) 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 Vikrant Singh Parmar (H-2019-24-M)** son of Shri Satish Kumar 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 have been fully acknowledged.

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CERTIFICATE – II

This is to certify that the thesis titled, **"Evaluation of *Bellis perennis* L. cultivars under different altitudinal gradients in Himachal Pradesh"**, submitted by **Mr Vikrant Singh Parmar (H-2019-24-M)** son of Shri Satish Kumar to Dr Yashwant Singh Parmar University of Horticulture & Forestry, (Nauni) Solan (HP) – 173 230, India in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE) 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.

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ABBREVIATIONS USED

%	:	Per cent
@	:	At the rate of
^{o}E	:	Degree East
^{o}N	:	Degree North
amsl	:	Above mean sea level
ANOVA	:	Analysis of variance
CD	:	Critical difference
cm	:	Centimeter
cm^2	:	Centimeter square
cv.	:	Cultivar
DAT	:	Days after transplanting
DF	:	Degree of freedom
et al.	:	Co-workers
F- cal	:	F- calculated
FYM	:	Farm Yard Manure
g	:	Gram
ha	:	Hectare
HP	:	Himachal Pradesh
i.e.	:	*id est* (that is to say)
ISTA	:	International Seed Testing Association
K	:	Potassium
kg	:	Kilogram
kg/ha	:	Kilogram per hectare
m	:	Meter
m^2	:	Meter square
mg	:	Milligram
mm	:	Millimeter
N	:	Nitrogen
NH	:	National highway
NS	:	Non-significant
^{o}C	:	Degree Celsius
P	:	Phosphorus
q	:	Quintal

q/ha	:	Quintal per hectare
RBD	:	Randomized Block Design
RH	:	Relative humidity
viz.	:	*videlicet* (namely)
w.e.f.	:	With effect from
w.r.t.	:	With respect to

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Chapter-1

INTRODUCTION

Bellis perennis L. commonly known as English daisy or Common daisy or Woundwort is a hardy or half hardy, low growing and clump forming annual to evergreen perennial which thrives very well in areas which remain wet for the most part of year (Misra and Misra, 2017). The generic name *Bellis* has been derived from a Latin word *bellus* meaning 'pretty'. It is a genus of 15 species of perennials from Europe and Mediterranean. *Bellis perennis* L. is a winter season herbaceous plant and belongs to the family Asteraceae. Common daisy is an excellent ornamental plant (Jin-Bo *et al.*, 1995). It is commonly used for carpet bedding, edging borders and in pots for winter flowering. In addition to its use as ornamental plant *Bellis perennis* also possesses various medicinal properties like antifungal, antibacterial and antioxidant characteristics (Desevedavy *et al.*, 1989). It is used for bruises, bleeding, muscular pain, purulent skin diseases, and rheumatism in traditional medicine (Morikawa *et al.*, 2011).

English daisy is a dwarf plant, 20-30 cm in height. The leaves are strap-shaped, tapering towards the tip and form into tuft at the base. The flowers are 2.5 to 5.0 cm across and the flower stalk is about 15 cm long. The flowers are single or double and the petals may be flat or quilled. The daisy is useful for bedding, edging, rock gardens, and for covering open spaces in beds of bulbs. It is suitable as pot plant and cut flowers also look delightful in low bowls. Plants raised from seeds are said to be better as they bear more flowers than those raised from clumps. Seeds are sown in September-October for flowering in the following February-March. The seedlings are transplanted at 4-6 leaf stage, when the plants are about 5 cm tall. They may be grown in situation sheltered from the afternoon sun (Randhawa and Mukhopadhyay, 1986).

Plants have the ability to alter their morphological and physiological traits in response to environmental variations and adjust the expression of these traits to accommodate their adaptability across multiple environments. The growth and establishment of plants can be influenced potentially by various climatic and environmental factors which are light regime, air temperature, water availability, wind, soil characteristics, altitude, aspect and slope. Out of these, the altitude or elevation is an important factor which affects the growth and

development of seedlings of plant as it affects micro and macro climate of the location. Elevation gradients influence plant performance both directly by affecting patterns of plant growth, physiology, morphology, metabolism, reproduction, and even interactions with animals and indirectly by modifying the length of growing season (Pato and Obeso, 2012). Elevation gradients are useful for examining plant responses to environmental changes, because a broad range of environmental factors changes with the elevation of the natural growing site. These factors include precipitation, mean temperature, daily thermal amplitudes, soil fecundity, wind speed, temperature extremes, atmospheric pressure, duration of snow-cover, length of the vegetation period, radiation intensities and soil types etc. which varies with altitudinal gradients and locations.

Himachal Pradesh has been endowed with a variety of agro-climatic conditions, which makes it possible to grow a large number of flower crops with excellent quality throughout the year in one or other part of the state. The climate in the state ranges from sub-tropical to wet and dry temperate. The state has wonderful climatic conditions that support growth and cultivation of ornamental plants. The different agro-climatic conditions prevailing in the state make it possible to grow a plethora of flowers ranging from annuals to biennials, perennials and bulbous plants. The favourable environmental conditions of low and mid hills are ideally suited for annual flower and seed production. These variations can be utilized for the production of quality seeds of different flower crops on commercial scale.

The present investigation was carried out under various locations in Himachal Pradesh with the aim to assess the impact of different elevations on plant growth, flowering and seed yield of English daisy. The healthy, disease free and stocky seedlings of uniform size of various cultivars of English daisy/common daisy were transplanted under different agro ecological situations in the state of Himachal Pradesh for experimentation.

The present study was carried out with the following objective:

- To assess the plant growth, flowering, seed yield and seed quality of Common daisy varieties under different elevations in Himachal Pradesh.

Chapter-2

REVIEW OF LITERATURE

English daisy or common daisy (*Bellis perennis* L.) is an important bedding plant extensively used in landscaping for carpet bedding. The available literature on different cultivation aspects of English daisy crop is scanty. Yet an effort is being made to review the available literature on the crop and other similar crops.

Bailey (1998) examined 152 pansy, 31 viola and two English daisy (*Bellis perennis* L.) lines in total. Selections such as the viola series Sorbet Blue, Alpine Summer, and Penny Blue) that gave consistent, dependable full-season performance despite the severely rainy winter were listed.

Vrsek *et al.* (2000) investigated the potential for biennial flowering plants to produce seeds in the climatic conditions of northwestern Croatia. Due to unfavourable weather circumstances, the start of blooming was delayed and the process of seed development was delayed, according to phenological observations. The seed yields of *Campanula medium, Bellis perennis, Dianthus barbatus,* and *Viola wittrockiana* were satisfactory, but *Dianthus caryophyllus* and *Cheiranthus cheiri* were found to be below average. Germination percentages varied from 65 percent in *V. wittrockiana* to 92 percent in *D. caryophyllus*.

Dierig *et al.* (2005) studied the effects of temperature and elevation on the plant growth, development and seed production of *Lesqurella fendleri* and *L. pallida*. Their objective was to determine field sites suitable for crop production. The experiment was conducted in the fall of 2003 at various sites in Arizona that ranged in elevation from 300 to 1200 m amsl and the temperature ranged from -13.2 to 38.8°C. They concluded that plants of *L.pallida* were more productive at an elevation of 1219 m amsl and *L. fendleri* was suitable for production in areas below 700 m amsl.

An experiment was conducted by Mahawer *et al.* (2010) to evaluate Dahlia cultivars under Aravalli hill conditions of Udaipur. Nine cultivars were evaluated in randomized block design with three replications and twelve plants per replication. Results of the experiment showed cultivar ‘Jyotsna’ took minimum number of days for flower bud initiation (81.60 DAT) and bud break (22.40 DAI) while minimum number of days for complete flower

opening were recorded in cultivar 'Korean Yellow'. Maximum flowering duration (90.73 days), number of flowers per plant (60.40) and freshness of flower (7.73 days) were recorded in cultivar 'NT Pompon'. Maximum flower diameter (19.66 cm) and average weight of flower (62.69 g) were recorded in cultivars 'Korean Yellow' and 'Blackout', respectively. From the results of experiment cultivar 'NT Pompon' was found to be the best under Udaipur conditions.

Narsude *et al.* (2010) conducted studies on growth and yield attributes of different African marigold (*Tagetes erecta* L.) genotypes under Marathwada condition. For various growth and yield parameters, the genotypes under investigation exhibited considerable differences. When compared to other genotypes, cv. 'Pakharsangavi Local' had the highest maximum plant height (114.64 cm), while cv. 'African Giant Double Mixed' had the lowest (87.98 cm). The genotype 'Tuljapur Local-2' had the largest plant spread (64.48 cm), while the genotype Marigold Orange Bunch had the smallest (51.98 cm). In genotype 'Pakharsangavi Local', the largest stem girth (5.37 cm) was found, whereas cv. 'Marigold Orange Bunch' had the smallest stem girth (4.00 cm). The genotype 'Tuljapur Local-1' had the most branches (21.46), whereas the genotype 'Latur Local' had the fewest (14.26). The genotype 'Tuljapur Local – 1' produced the highest number of flowers (71.00), yield per plant (630.48 g), and yield per hectare (24.67 MT/ha), with 'Pakharsangavi Local' and 'Tuljapur Local' genotypes coming in second and third, respectively. The genotype 'Marigold Orange Bunch' took the most days (109.67) to reach the last picking point, and the flowering period was likewise longer (56.33 days), whereas the genotype 'Mulegaon Local' had a shorter blooming period (42.00 days). In genotype 'Tuljapur Local – 2', the minimum days (97.33) were necessary for last picking.

A study was conducted by Raghuvanshi and Sharma (2011) on varietal evaluation of French marigold (*Tagetes patula* Linn.*)* under mid-hill zone of Himachal Pradesh. The study of various traits showed highly significant results among different cultivars. Maximum plant height (35.80 cm), seed yield per plant (0.54 g) and seed yield per square meter (9.06 g) was recorded in cultivar 'Safari Queen'. Flower diameter (5.26 cm) and 1000 seed weight (2.60 g) was observed maximum in cultivar 'Bonzana bolero'. 'Safari tangerine' cultivar showed maximum duration of flowering (39.67 days).

Pandey *et al.* (2012) conducted evaluation of gladiolus cultivars under subtropical conditions of Jammu. Fifty six cultivars were evaluated out of which thirty two were exotic

and twenty four were Indian. The study was conducted at Jammu. The results of the study showed that four cultivars namely 'White Prosperity', 'Eurovision', 'Jyotsna' and 'American Beauty' were found to be superior than others for various vegetative and flowering characteristics. Plant height (133 cm), number of leaves per plant (10) and number of florets per spike (19) was maximum in 'Eurovision' while, maximum floret diameter was found maximum in cultivar 'White Prosperity'.

Zosiamliana *et al.* (2012) studied growth, flowering and yield characteristics of seven cultivars of China aster (*Callistephus chinensis* Ness.) at Agricultual Research Institute, Hyderabad to identify suitable China aster cultivars for open conditions of Hyderabad. The results of the study showed highly significant variation for different growth, floral, and flower yield parameters among the cultivars. It was observed that variety Phule Ganesh Violet produced maximum plant height, number of primary and secondary branches, plant spread and number of leaves. For flowering characters, cv. 'Phule Ganesh Pink' took minimum number of days for first flower bud initiation (57.20), first flowering (66.73), 50 % flowering (85.67), and flowering duration (60.96). Cultivar 'Phule Ganesh White' showed maximum flower diameter (7.37 cm), stalk length (34.78 cm) and vase life both as cut (9.13 days) and loose (4.73 days) flower. Cultivar 'Phule Ganesh White' also produced maximum number of flower per plant (36.73) and yield both per plant (208.81 g) and per hectare (23.20 t / ha). From the results of the study cv. 'Phule Ganesh White' variety is recommended for commercial cultivation under Hyderabad Conditions.

A study on the growth and yield parameters of different genotypes of China aster (*Callistephus chinensis* Nees.) was conducted by Munikrishnappa *et al.* (2013) under transitional tract of northern Karnataka. Investigation was done during Rabi season at University of Agricultural Sciences, Dharwad. Results of the study showed that variety 'Phule Ganesh Violet' recorded the highest plant height, plant spread and number of primary branches at different stages of plant growth. Variety 'Violet Cushion' recorded the least plant height, plant spread. Variety 'Phule Ganesh Purple' was found superior for secondary branches per plant. Flower yield (37.91 t / ha) was recorded maximum in variety 'Phule Ganesh White' and minimum was recorded in variety 'Mixed Variety Local' (9.97 t/ ha). Number of cut flowers per plant was highest (55.43) in variety 'Phule Ganesh Violet' and the lowest number of cut flower per plant was produced in var. 'Shashank' (40.92).

Khanal (2014) studied the effect of growing conditions of Marigold in Ilam District of Nepal. Plant growth and flowering characteristics was observed in different conditions viz., plastic house, shade house and open field. Different growing conditions exhibited variation in temperature and sunlight intensity which influenced flower growth and quality of marigold. They concluded that the polyhouse conditions were better for plant growth characteristics followed by flowering behaviour.

Kumar (2014) conducted an experiment to evaluate seven genotypes of Chrysanthemum under open growing conditions for flowering traits. The experiment was laid out in Randomized Block Design with three replications at IIHR, Bengaluru from 2010-11 to 2012-13. Significant variation was observed in flowering traits. Results of the experiment showed that genotype 'Anmol' registered maximum number of flowers/plant (81.51) and flowering duration (43.14 days) while, genotype 'Garden Beauty' registered maximum plant height (47.25 cm) and flower diameter (5.03 cm). Maximum average weight of flower (2.59 g) and flower yield/plant (131.43 g) was recorded in genotype 'Autumn Joy'. Genotype 'Winter Queen' had maximum number of sprays per plant (6.89). From the observed results of the experiment, genotypes 'Winter Queen', 'Garden Beauty' and 'Autumn Joy' were found best for garden display.

Kumar *et al.* (2014) conducted an experiment to evaluate genotypes of gerbera for cut flower production under different growing conditions of Kashmir. Twenty six varieties were evaluated for cut flower production under polyhouse and field conditions. The results obtained showed that variety 'Dune' was best for polyhouse and 'Dana Ellen' for open field conditions.

Sarkar *et al.* (2014) conducted a study to evaluate gladiolus cultivars with respect to flowering attributes in Darjeeling hills of west Bengal. Thirty cultivars were evaluated. Cultivar 'Jester' produced largest floret size (14.42 cm) while, highest spike length (125.36cm), highest number of florets per spike (19.92) was observed in variety 'Candiman'. Maximum duration of flowering (22.29 days) was observed in cultivar 'White Prosperity and highest vase life was observed in variety 'American Beauty'. The study showed that cultivars 'Jester', 'Candiman', 'White Prosperity' and 'American Beauty' gave best results and therefore, can be recommended for commercial cultivation in North- Eastern hilly region.

Yadav *et al.* (2014) investigated the flowering characteristics of 11 chrysanthemum genotypes for loose flower production and discovered that the genotype ‘Jayanti' had the most number of flowers per branch, followed by ‘Gauri'. The cultivars ‘Pompon Rosy Pink,' ‘Decorative White,' ‘Anemone Silver,' and ‘Flirt' had minimum number of flowers per branch.

Chourasia *et al.* (2015) conducted an experiment to evaluate ten different cultivars for growth, flowering, spike yield, and corm yield under Saurashtra region of Gujarat with the aim of finding most suitable variety for cultivation. The experiment was laid out in Randomized Block Design with three replications. Significant differences were recorded for different characters among varieties. Variety ‘Poppy Tear’ showed maximum plant height (122.87cm). Maximum number of leaves (11.57) and maximum days to sprouting of corm (26.73) were recorded in varieties ‘American Beauty’ and ‘White Prosperity’, respectively. From the resuts of the experiment it was concluded that variety ‘Candiman’ was most suitable for cultivation under Saurashtra region of Gujarat as maximum spike diameter (1.230 cm), floret neck diameter (1.97 cm), diameter of floret (15.50 cm), longest duration of flowering (24.00 days), number of spikes per plant (1.87) and number of florets per spike (23.73) were recorded in it.

Gupta *et al.* (2015) conducted an experiment for varietal evaluation of different hybrids of Dahlia (*Dahlia variabilis* L.) under Allahabad agro- climatic conditions. Hybrids ‘Santasy Ma’, ‘S.P. Kamala’, ‘Kenya Blue’, ‘S.P. Glory of India’, ‘Kenya white’, ‘Nandini’, ‘S.P. Sri Radha’, ‘Mangal Pandey’, and ‘Eternity Sport’ were evaluated on the basis of different growth yield and tuber parameters. The experiment was laid out in simple randomized block design with three replications and nine treatments. The results showed that maximum plant height (59.27 cm) was recorded in hybrid ‘Nandini’. Maximum number of leaves per plant (29.46) was observed in hybrid ‘Kenya blue’. Maximum plant spread (53.52 cm) was recorded in hybrid ‘Eternity Sports’. Maximum number of primary branches per plant (7.87) was found with hybrid ‘S.P. Glory India’. Minimum days taken for first bud appearance (38 days) were observed in hybrid ‘Mangal Pandey’. Maximum diameter of fully opened flower (24.5 cm) was found in hybrid ‘Kenya Blue’. Maximum weight of single flower (107.74 g) was found in hybrid ‘Kenya White’. Maximum flower duration (14.06 days) was found in hybrid ‘Eternity sport’. Maximum number of flowers per plant (9.06) was found in hybrid ‘S.P. Glory of India’. Maximum flower yield per plant (881.42 g) was found

in hybrid ‘Kenya white’. Maximum weight of single tuber (150.8 g) was found in hybrid ‘Nandini’. Maximum numbers of tuber per plant (9.6) was found in hybrid ‘Eternity Sport’. Maximum yield of tuber per plant (276.93 g) were found in hybrid ‘S.P. Sri Radha’.

Kumar *et al*. (2015) evaluated chrysanthemum cultivars appropriate for loose flower production in the Chhattisgarh plains. Cultivar ‘Decorative White’ was found to be better for vegetative growth characteristics, with maximum plant height (60.9 cm), plant spread (40 cm), and number of branches per plant (16). Treatments showed significant differences in terms of flowering characteristics. Variety ‘Sunil' produced flowers with a maximum diameter of 7.60 cm and floret size of 2.1 cm. The variety ‘Decorative White' had the most flowers per plant (42) and was in excellent shape. The cultivar ‘Jayanti' produced the highest yield (18.90 kg) and the most flowers per branch (8).

Negi *et al.* (2015) conducted an experiment to evaluate chrysanthemum cultivars suitable for low hill conditions of Himachal Pradesh. Twelve cultivars were evaluated out of which five were standard types namely ‘Fiji Yellow’, ‘Purnima’, ‘Tata Centuary’, ‘Thaichang Queen’, ‘White Star’ and remaining varieties were spray type namely ‘Ajay’, ‘Baggi’, ‘Discovery’, ‘Nanako’, ‘Punjab Anuradha’, ‘Surf’ and ‘White Bouquet’. Among the standard type cultivars, ‘Purnima’ took minimum number of days to bloom (129 days) while maximum days to bloom were taken by cv. ‘White Star’ (136.66 days). Maximum plant height and duration of flowering was observed in Cv. ‘Purnima’. Maximum flower diameter (10.66 cm) was also observed in cv. ‘Purnima’. Among the spray type cultivars evaluated, cv. ‘Baggi’ was found best in terms of time to bloom (125 days), plant height (75.66 cm) and flower diameter (5 cm). The results of the experiment showed that the best suitable cultivars for cultivation under the low hill zone of Himachal Pradesh were cv. ‘Purnima’ among standard types and cv. ‘Baggi’ among spray types.

Chowdhuri *et al.* (2016) evaluated performance of different varieties of China aster (*Callistephus chinensis* L Ness) in Sub tropical belt of West Bengal. Evaluation was conducted at Mondari Farm of Bidhan Chandra Krishi Viswavidyalya. Varieties evaluated were ‘Kamini’, ‘Poornima’, ‘Shashank’, ‘Aadya’, ‘Archana’, ‘Phule Ganesh White’, ‘Phule Ganesh Violet’ and ‘Phule Ganesh Purple’. Among these evaluated varieties ‘Shashank’ is found to be the best for cut flower production and ‘Archana’ is found best for potted plant production in sub-tropical belt of West Bengal.

Dewan *et al.* (2016) conducted a study in 2015-2016 to evaluate Chrysanthemum genotypes under West Garo Hills District, Meghalaya. The experiment was laid out in Randomized Block Design with three replications and fifteen varieties of chrysanthemum were evaluated to identify suitable variety for successful cultivation and flower production. Uniform package of practices were followed throughout the experiment. The study showed that for vegetative and flowering characters cultivars 'Calabria', 'Yellow Star', 'AAU Yellow', 'Gambit' and 'Solan Shringar' showed significant results. Maximum plant height was recorded in cultivar 'Yellow Star' (49.65 cm). Minimum number of days to full bloom were recorded in cultivar 'Shayana' (72.29 days) followed by cultivar Calabria (82.44 days). While, maximum flower diameter (8.46 cm) and maximum flower longevity after full bloom was observed in cultivar Gambit (24.72 days). Maximum number of flower head per plant (42.34) was observed in cultivar Calabria.

Girange *et al.* (2016) conducted an experiment at the Horticulture Section, College of Agriculture, Nagpur, with the goal of evaluating several genotypes of gaillardia for growth, blooming, and yield parameters. The experiment was set up with seven genotypes ('Double Mix', 'NG 01', 'NG 02', 'NG 03', 'NG 04', 'NG 05', and 'NG 06') planted in three replications using Randomized Block Design. The experiment's findings revealed that the genotype 'NG 05' had the highest plant height (85.68 cm). Days to first flower bud initiation (55.49 days), days to flower opening (7.13 days), days to 50% flowering (65.19 days), and days to first flower harvesting (72.35 days) were all observed early in genotype 'NG 04' in terms of flowering parameters. The genotype 'NG 04', on the other hand, has a much longer flowering period (55.24 days).

Kireeti *et al.* (2017) conducted an evaluation experiment of different characters of twenty four varieties of chrysanthemum (*Dendranthema grandiflora* Tzevelev) during the year 2016-17 in humid coastal zone of Andhra Pradesh with an aim to identify suitable varieties. The results showed that var. 'Pusa Centenary' had the largest flower diameter (7.84 cm), the earliest flowering (63.01 days), and the highest flower production (189.50 g/plant), followed by 'Neelima' (188.67 g/plant), and 'Gulmohar' (179.10 g/plant). Though varieties 'Yellow Gold,' 'Haldi Ghati,' and 'White Prolific' yielded less than 'Pusa Centenary' (1293.41 g/plot, 1015.85 g/plot, and 1480.52 g/plot, respectively), they were deemed to be suited for this region because of their bloom colour and appearance.

Manjula *et al.* (2017) conducted a trial for evaluation of twenty five Dahlia genotypes for growth, yield and quality traits under Hill Zone of Karnataka. Significant differences were found for all growth, flowering, yield and quality parameters. Genotype 'Joyal Singh' showed minimum number of days to first flowering (52.92 days), 50% flowering (69.80 days), complete flowering (87.80 days) and also longest duration of flowering (67.10 days). Genotype 'Sourav' showed maximum number of flowers per plant (44.00) and number of tubers per plant (10.75). For quality parameters, genotype 'Kamala' showed highest weight of flower (29.75 g), while 'Gagi' genotype showed maximum tuber weight and 'Pusa Sona' showed maximum flower diameter (17.16 cm). 'Chittaranjan' genotype showed maximum vase life (6.60 days).

A study on evaluation of varieties of Chrysanthemum (*Chrysanthemum morifolium* Ramat.) was conducted by Patil *et al.* (2017) under ecological conditions of sub- humid zone of Rajasthan for different flowering traits. The maximum characters investigated differed greatly, according to the experimental results. Maximum fresh flower weight (18.14 g), flower diameter (11.92 cm), and longest stalk length were discovered to be superior in the variety 'White Star' (28.52 cm). 'Thai Chen Queen' has the longest vase life (18.00 days) and 'Pusa Chitraksha' has maximum number of flowers per plant (47.67).

Raghupati *et al.* (2017) conducted an experiment to study varietal evaluation of medium decorative Dahlia under subtropical plains of West Bengal. The experiment was carried out from November 2014 to April 2015 in well drained sandy loam soil having pH 6.5 and was laid out in randomized block design with three replications. 15 varieties were selected for evaluation under in open field conditions. The results of the experiment showed that cultivars 'Arab Queen' and 'Aditya' recorded maximum plant height (73.82, 72.0 cm). Variety 'Aditya' recorded maximum number of days for complete flowering while cultivar 'Arab Queen' showed maximum flower diameter. The results of the experiment showed that cultivar 'Dhoni' can be grown for early crop and for long duration crop variety 'Aditya' is suitable.

Sil *et al.* (2017) conducted a study to assess the growth and flowering of 11 Gerbera varieties in a polyhouse. There were substantial differences in growth, yield, and quality parameters among the cultivars evaluated. RBD was used to perform statistical analysis on the data (Randomized Block Design). Cultivar 'Balance' generated the most leaves (36.47),

cv. ‘Stanza’ had the highest plant height (55.52 cm), and cv. ‘Stanza’ had the longest leaf length (33.81 cm) in West Bengal's warm humid subtropical environment. Cultivar ‘Inferno’ produced the largest flowers, with an average diameter of 10.27 cm, among the varieties. The highest measurement of floral disc diameter was found in cv. ‘Jaffna’, at 2.41 cm. In cv. ‘Daneallean’, the shortest time to harvest maturity (17.61) was recorded. Cultivar ‘Preintense’ has the longest field life, according to observations (23.84 days). Cultivar ‘Stanza’ and ‘Rosalin’ produced the most blooms (13.88) while maintaining the highest yield and quality characteristics. Cultivar ‘Preintense’ produced the longest stalk (58.83 cm). ‘Rosalin’, with a vase life of 15.97 days, was the cultivar with the longest vase life. ‘Stanza’, ‘Rosalin’, ‘Preintense’, and ‘Inferno’ have been the best-performing cultivars in terms of total performance.

A study was conducted by Singh *et al.* (2017) to evaluate growth and flowering of ten varieties of gerbera *viz.* ‘Laura’, ‘Szantal’, ‘Delfin’, ‘Newada’, ‘Olympia’, ‘Koromoran’, ‘Partrizia’, ‘Rock’, ‘Feliks’ and ‘Samuraj’ under naturally ventilated polyhouse in Bhagalpur conditions of Bihar. They concluded that variety ‘Partriza’ gave the best performance exhibiting longest stalk length and more number of cut flowers per plant.

Byadwal *et al.* (2018) conducted an experiment during the months of March to September 2017 at College of Horticulture & Forestry, Jhalrapatan, Jhalawar (Agriculture University, Kota) to assess the performance of the twelve gaillardia genotypes. In the genotype ‘Genotype-3', the maximum plant height (81.03 cm) and leaf width (4.38 cm) were measured. The genotype ‘Genotype-2’ generated the greatest number of main branches per plant (18.87) fresh weight (1626.93 g) and dry weight (321.46 g) of plant was reported in ‘Genotype-2’ correspondingly. The genotype ‘Genotype-6' had the greatest plant spread (73.70 cm). In ‘Genotype-7', the greatest leaf length (11.67 cm) was observed. In ‘Genotype-11,' maximum flower diameter (6.29 cm), days to first flower opening (42.60 days), days to 50% flowering (64.93 days), number of flowers per plant (131.35), weight of flowers per plant (578.72 g), weight of flower per plot (45.89 kg), and the highest flower yield per hectare (395.26 q/ha) were recorded.

Mahantesh *et al.* (2018) assessed different African marigold genotypes for vegetative, floral and yield characters under southern Telangana conditions. The study was done at the College of Horticulture Mojerla to assess several African marigold (*Tagetes erecta* Linn.) genotypes for vegetative, floral, and yield characteristics on performance of 8 genotypes in

semi-arid climatic conditions in Hyderabad, Telangana.. For growth, flowering, and yield measures, all of the genotypes exhibited substantial differences. The ‘T5-Double Orange’ genotype had the highest plant height (81.79 cm). In genotype ‘T1-Arka Agni’, maximum plant spread in (E-W) was reported (52.80 cm). ‘T4-Erecta Naana Moon Light’ was the cultivar with the greatest stem girth (5.17 cm). In ‘T1-Arka Agni’, the greatest stem diameter (1.23 cm) was found. ‘T1-Arka Agni’ has the most number of main branches (12.40) and most secondary branches (24.13). The ‘T4-Erecta Naana Moon Light’ genotype had taken the shortest time to first flower bud appearance (46.63 days). In terms of first flower opening, the genotype ‘T3-Arka Bangara-2’ (48.40 days) was the earliest. In ‘T4-Erecta Naana Moon Light’, the flower's largest diameter was measured (6.13 cm).

Pandey *et al*. (2018) studied the impact of climatic conditions on the production of horticultural crops. They found that due to climate change, low production of horticultural crops was featured particularly for flowering in Saffron and Orchids grown under open field conditions. Flowering crops required high humidity and water which was quite difficult to meet out for the survival. So, they are affected either by drought or excessive rains, floods and seasonal variations. They concluded that flower production under open field conditions is severely affected and gives poor flowering, improper floral development and colour. In jasmine, low temperature (19°C) leads to reduction in flower size. Similarly, high temperature above 35°C leads to flower bud drop and production of unmarketable spikes in tropical orchids.

In another experiment Roopa *et al*. (2018) assessed twenty chrysanthemum varieties at Mudigere, Karnataka, with the goal of identifying suitable varieties based on diverse features in the hill zone of Karnataka. The results of the study found that the variety ‘Kolar Local' took minimum days for appearance of first flower (90.59 days) and 50 percent of flowering (99.66 days). Variety ‘Sharad Mala’ took maximum days for first flower appearance and 50 percent flowering (149.08 and 169.35, respectively) and minimum flowering duration and crop duration was also observed in the same variety (45.43 days and 190.29 days, respectively). Maximum flower diameter (5.75cm) and individual flower weight (3.24 g) was also observed in variety ‘Kolar local’. From the result of study it is found that variety ‘Kolar local’ was found best for cultivation in Karnataka hill zone.

Atal *et al.* (2019) conducted studies on performance of China aster varieties in southern Rajasthan agro- climatic conditions. Eight varieties were evaluated for cut flower,

loose flower and seed production. Cultivar 'Phule Ganesh-Violet' gave maximum plant height (69.87 cm), plant spread (36.33 cm), spray length (34.93 cm), number of flowers per plant (84.77), number of flowers per spray (6.73), number of spray per plant (12.60), flower diameter (6.47 cm), weight of 10 flowers (15.60 g), while cultivar 'Arka Archana' was observed early for first (50.13 days) and last (98.47 days) bud appearance, first (56.33 days) and last (106.67 days) flower opening, days taken to 50% flowering (85.33 days), maximum flowering duration (55.40 days), maximum vase life (8.53 days) and shelf life (5.47 days). Among the different cultivars evaluated, cultivar 'Phule GaneshViolet' gave best results in terms of flower yield while cultivar 'Arka Archana' was found early for flowering and best for flower vase life and shelf life.

Bhattarai *et al.* (2019) conducted an experiment with the aim to determine the differences in flowering behaviour of twenty species of winter annuals, mostly used for landscaping purpose under different agro-climatic conditions, in the Terai region of West Bengal, (India) under open field and protected conditions. The species used in experiment included *Bellis perennis.* They recorded flowering parameters such as days required for flower bud initiation (FBI), days needed for flower bud development (FBD), days required for blooming as well as time taken for wilting of flower were recorded in each plot and their average was worked out. They observed that *Calendula officinalis* exihibited earliness in FBI (23.25 DAT), FBD (32.88 DAT), blooming (35.50 DAT) and wilting (43.00 DAT) under open conditions and the late flowering was found in *Antirrhinum majus* (74.67 DAT). For *Bellis perennis* L. days for FBI (40 DAT), FBD (46.70 DAT) blooming (48.90 DAT) were observed. The delayed wilting was observed in *Helichrysum bracteatum* (94.30 DAT) both under field and protected conditions while, in *Bellis perennis* L. days taken for wilting under open and protected conditions were 58.40 (DAT) and 80 (DAT), respectively. *Iberis umbellata* took minimum time (6.17 days) to reach flower bud development from flower bud initiation stage. The shortest period for wilting of flowers was recorded in *Eschscholtzia californica* (2.00 days) under protected conditions, while, *Helichrysum bracteatum* required the maximum time period (21. 84 days) from blooming to wilting.

Chakraborty *et al.* (2019) conducted an experiment to check the variation in seed production potential of China aster genotypes in the new alluvial zone of West Bengal during 2016-17 to 2017-18. They raised China aster seed in individual plots using standard agronomic practices and intercultural operations. Field performance of seven genotype of

China aster was observed for different parameters. They concluded that highest seed yield was recorded in cv. ‘Arka Poornima’ and lowest seed yield was observed cv. ‘Arka Aadya’.

Jangde *et al.* (2019) conducted an experiment in which six gerbera cultivars were tested in a polyhouse with natural ventilation. The experiment took place in the Centre of Excellence on Protected Cultivation (DTTC), Department of Floriculture and Landscape Architecture, IGKV, Raipur, during the winter season of 2015-16. ‘Alcochete’, ‘Toscana’, ‘Corona’, ‘Fredi’, and ‘Livia’ were among the cultivars tested. The plants were cultivated in a 25 cm by 25 cm raised bed. Cultivar ‘Livia’ had the highest plant height and leaf length (55.51cm), (42.16cm), while cv. ‘Corona’ had the highest plant spread, leaf breadth, and number of suckers per plant (86.05cm), (11.44cm), and (2.18). Cultivar ‘Fredi’ was recorded more number of leaves (20.15) and flowers (10.26) per plant.

A study was conducted at College of Agriculture Bheemarayanagudi to evaluate sixteen African marigold genotypes for flower yield and xanthophyll content using CRBD by Naik *et al.* (2019). Observations recorded showed that cv. ‘Arka Bangara-2’ (21.77 t/ha), cv. ‘Maxima Yellow’ (19.01 t/ha), cv. ‘Arka Agni’ (17.13 t/ha), and cv. ‘Indam Yellow’ (7.51 t/ha) had the highest flower output. The cv. ‘Arka Agni’ had the highest xanthophyll content (21.37 g/kg and 20.80 kg/ha of fresh flowers), followed by the cv. Ashoka Orange (15.08 g/kg).

Salve *et al.* (2019) conducted a study to evaluate performance of promising genotypes of Gaillardia (*Gaillardia pulchella* L.) for yield attributes and storage study. The goal of this study was to evaluate prospective gaillardia genotypes for yield features and storage performance at the Horticulture section of the College of Agriculture in Pune. The genotypes MG-9-1, MG-2-2, and MG-6-2 demonstrated higher storage performance and quantitative characters based on the findings of the experiment.

Negi *et al.* (2020) evaluated the performance and flower characterization of nineteen newly evolved genotypes of chrysanthemum along with cultivar ‘Ajay’ as a standardized check for cut flower production at Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan and ICAR-IARI Regional Research Station, Katrain, Kullu Valley of H.P for two successive years 2017 and 2018. On the basis of number of cut stems per plant, the genotypes ‘UHFSChrs117’, ‘UHFSChrs122’, ‘UHFSChrs125’, and ‘UHFSChrs131’ exhibited superiority for cut flower production.

Srinivas and Rajasekharam (2020) studied performance of 20 marigold genotypes in Tirupati's tropical climate. The experiment was conducted at Citrus Research Station in Tirupati during the winter seasons of 2016-17 and 2017-18, using a Randomized block design (RBD) with three replications. For growth, flowering, and yield characteristics, all genotypes exhibited significant differences. Plant spread was best in cv. 'Vikrant Yellow' (62.3 cm), number of buds per plant was best in cv. 'Pusa Narangi Gainda' (70.6), blooming time was best in cv. 'Tennis Ball' (68.2 days), and flower production per hectare was highest in cv. 'Vikrant Yellow' (2168 q). The genotype 'Pusa Narangi Gainda' had the largest stem diameter (2.1 cm) and the highest dry weight of plant (62.27 g) in cv. 'Semi Tall Orange', whereas it was the lowest in cv. 'AW Dwarf Yellow' (9.8 g). Cultivar 'Astagandaha' and 'Suvarna Yellow' had the largest flower diameter (8.2 cm), while cv. 'AW Dwarf Yellow' had the smallest (4.3 cm).Cultivar 'Suvarna Yellow' produced the highest dry flower weight (2.2 g).

Kumar *et al.* 2021 evaluated Dahlia (*Dahlia variabilis* L) cultivars for growth and flowering characteristics under sub-montane, sub tropical low hill zone of Himachal Pradesh. Results showed significant differences among different cultivars for growth and yield parameters. Results of study showed that cultivar 'Shanti' recorded maximum plant height (118.29 cm) and 'Black Eternity' variety had maximum plant spread (58.67 cm). Cultivar 'Giani Zail Singh' took maximum number of days (74.67 days) for the flower bud initiation whereas the minimum number of days for flowering was taken by the cultivar 'Bada Kachari' (102.42 days). Maximum flowering duration (107.56 days) was shown by cultivar 'Red Army'. Largest flower size was observed in cv. 'Kenya Orange' (26.28 cm). Results of evaluation showed that cv. 'SP Kamla' was found superior in terms of yield and other qualitative traits among all the tested cultivars. Among the cultivars evaluated the cultivar 'Bada Kachari' can be grown for early crop whereas cv. 'Red Army' was found suitable for longer flower duration.

Chapter-3

MATERIALS AND METHODS

The present investigation entitled, **"Evaluation of *Bellis perennis* L. cultivars under different altitudinal gradients in Himachal Pradesh"** was carried out at three different locations with varying altitudinal gradients in Himachal Pradesh during year 2020-21.

The details of the materials used and techniques used during the course of studies have been given below:

3.1 EXPERIMENTAL SITES

3.1.1 RHR&TS (Regional Horticultural Research and Training Station), Dhaulakuan: The Research Station is situated in Paonta Block of District Sirmaur, located along side the Nahan-Paonta road (NH-72) having latitude 30°30'20" N and Longitude 77°20'30" E having an altitude of 468 m amsl located in the sub tropical, sub montane and low- hill zone of Himachal Pradesh.

3.1.2 Khaltoo Farm, Nauni: Experimental Farm at Khaltoo, Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan is at latitude of 30°51'7" N and longitude 77°10'56" E having an altitude of 1060 m amsl. The area falls under mid hill zone of Himachal Pradesh.

3.1.3 Floriculture Farm, Nauni : Research Farm of the Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan is situated at Nauni about 15 km away from Solan on Solan-Rajgarh Road at latitude of 30°51'0" N and longitude of 77°11'0" E. The elevation of the farm is 1276 m amsl. It falls in the mid-hill zone of Himachal Pradesh.

3.2 CLIMATE

3.2.1 RHR&TS, Dhaulakuan: Climate of the area is sub-tropical monsoon type and is characterized by hot summers and slightly cold winters. Generally, December and January are the coldest months and May to July are the hottest months.

3.2.2. Khaltoo Farm, Nauni: Climate of the area is sub-temperate and semi-humid mostly characterized by mild summers and cold winters. Generally, December and January months are the coldest, while May and June are the hottest months.

3.2.3. Floriculture Farm, Nauni: The climate of this area, in general, is sub-temperate to sub-tropical and is characterized by mild summers and cool winters. May and June are the hottest months while January and February are the coldest. Maximum rainfall is received during July to September (Monsoon season).

(The mean monthly weather data pertaining to the period of crop growth, flowering and seed yield of different locations is presented in Appendix-I)

3.3 CULTIVATION PRACTICES

3.3.1 Seeds

The seeds of six cultivars of English daisy namely 'Single Meadow', 'Monstrosa Double White', 'Monstrosa Double Mix' 'Pomponette Rose', 'Pomponette Red' and 'Pomponette Mix' were procured from Biocarve Seeds Company, Dhablan, Patiala. Healthy, disease-free, bold, uniform and true-to-type seeds of the six cultivars were selected to undertake the present study. Light, wrinkled and damaged seeds were discarded and only healthy seeds were sown to raise the crop.

3.3.2 Nursery raising

Raised beds were prepared for raising the nursery. The soil was dug deep up to a depth of 30 cm after which it was levelled and all the pebbles, stones and unwanted plants were removed. Well rotten FYM (Farm Yard Manure) at the rate of 5 kg/m^2 was incorporated and mixed thoroughly with the soil for nursery raising. The beds of size1 m × 1 m × 0.15m (L×B × H) were prepared. Seeds were sown in rows about 5 cm apart in the month of November. After placing seeds in rows, these were covered with a fine layer of sieved well rotten farm yard manure (FYM). Irrigation of nursery beds was done with the help of watering can having fine rose. Nursery beds were then covered with polyethylene sheet. This polyethylene sheet was removed as soon as seeds started germinating. Seedlings of about four to six leaf stage were used for transplanting.

3.3.3 Field preparation

The study was conducted under open-field conditions. The land was ploughed up to a depth of 30 cm and then leveled. The stones,pebbles and other unwanted material were

Plate-1: An overview of field preparation and transplanting of seedlings

removed manually. Raised plots of size 1.0 m × 1.0 m × 0.15 m (L × B × H) were prepared and leveled properly to laid out the experimental trial.

3.3.4 Manures and fertilizers

5-10 kg/m^2 well rotten farm yard manure was incorporated into the soil and mixed thoroughly before transplanting. A basal dose of N: P: K (30:20:20 g/m^2) in the form of Urea, SSP and MOP was also added to the experimental plots at the time of planting. Full dose of P and K and half dose of N (15 g/m^2) were applied at the time of planting and another dose of 15g/m^2 nitrogen was applied one month after transplanting the seedlings in the plots.

3.3.5 Transplanting

Healthy, disease-free and bold seedlings of uniform size were transplanted into the raised beds on 3/12/2020. The seedlings were planted at a spacing of 25 × 25 cm (Row to row and plant to pant) with planting density of 16 plants / m^2. After transplanting, light irrigation was done to establish them in the main field and ensuring a good crop stand.

3.3.6 Irrigation

Irrigation was done in a judicious manner throughout the study. Light irrigation was done in the morning and evening hours during the initial stage of study i.e. after transplanting the seedlings for their better establishment and growth. Once the plants were properly established, the irrigation was done on alternate days depending upon the moisture status of soil.

3.3.7 Cultural Practices

3.3.7.1 Weeding

The main weeds which were noticed in the field during the course of study were *Oxalis sp., Cyperus rotundus, Chenopodium album, Trifolium repens, Taraxacum officinale, Portulaca oleracea, Cirsium arvense, Digitaria sp., Amaranthus sp.* etc. Weeds were removed manually and with the help of hand hoe also from the plots as and when they appeared.

3.3.7.2 Hoeing

Hoeing was initiated right after the establishment of seedlings in the beds. It was practiced when a hard crust was formed over the soil surface. Also hoeing was done to remove weeds for proper growth of established plants.

3.5 EXPERIMENT METHODOLOGY

The present research was accomplished by transplanting the seedlings and crop established of six conducting experiments on nursery, flower production, seed yield and quality of six English daisy cultivars 'Single Meadow', 'Monstrosa Double White', 'Monstrosa Double Mix', 'Pomponette Rose', 'Pomponette Red' and 'Pomponette Mix' from December, 2020 to April 2021 under the selected field conditions. However, laboratory studies were done April 2021 onwards to test the seed quality parameters. Details of experiments conducted were as given below in RCBD (factorial).

Treatment Details:

Factor (A): Altitudinal gradients (AG) = 3

AG-1 = RHR&TS, Dhaulakuan

AG-2 = Experimental Farm at Khaltoo, Department of Seed Science and Technology of Dr. YS Parmar University of Horticulture and Forestry, Nauni

AG-3 = Experimental Farm, Department of Floriculture and Landscape Architecture of Dr. YS Parmar University of Horticulture and Forestry, Nauni

Factor (B): English daisy Cultivars = 6 ('Single Meadow', 'Monstrosa Double White', 'Monstrosa Double Mix' , 'Pomponette Rose', 'Pomponette Red' and 'Pomponette Mix')

Treatment combinations	=	6 x 3=18
Number of replications	=	3
Number of replications	=	4 (for laboratory observations)
Design of experiment	=	Randomized Complete Block Design (factorial) for field observations with three replications Complete Randomized Design (factorial) for laboratory observations with four replications

3.5.1 Observations recorded:

Field observations:

1. **Days taken to first flowering:** The days taken to first flowering were recorded as the number of days taken from the date of transplanting to the appearance of first flower opening.

Single Meadow Daisy

Monstrosa Double White

Monstrosa Double Mix

Pomponette Pink

Pomponette Red

Pomponette Mix

Plate -2: Evaluated cultivars of *Bellis perennis* L.

(a) Vegetative stage

(b) Flowering stage

Plate – 3: A field view of vegetative and flowering stages

2. **Days taken for full blooming:** Days taken for full blooming were recorded as total number of days from transplanting to the stage when more than 75% of crop was in flowering.
3. **Plant height (cm):** The plant height was measured with a meter scale from the ground level to the tip of the plant at the time of peak flowering for every plant. The average height of plants was worked out and expressed in centimeters.
4. **Flower head diameter (cm):** Flower head diameter of randomly selected five flower heads in each plant was measured as distance between apices of petals in East to West and North to South directions and then the average was worked out.
5. **Number of flower heads per plant:** Total numbers of flower heads were counted from five individual plants selected randomly in a plot, produced during the entire season.
6. **Duration of flowering:** This observation was recorded as the counting of number of days from opening of first flower to opening of last flower in a plot.
7. **Number of seeded heads per plant:** The total number of seeded heads produced was collected per plant was counted during the entire season in randomly selected five plants of each plot and the average number of seeded heads per plant was worked out accordingly.
8. **Number of seeds per head:** Number of seeds in each flower head were counted from ten flower heads selected at random and average was worked out to calculate number of seeds per flower head in each treatment combination.
9. **Seed yield per plant (g):** The seeds harvested from each of plants growing in a plot were dried in shade and then properly cleaned and weighed with the help of an electronic balance and average was worked accordingly.
10. **Seed yield per plot (g)/per hectare (kg):** The seed yield per plot was worked out by following formula:

Seed yield per plot = Seed yield per plant × Number of plants growing in a plot square meter.

However, the seed yield per hectare was worked out on the basis of seed yield obtained per plot (measuring 1.0 × 1.0 m) as per the formula given below:

$$\text{Seed yield per ha (kg)} = \frac{\text{Seed yield per plot (g)} \times 7500\ m^2}{1000}$$

Laboratory Observations:

11. **1000 seed weight (g):** 1000 seeds were counted manually from each treatment combination and then weighed using electronic balance and weight was expressed in grams.

12. **Seed germination (%):** The germination test was carried out as per the ISTA guidelines. Four hundred seeds from each treatment were taken randomly and the test was carried out in four replications, having 100 seeds in each. The seeds were allowed to germinate using petri plate method at 25°C. Total number of normal seedlings germinated were counted after 6 days (Agarwal, 2018) and expressed in percentage. Germination percentage was calculated by using the formula:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds used}} \times 100$$

13. **Seedling length (cm):** Ten normal seedlings selected at random treatment wise were used to work out the seedling length. Total seedling length was worked out by taking the total length of seedlings from the tip of the apex leaf to the tip of primary root with the help of a scale and expressed as mean value in centimeter (cm)

14. **Seedling dry weight (mg):** Ten normal seedlings selected for measuring seedling length treatment wise were also used to work out seedling dry weight. Seedlings were put in butter paper pocket and kept in Hot Air oven at 50°C for 48 hours. Dry weight of each seedling was recorded and the mean value was expressed in milligrams (mg).

15. **Seed vigour index-I (Length):** Seed vigour index - I was calculated as per the formula suggested by Abdul-Baki and Anderson (1973) as given below:

    Seed vigour index - I = Germination percentage (%) × Seedling length (cm)

16. **Seed vigour index - II (Mass):** Seed vigour index - II was calculated as per the formula suggested by Abdul-Baki and Anderson (1973) as given below:

    Seed vigour index - II = Germination percentage (%) x Seedling dry weight (mg)

❖ In addition to above recorded observations, telephonic interview of Farm Manager of Biocarve Seeds Company, Dhablan, Patiala (Punjab) was also conducted. The purpose of the interview was to conduct SWOT analysis of English daisy crop for production of quality seeds.

3.6 STATISTICAL ANALYSIS

The data recorded were analyzed by using MS-Excel & OPSTAT. The mean value of data was subjected to analysis of variance as described by Gomez and Gomez (1984) for using of Randomized Complete Block Design (factorial) for various observations recorded in field and Completely Randomized Design (factorial) for the observations of laboratory.

ANOVA for CRD (factorial) were calculated as follows:

Source of variation	**Degree of freedom**	**Sum of squares**	**Mean sum of squares (M)**	**F Cal**
Replications (r)	(r-1)	S_r	$S_r/(r-1) = M_r$	M_r/M_e
Treatments (t)	(t-1)	S_r	$S_r/(r-1)=M_r$	M_r/M_e
Altitudinal gradients (a)	(a-1)	S_a	$S_a/(a-1)$	M_a/M_e
Cultivars (c)	(c-1)	S_c	$S_c/(c-1)$	M_b/M_e
Altitudinal gradients (a) × Cultivars (c)	(a-1) (c-1)	S_{ac}	$S_{ac}/(a-1)(c-1)$	M_{ab}/M_e
Error	r(t-1)	S_{tr}	S_{tr} /(t-1)(r-1)	M_{tr}/M_e
Total	(tr-1)	S_{tr-1}		

ANOVA for RBD (factorial) were calculated as follows:

Source of variation (SV)	**Degree of freedom (df)**	**Sum of squares (SS)**	**Mean sum squares (MSS)**	**F Cal**
Replications (r)	(r-1)	S_r	$S_r/(r-1) = M_r$	M_r/M_e
Altitudinal gradients (a)	(a-1)	S_a	$S_b/(a-1) = M_b$	M_b/M_e
Cultivars (c)	(c-1)	S_c	$S_m/(c-1) = M_m$	M_m-/M_e
Altitudinal gardients (a) × Cultivars (c)	(a-1)(c-1)	S_{ac}	$S_{bm}/(a-1)\ (c-1) = M_{bm}$	M_{bm}/M_e
Error	(t-1)(r-1)	S_{tr}	$S_{tr}/(t-1)\ (r-1) = M_e$	
Total	(tr-1)	S_{tr-1}		

Where,

r = Number of replications

a = Altitudinal gradients

c = Cultivars

The standard error of mean SE (m) and critical difference (CD) for comparing the means of any two treatments were calculated as below:

$$\text{SE (mean)} = \pm (Me/r)^{½}$$

$$\text{SE (d)} = \pm (2Me/r)^{½}$$

$$CD_{(0.05)} = \text{SE (d) x } t_{(0.05)}\ (r-1)\ (t-1)\ df$$

Where,

SE (mean)	=	Standard error of mean
SE (d)	=	Standard error of difference
$CD_{(0.05)}$	=	Critical difference at 5 percent level of significance

The calculated ‘F’ values were compared with the tabulated ‘F’ values at 5 % level of significance. If the calculated ‘F’ value was higher than the tabulated, it was considered to be significant. All the characters which showed significant differences among treatments were further subjected to the analysis for the different parameters.

Chapter-4

RESULTS AND DISCUSSION

The present investigation entitled, **"Evaluation of *Bellis perennis* L. cultivars under different altitudinal gradients in Himachal Pradesh"** was conducted at three different locations in Himachal Pradesh

The analysis of variances for various parameters under study has been presented in Appendix-II. The results obtained during the course of investigations are presented in this chapter and discussed accordingly on the basis of available literature and classical knowledge as well.

4.1 DAYS TAKEN TO FIRST FLOWERING (days)

Data recorded on days taken to first flowering of English daisy cultivars grown under three different altitudinal gradients namely, Dhaulakuan, Floriculture farm and Khaltoo farm, Nauni have been presented in Table 4.1. The altitudinal gradients, cultivars and their interactions have exhibited significant effects w.r.t. days to first flowering (Appendix-II).

Among the different altitudinal gradients selected at different locations, minimum time for first flowering (53.94 days) was taken by the plants grown at altitudinal gradient of Dhaulakuan (AG-1) and found to be significantly lowest in comparison to other altitudinal gradients. However, maximum time required for first flowering (67.05 days) was observed in the plants grown at altitudinal gradient of Floriculture farm (AG-3) and found to be significantly highest in comparison to other altitudinal gradients (locations).

Among different cultivars, significantly minimum time to first flowering (54.27 days) was observed in cv. 'Pomponette Red' and it was maximum (69.40 days) in cv. 'Monstrosa Double Mix'.

The interaction effects of altitudinal gradients and cultivars had exhibited minimum time to production of first flowers (46.53 days) in the interaction, AG-1 × C_5 i.e. growing of cv.

'Pomponette Red' at altitudinal gradient of Dhaulakuan and it was found to be significantly lowest time among the other interactions. While, maximum time for appearance of first flower (74.60 days) was noted in the interaction, AG-3 × C_3 i.e. growing of cv. 'Monstrosa Double Mix' at the altitudinal gradient of Floriculture farm at Nauni and it was statistically at par with interaction, AG-3 × C_2 (73.27 days).

Table 4.1: Effect of altitudinal gradients on days taken to first flowering of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	50.27	62.73	61.67	51.77	46.53	50.70	**53.94**
AG-2 (Khaltoo farm,Nauni)	61.93	70.90	71.93	63.47	56.60	64.20	**64.84**
AG-3 (Floriculture farm, Nauni)	64.23	73.27	74.60	65.47	59.67	65.07	**67.05**
Mean	**58.81**	**68.97**	**69.40**	**60.23**	**54.27**	**59.99**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.58			
Cultivars(C)			:	0.83			
Altitudinal gradients × Cultivars			:	1.44			

Number of days taken for first flowering is an important character that signifies earliness or late flowering of plants which determines availability of flowers for further uses. The variation in time taken for flowering among altitudinal gradients and cultivars might be due to the effect of genetic makeup of the cultivars grown as well as the influence of genotype and environmental conditions (Roopa *et al.*, 2018).

4.2 DAYS TAKEN TO FULL BLOOMING (days)

Data observed on days taken to full blooming of different cultivars of English daisy grown under three selected altitudinal gradients namely, Dhaulakuan, Floriculture farm, Nauni and Khaltoo farm, Nauni have been presented in Table 4.2. The altitudinal gradients and cultivars including their interactions have exerted significant effects w.r.t. time needed for full blooming (Appendix- II).

Table 4.2: Effect of altitudinal gradients on days taken to full blooming of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	92.73	99.80	100.00	96.80	94.13	95.27	**96.46**
AG-2 (Khaltoo farm,Nauni)	102.33	110.27	111.53	106.07	106.20	106.00	**107.07**
AG-3 (Floriculture farm, Nauni)	107.53	116.93	116.23	112.93	111.40	113.00	**113.01**
Mean	**100.87**	**109.00**	**109.26**	**105.27**	**103.91**	**104.76**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.42			
Cultivars(C)			:	0.59			
Altitudinal gradients × Cultivars			:	1.02			

Minimum time taken for full blooming (96.46 days) was recorded in the plants grown under Dhaulakuan conditions and maximum days for full blooming (113.01 days) were taken by the plants grown at Floriculture farm, Nauni.

Among the different cultivars evaluated, minimum days taken for full blooming (100.87 days) were found in cv. 'Single Meadow' and reported to be significantly lowest in comparison to other cultivars evaluated. However, the plants of cv. 'Monstrosa Double Mix' took longest time for full blooming (109.26 days) and observed to be statistically at par with time taken for the plants of cv. 'Monstrosa Double White' (109.00 days).

The interaction between altitudinal gradients of different locations and cultivars revealed that significantly least time for full blooming (92.73 days) was reported with the interactive effects of AG-1 × C_1 i.e. growing of cv. 'Single Meadow' at the altitudinal gradient of location Dhaulakuan. However, maximum time for full blooming (116.93 days) was noted in the interaction, AG-3 × C_2 i.e. when cv. 'Monstrosa Double White' was grown at the Floriculture farm location and detected to be statistically at par with AG-3 x C_3 (116.23 days).

The differences in early and late blooming habits of evaluated cultivars may be ascribed to their genetic makeup of the cultivars evaluated. Srilatha et *al.* (2015) as well as Thakur *et al.*

(2018) have also documented similar results. The variation among different altitudinal gradients of selected locations for days taken to full blooming may be due to the differential effects of environmental conditions prevailing at the altitudinal gradients of selected locations. The varied temperature conditions under different locations might have also influenced time period required by some annuals for full blooming (Craufurd and Wheeler, 2009).

4.3 PLANT HEIGHT (cm)

A perusal of data elucidated in Table 4.3 indicates that selected locations based on different altitudinal gradients, cultivars and their interactions have influenced plant height of significantly (Appendix-II).

Table 4.3: Effect of altitudinal gradients on plant height (cm) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	30.76	18.47	18.65	19.52	20.26	19.54	**21.20**
AG-2 (Khaltoo farm,Nauni)	28.62	16.92	17.06	18.18	19.04	17.89	**19.62**
AG-3 (Floriculture farm, Nauni)	27.27	16.47	16.37	18.58	19.28	19.46	**19.57**
Mean	**28.89**	**17.29**	**17.36**	**18.76**	**19.53**	**18.96**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.26			
Cultivars(C)			:	0.37			
Altitudinal gradients × Cultivars			:	0.64			

Among different altitudinal gradients, maximum height of plants (21.20 cm) was acquired at the location Dhaulakuan (AG-1) and found to be significantly highest than other locations. However, significantly lowest height (19.57 cm) was noted in the plants grown at altitudinal gradient of Floriculture farm, Nauni (AG-3) and found to be statistically at par with Khaltoo farm (AG-2).

The, significantly tallest plants (28.89 cm) were produced in cv. 'Single Meadow' and shortest plants (17.29 cm) were observed in 'Monstrosa Double White' and reported to be statistically at par with the plants of cv. 'Monstrosa Double Mix' (17.36 cm).

The interactive effects of altitudinal gradients selected at three different locations and cultivars exhibited maximum plant height (30.76 cm) in AG-1 × C_1 interaction *i.e.* growing of plants of cv. 'Single Meadow' at the altitiudinal gradient of Dhaulakuan location and was significantly highest. However, lowest plant height (16.37 cm) was noted in the interaction, AG-3 × C_3 *i.e.* growing of cv. 'Monstrosa Double Mix' at Floriculture farm of Nauni which was observed to be statistically at par with interactive influence of AG-3 x C_2 (16.47 cm).

The higher plant height observed in cv. 'Single Meadow' at all the selected farms may be due to its superior genetic makeup. The results are supported by the findings of Khanvilkar *et al.* (2003) which were carried out in marigold. Among different locations, maximum plant height was observed in Dhaulakuan (AG-1) which may be due to the fact that this very experimental farm might have supplied favourable environmental factors more efficiently in comparison to other altitudinal gradients (locations), this result can get the support of work under taken in marigold by Mahantesh *et al.* (2018).

4.4 FLOWER HEAD DIAMETER (cm)

The perusal of data contained in Table 4.4 clearly indicated that different altitudinal gradients selected at three different locations, cultivars and their interactions had exerted significant influence on the diameter of flower heads (Appendix-II).

Among the influence of different altitudinal gradients, maximum flower head diameter (3.15 cm) was noted at Dhaulakuan (AG-1) which was found to be significantly highest. However, minimum diameter of flower head (2.87 cm) was observed in the plants flowered at the Floriculture farm, Nauni (AG-3) and was reported to be significantly lowest comparatively.

Among the cultivars evaluated, cv. 'Monstrosa Double White' produced significantly largest sized flower heads (4.44 cm). Whereas, significantly lowest flower head diameter (2.11 cm) was recorded in cv. 'Pomponette Rose'.

The interaction, AG-1 × C_2 i.e. when plants of Monstrosa Double White cultivar was grown under Dhaulakuan conditions exhibited largest flower heads (4.62 cm) in comparison to all other interactions. Whereas, minimum flower head diameter (1.98 cm) was observed in the

interaction, AG-3 × C_4 i.e. when plants of cv. 'Pomponette Rose' were grown at the altitudinal gradient of Floriculture farm and was observed to be lowest significantly.

Table 4.4: Effect of altitudinal gradients on flower head diameter (cm) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	2.87	4.62	4.50	2.24	2.39	2.29	**3.15**
AG-2 (Khaltoo farm,Nauni)	2.64	4.41	4.37	2.10	2.20	2.11	**2.97**
AG-3 (Floriculture farm, Nauni)	2.58	4.29	4.23	1.98	2.11	2.04	**2.87**
Mean	**2.70**	**4.44**	**4.37**	**2.11**	**2.23**	**2.15**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.02			
Cultivars(C)			:	0.03			
Altitudinal gradients × Cultivars			:	0.05			

The observed variations in the diameter of flower heads among the cultivars evaluated under selected locations could be due to the effect of genetic variability as well as prevailing environmental factors and their interactions too. The requisite variation in temperature at different locations during growing period could also be the possible reason for variation in diameter of flower heads in different locations (altitudinal gradients). The results got support from the documented results of Zosiamliana *et al.* (2013), Rai and Choudhary (2016), Kumar *et al.* (2017) and Bhargav *et al.* (2018) in China aster.

4.5 DURATION OF FLOWERING (days)

A cursory look of analyzed data w.r.t. duration of flowering of English daisy cultivars grown under three altitudinal gradients selected at different locations namely, Dhaulakuan, Khaltoo farm, Nauni and Floriculture farm Nauni given in Table 4.5 and clearly exhibit significant influence of altitudinal gradients, cultivars and their interactions (Appendix-II).

The flowering duration recorded to be the highest (66.00 days) statistically at altitudinal gradient of Floriculture farm, Nauni (AG-3) and significantly minimum duration of flowering (55.34 days) was noted at the altitudinal gradient of Dhaulakuan location (AG-1).

There was significant variation in flowering duration of plants of different cultivars. Maximum duration of flowering (64.35 days) was observed in cv. 'Pomponette Red'. However, significantly minimum flowering duration (58.35 days) has been recorded for the plants of cv. 'Single Meadow'.

Table 4.5: Effect of altitudinal gradients on duration of flowering (days) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	53.53	55.17	54.67	55.12	58.27	55.27	**55.34**
AG-2 (Khaltoo farm,Nauni)	59.57	63.50	62.97	62.70	65.09	61.80	**62.60**
AG-3 (Floriculture farm, Nauni)	61.96	66.40	66.13	65.79	69.70	66.00	**66.00**
Mean	**58.35**	**61.69**	**61.26**	**61.20**	**64.35**	**61.02**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.52			
Cultivars(C)			:	0.74			
Altitudinal gradients × Cultivars			:	1.28			

The interactive influences exerted by the altitudinal gradients selected at various locations and cultivars grown presented the highest duration of flowering (69.70 days) in the interaction, AG-3×C_5 i.e. growing of plants of cv. 'Pomponette Red' at Floriculture farm location (AG-3) which was significantly highest. However, minimum flowering duration (53.52 days) was noted in interaction AG-1× C_1 i.e. growing plants of cv. 'Single Meadow' at the altitudinal gradient of Dhaulakuan location (AG-1) which was statistically similar with interaction AG-1× C_3 (54.67 days).

The genetic control of the characters and modification in their expression due to environmental conditions might be the possible cause of observed variations in duration of flowering. The genotype of the plant, environmental influence and other management factors determine the variation in flowering duration among the cultivars (Prabhu *et al.*, 2018). Variation for earliness or lateness in flowering seems to be genetically controlled (Kireeti *et al.*, 2017) and similar findings with respect to flowering duration among the genotypes have also been reported

in chrysanthemum under different environmental conditions by Behera *et al*. (2002), Srilatha *et al*. (2015) and Thakur *et al.* (2018).

4.6 FLOWER HEADS PER PLANT

A glance of data in Table 4.6 reveals that number of flower heads produced per plant in English daisy cultivars grown under the selected altitudinal gradients of Dhaulakuan, Khaltoo farm and Floriculture farm has been influenced significantly with effects of altitudinal gradients, cultivars and their interactions as well (Appendix-II).

The significantly maximum flower heads per plant (67.92) were recorded under the altitudinal gradient of Dhaulakuan location (AG-1). Whereas, least number of flower heads per plant (63.80) was produced by the plants grown under the altitudinal gradient of Floriculture farm (AG-3) and was significantly lowest.

The plants of cv. 'Single Meadow' produced significantly highest number of flower heads (143.25). In contrast, minimum flower heads per plant (36.88) were noted in the plants of cv. 'Monstrosa Double White' and was found to be statistically at par with cv. 'Monstrosa Double Mix' (37.65).

Table 4.6: Effect of altitudinal gradients on number of flower heads per plant of English daisy cultivars

Cultivars / **Altitudinal Gradients**	**C_1 (Single Meadow)**	**C_2 (Monstrosa Double White)**	**C_3 (Monstrosa Double Mix)**	**C_4 (Pomponette Rose)**	**C_5 (Pomponette Red)**	**C_6 (Pomponette Mix)**	**Mean**
AG-1 (RHR&TS, Dhaulakuan)	146.85	38.33	38.39	58.41	65.81	59.70	**67.92**
AG-2 (Khaltoo farm,Nauni)	142.63	37.15	37.99	56.31	61.08	56.39	**65.26**
AG-3 (Floriculture farm, Nauni)	140.26	35.17	36.58	54.83	60.43	55.52	**63.80**
Mean	**143.25**	**36.88**	**37.65**	**56.51**	**62.44**	**57.20**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.75			
Cultivars(C)			:	1.06			
Altitudinal gradients × Cultivars			:	1.84			

As regards the influence of altitudinal gradients and cultivars, maximum number of flower heads per plant (146.85) was observed in the interaction, AG-1 × C_1 i.e. when cv. 'Single Meadow' was grown at an altitudinal gradient of Dhaulakuan location (AG-1) and found to be significantly highest. However, lowest flower heads per plant (35.17) were counted in AG-3 × C_2 i.e. when plants of cv. 'Monstrosa Double White' were cultivated at Floriculture farm and was found to be at par with the interaction AG-3 × C_3 (36.58 days).

Production of flower heads is directly related to vegetative growth and is highly dependent upon the inherent genetic traits of different cultivars as postulated by Sarkar *et al*. (2020) in China aster. More number of flowers produced per plant might be due to availability of favourable environmental conditions at the time of flowering and luxuriant vegetative growth before flowering which ultimately resulted in increased photosynthesis. These results are in conformity with the results obtained in candy tuft by Sharma *et al.* (2017), Kumar and Kaur (2000) in phlox, Kumar and Kaur (2001) in coreopsis and Sharma (2012) in pansy had also documented matchable results.

4.7 NUMBER OF SEEDED HEADS PER PLANT

An appraisal of Table 4.7 shows that there is significant difference among different cultivars of English daisy for number of seeded heads per plant under three different altitudinal gradient selected at Dhaulakuan, Khaltoo farm and Floriculture farm locations (Appendix-II).

Table 4.7: Effect of altitudinal gradients on number of seeded heads per plant of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	100.03	27.28	27.71	39.53	46.40	41.89	**47.14**
AG-2 (Khaltoo farm,Nauni)	96.12	25.73	26.54	38.30	43.14	40.36	**45.03**
AG-3 (Floriculture farm, Nauni)	94.40	25.10	26.26	37.30	42.89	39.34	**44.22**
Mean	**96.85**	**26.04**	**26.84**	**38.38**	**44.14**	**40.53**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.65			
Cultivars(C)			:	0.91			
Altitudinal gradients × Cultivars			:	1.58			

As far as the effect of different altitudinal gradients selected at three different locations is concerned, the highest number of seeded heads per plant (47.14) was produced under altitudinal gradient of Dhaulakuan locations and was found to be significantly highest. However, significantly minimum number of seeded heads per plant (44.22) was recorded under altitudinal gradient of Floriculture location.

Among the cultivars, highest number of seeded heads per plant (96.85) was recorded in the cv. 'Single Meadow' and found to be significantly highest. However, least number of seeded heads per plant (26.04) was counted in cv. 'Monstrosa Double White' and was matchable with cv. 'Monstrosa Double Mix' (26.84).

The interaction between altitudinal gradients selected at three different locations and cultivars on the number of seeded heads produced per plant revealed that maximum seeded heads per plant (100.03) were produced in the interaction AG-1 × C_1 i.e. when cv. 'Single Meadow' is grown at altitudinal gradient of Dhaulakuan location and was found to be highest significantly. While, least number of seeded heads per plant (25.10) were noted in the interaction AG-3 × C_2 *i.e.* when plants of cv. 'Monstrosa Double White' were grown under altitudinal gradients of Floriculture farm and was found to be statistically at par with AG-2 × C_2 (25.73), AG-2 × C_3 (26.54), and AG-3 × C_3 (26.26).

The increased number of seeded heads per plant can be attributed to the more number of flowers produced per plant as a result of the favourable weather conditions. Furthermore, enhanced photosynthesis under favourable conditions results in higher accumulation of photosynthates, which leads to increased production of seeded heads. Also, more number of heads/plant could be attributed to abundant vegetative growth (plant height, plant spread and number of side stems/plant) and more number of flowers/stem maximum as postulated by Sharma *et al*., 2015. Similar results for increased number of capsules/plant in earlier period have also been reported by Sharma (2012) in pansy.

4.8 NUMBER OF SEEDS PER HEAD

A cursory glance of data on number of seeds per head in the table 4.8 clearly indicate that altitudinal gradients, English daisy cultivars and their interactions have influenced the seeds produced in each head significantly (Appendix-II).

Among different altitudinal gradients, maximum seeds per head (217.79) were observed in AG-1 *i.e.* Dhaulakuan farm and found to be significantly highest. However, minimum seeds per head (212.31) were counted in AG-3 (Floriculture farm, Nauni) and found significantly lowest.

As regards effects of evaluated cultivars, significantly highest number of seeds per head (296.55) was obtained in cv. 'Monstrosa Double White'. However, significantly minimum number of seeds per head (137.15) was noted in cv. 'Pomponette Rose'.

The interactive influences of locations and cultivars was found to be non significant. However, maximum seeds per head were noted in the interaction, AG-1 × C_2 (299.24) i.e. growing of plants of cv. Monstrosa Double White at the altitudinal gradient of Dhaulakuan location. Whereas, minimum number of seeds per head (134.75) was recorded in AG-3 × V_4 i.e. when cv. 'Pomponette Rose' is grown at the altitudinal gradient of floriculture farm.

Table 4.8: Effect of altitudinal gradients on number of seeds per head of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	224.50	299.24	295.97	140.03	184.77	162.26	**217.79**
AG-2 (Khaltoo farm,Nauni)	221.51	296.49	293.35	136.66	180.65	157.35	**214.34**
AG-3 (Floriculture farm, Nauni)	219.37	293.92	292.59	134.75	178.52	154.68	**212.31**
Mean	**221.79**	**296.55**	**293.97**	**137.15**	**181.31**	**158.10**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.93			
Cultivars(C)			:	1.31			
Altitudinal gradients × Cultivars			:	NS			

More number of seeds per head can be the result of producing large flowers mainly due to enhanced plant growth and increased translocation of photosynthates from vegetative to reproductive parts under favourable climatic conditions. Further, the prolonged seed maturation after anthesis is also responsible for better seed filling leading to increasing number of seeds per

head. The results got support from the findings of Bajad *et al.* (2018) recorded in China aster, Dhatt and Kumar (2010) in larkspur and Sharma (2012) in pansy.

4.9 SEED YIELD PER PLANT (g)

Data noted for seed yield per plant (g) of English daisy cultivars grown under three different altitudinal gradients of Dhaulakuan, Floriculture farm and Khaltoo farm have been presented in Table 4.9. The altitudinal gradients, cultivars and their interactions have shown significant effects w.r.t. seed yield per plant (Appendix-II).

Table 4.9: Effect of altitudinal gradients on seed yield per plant (g) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	3.18	1.29	1.28	0.71	1.19	0.91	**1.43**
AG-2 (Khaltoo farm,Nauni)	2.92	1.17	1.18	0.66	1.03	0.82	**1.30**
AG-3 (Floriculture farm, Nauni)	2.81	1.11	1.15	0.63	1.00	0.78	**1.25**
Mean	**2.97**	**1.19**	**1.20**	**0.67**	**1.08**	**0.83**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.02			
Cultivars(C)			:	0.03			
Altitudinal gradients × Cultivars			:	0.06			

As far as the effect of altitudinal gradients at different locations is concerned, significantly highest seed yield per plant (1.43 g) was collected under altitudinal gradient of Dhaulakuan location. While, minimum seed yield per plant (1.25 g) was produced under altitudinal gradient of Floriculture farm conditions among other selected locations and was significantly lowest.

Among different cultivars evaluated, highest seed yield (2.97 g) was noted for cv. 'Single Meadow' and was found to be significantly higher as compared to other cultivars. Whereas, significantly minimum seed yield per plant (0.67 g) was recorded in cv. 'Pomponette Rose'.

Among all the interactions significantly maximum seed yield per plant (3.18 g) was observed in the interaction AG-1 × C_1 i.e. when cv. 'Single Meadow' was grown under altitudinal gradient of Dhaulakuan location. In contrast , minimum values for the seed yield per plant (0.63g) was found in the interaction, AG-3 × C_4 i.e. when cv. 'Pomponette Rose' was grown under altitudinal gradient of Khaltoo location and found to be statistically equal with the interaction AG-2 × C_4 (0.66 g).

More seed yield per plant had been resulted due to increased number of flower heads/plant along with more number of seeds/head. Further, the luxuriant vegetative growth of plants might have resulted in increased accumulation of photosynthates and these photosynthates were diverted to the reproductive parts, resulting in increased number of flowers per stem and capsules per plant and in turn increased seed yield per plant (Sharma *et al.*, 2015). These findings are in line with findings for increased seed yield by Kumar and Kaur (2000) in phlox and Dhatt and Kumar (2007) in coreopsis.

4.10 SEED YIELD PER PLOT (g) AND PER HECTARE (kg)

Data noted for seed yield per plot (g) and per hectare (kg) of English daisy cultivars grown under three different altitudinal gradients of Dhaulakuan, Floriculture farm and Khaltoo farm has been presented in Tables 4.10.1 and 4.10.2 respectively. The altitudinal gradients, cultivars and their interactions have shown significant effects w.r.t. seed yield per plant/ per hectare (kg) (Appendix-II).

As far as the effect of altitudinal gradients at different locations is concerned, significantly highest seed yield per plot (22.83 g) and per hectare (171.25 kg) was found under altitudinal gradient of Dhaulakuan location. While, minimum seed yield per plot (19.95 g) and per hectare (149.65 kg) was produced under altitudinal gradient of Floriculture farm conditions among all selected locations and observed to be significantly lowest.

Among different cultivars evaluated, highest seed yield per plot (47.53 g) and per hectare (356.51 kg) was noted for cv. 'Single Meadow' and was found to be significantly high as compared to other cultivars. Whereas, significantly lowest seed yield per plot (10.67 g) and per hectare (80.06 kg) was recorded in cv. 'Pomponette Rose'.

Table 4.10.1: Effect of altitudinal gradients on seed yield per plot (g) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	50.87	20.67	20.43	11.40	19.14	14.50	**22.83**
AG-2 (Khaltoo farm,Nauni)	46.67	18.75	18.86	10.57	16.54	13.16	**20.76**
AG-3 (Floriculture farm, Nauni)	45.06	17.77	18.34	10.05	16.05	12.43	**19.95**
Mean	**47.53**	**19.06**	**19.21**	**10.67**	**17.24**	**13.36**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.36			
Cultivars(C)			:	0.51			
Altitudinal gradients × Cultivars			:	0.88			

Table 4.10.2: Effect of altitudinal gradients on seed yield per hectare (kg) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	381.50	155.00	153.26	85.48	143.53	108.71	**171.25**
AG-2 (Khaltoo farm,Nauni)	350.05	140.60	141.43	79.28	124.04	98.70	**155.68**
AG-3 (Floriculture farm, Nauni)	337.97	133.27	137.56	75.41	120.42	93.25	**149.65**
Mean	**356.51**	**142.96**	**144.08**	**80.06**	**129.33**	**100.22**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	2.70			
Cultivars(C)			:	3.82			
Altitudinal gradients × Cultivars			:	6.61			

Among all the interactions, significantly maximum seed yield per plot (50.87 g) and per hectare (381.50 kg) was observed in the interaction, AG-1 × C_1 i.e. when cv. 'Single Meadow' is grown under altitudinal gradient of Dhaulakuan location. In contrast, minimum values for the seed yield per plot (10.04 g) and per hectare (75.41 kg) were found in the interaction, AG-3 × C_4 i.e. when cv. 'Pomponette Rose' is grown under altitudinal gradient of Khaltoo location and

found to be statistically equal with the interaction, AG-2 × C_4 having seed yield per plot (10.57 g) and per hectare (79.28 kg).

More seed yield recorded per plot and per hectare had been resulted due to increased number of heads/plant along with more number of seeds/head. Further, the luxuriant vegetative growth of plants could have resulted in increased accumulation of photosynthates and these photosynthates were diverted to the reproductive parts, resulting in increased number of flowers per stem and capsules per plant and in turn increased seed yield per plant, per plot and per hectare as well (Sharma *et al.*, 2015). The same findings have been reported by Dhatt and Kumar (2007) in coreopsis.

4.11 1000 SEED WEIGHT (g)

Data observed for 1000 seed weight of various cultivars of English daisy grown under three different altitudinal gradients of Dhaulakuan, Floriculture farm, and Khaltoo farm have been presented in Table 4.1 and the effects of cultivars and altitudinal gradients w.r.t. 1000 seeds weight are significant whereas, the influence of their interactions was found to be non significant (Appendix-II).

Table 4.11: Effect of altitudinal gradients on 1000 seed weight (g) of English daisy cultivars

Cultivars / **Altitudinal Gradients**	**C_1 (Single Meadow)**	**C_2 (Monstrosa Double White)**	**C_3 (Monstrosa Double Mix)**	**C_4 (Pomponette Rose)**	**C_5 (Pomponette Red)**	**C_6 (Pomponette Mix)**	**Mean**
AG-1 (RHR&TS, Dhaulakuan)	0.142	0.158	0.156	0.129	0.140	0.133	**0.143**
AG-2 (Khaltoo farm,Nauni)	0.137	0.154	0.151	0.126	0.133	0.130	**0.138**
AG-3 (Floriculture farm, Nauni)	0.136	0.151	0.149	0.125	0.131	0.128	**0.137**
Mean	**0.138**	**0.154**	**0.152**	**0.127**	**0.134**	**0.130**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	0.002			
Cultivars(C)			:	0.002			
Altitudinal gradients × Cultivars			:	NS			

As regards the influence of altitudinal gradients, maximum 1000 seed weight (0.143g) was observed at the altitudinal gradient of Dhaulakuan and found to be significantly highest.

Whereas, minimum 1000 seed weight (0.137 g) was recorded under Floriculture farm of Nauni (AG-3) and it was statistically matchable with 1000 seed weight at Khaltoo farm (AG-2).

The seed lot of cv. 'Monstrosa Double White' showed maximum 1000 seed weight (0.154g) and it was found to be statistically at par with cv. 'Monstrosa Double Mix' (0.152 g). While, significantly minimum 1000 seed weight (0.127g) was exhibited by cv. 'Pompontte Rose' and was found to be significantly lowest.

Interactive effects of altitudinal gradients and cultivars had exhibited non significant effects on 1000 seeds weight (Appendix-II). However, 1000 seed weight noted to be highest (0.160 g) in the interaction, AG-1 x C_2 i.e. when plants of cv. 'Monstrosa Double White' were planted at Dhaulakuan farm. Whereas, minimum 1000 seed weight (0.125 g) was noted in the interaction, AG-3 × C_4 i.e. when plants of cv. 'Pomponette Rose' were grown under the altitudinal gradient of Floriculture farm.

1000 seeds weight is an important parameter which decides the boldness of seeds. In general, greater the weight of thousand seeds, boldness of seeds would be towards higher side. So, seed weight is directly proportional to the boldness of seeds. It is also well documented that bold seeds are more vigorous. Boldness of seed might be due to superiority of genotypes as well as suitable environment factors. The results are in conformity with the findings of Munikrishnappa (2011) and Sultan and Nassour (2019).

4.12 SEED GERMINATION PERCENTAGE (%)

Data appended in the Table 4.12 indicated that different locations, cultivars and their interactions have significant effects on the germination percentage of seeds (Appendix- II).

As regards the effect of altitudinal gradients, maximum germination percentage (82.33 %) was recorded at Dhaulakuan farm which was found to be significantly highest among all the altitudinal gradients. Whereas, minimum germination percentage (75.83%) was observed in AG-3 (Floriculture farm) and it was found to be significantly lowest.

Among different cultivars, highest germination percentage (85.50%) was noted for cv. 'Monstrosa Double White' and it was found to be statistically equal with cv. 'Monstrosa Double

AG - 1 × C2

AG - 1 × C1

AG - 3 × C2

AG – 3 × C1

Plate -4: Comparative overview of maximum and minimum seed germination (%)

Mix' (84.67%) and cv. 'Pomponette Red' (85.00%). While least germination percent (67.17 %) was observed in cv. 'Single Meadow' and it was lowest significantly.

Table 4.12: Effect of altitudinal gradients on seed germination percentage (%) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	68.75 (56.00)	90.75 (72.35)	89.50 (71.12)	76.00 (60.65)	90.25 (71.94)	78.75 (62.54)	**82.33 (65.77)**
AG-2 (Khaltoo farm,Nauni)	68.00 (55.54)	83.50 (66.03)	84.00 (66.42)	76.00 (60.69)	86.25 (68.42)	75.75 (60.49)	**78.92 (62.93)**
AG-3 (Floriculture farm, Nauni)	64.75 (53.57)	82.25 (65.09)	80.50 (63.79)	73.00 (58.68)	78.50 (62.37)	76.00 (60.70)	**75.83 (60.70)**
Mean	**67.17 (55.04)**	**85.50 (67.82)**	**84.67 (67.11)**	**75.00 (60.01)**	**85.00 (67.58)**	**76.83 (61.24)**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	1.13			
Cultivars(C)			:	1.60			
Altitudinal gradients × Cultivars			:	2.78			

*Figures in the parenthesis are angular transformed values

Interaction effects of location and cultivars exhibited on seed germination percentage was found to be significant (Appendix-II). The interaction, AG-1 × C_2 showed maximum seed germination percentage (90.75%) *i.e.* when plants of cv. 'Monstrosa Double White' were grown at Dhaulakuan farm and the interaction was found to be statistically at par with AG-1 × C_3 (89.50%) and AG-1 × C_5 (90.25%). However, AG-3 × C_1 exhibited minimum germination percentage (64.75%) i.e. when cv. 'Single Meadow' was grown at floriculture farm (AG-3) and was found to be significantly lowest.

Seed germination is one of the key parameters to determine the physiological aspects of seed quality. It gives an idea about the ability of seeds to produce normal, healthy and stocky seedlings in the nursery and under field conditions. Monstrosa Double White cultivar had produced better quality seeds seedling grown at Dhaulakuan Farm exhibited highest seed germination percent which may be ascribed to the reasons that seeds obtained from large flowers that have sufficient food reserves produced healthy and bold seeds which ultimately resulting better seed germination. The variation in seed germination percentage might be due to genetic makeup and variation in the environmental factors during production. Similar results have also been reported by Bajad *et al.* (2018).

4.13 SEEDLING LENGTH (cm)

An appraisal of data in Table 4.13 reveals that seedling length of the seed lots of English daisy cultivars grown under the selected altitudinal gradients of Dhaulakuan, Khaltoo farm and Floriculture farm has been influenced significantly with effects of altitudinal gradients, cultivars and their interactions as well (Appendix-II).

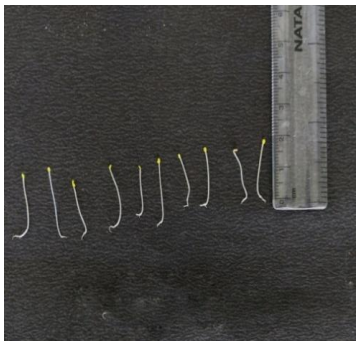
As far as the effects of different altitudinal gradients on length of the seedlings is concerned, the seedlings produced under Dhaulakuan conditions (AG-1) were the longest (2.45 cm) and was found to be significantly tallest. In contrast, the seedling length observed for the seed lot grown under Floriculture farm (AG-3) conditions was the shortest (2.20 cm) significantly.

Among different cultivars, 'Monstrosa Double White' had produced longest seedlings (2.59 cm) which was at par with cv. 'Monstrosa Double Mix' (2.55 cm). Whereas, cv. 'Pomponette Rose' produced the shortest seedlings (2.09 cm) which was at par with seedling length observed in cv. 'Pomponette Mix' (2.12 cm).

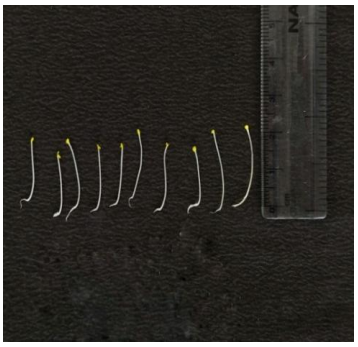
Table 4.13: Effect of altitudinal gradients on seedling length (cm) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	2.41	2.75	2.73	2.18	2.43	2.23	**2.45**
AG-2 (Khaltoo farm,Nauni)	2.22	2.54	2.59	2.06	2.19	2.09	**2.28**
AG-3 (Floriculture farm, Nauni)	2.20	2.49	2.35	2.02	2.12	2.04	**2.20**
Mean	**2.27**	**2.59**	**2.55**	**2.09**	**2.25**	**2.12**	
$CD_{0.05}$: Altitudinal Gradients (AG) : 0.04							
Cultivars(C) : 0.06							
Altitudinal gradients × Cultivars : 0.10							

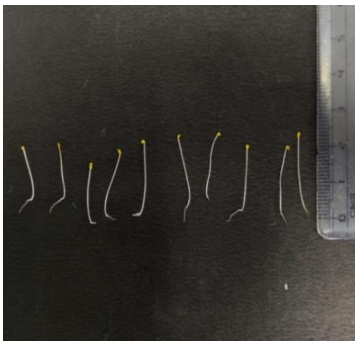
The interaction between cultivars and locations revealed that maximum seedling length (2.75cm) was observed in the interaction AG-1 × C_2 i.e. when seeds of cultivar 'Monstrosa



AG-1×C1

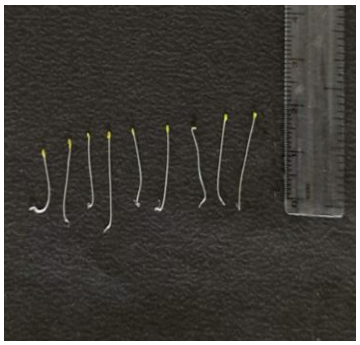


AG-1×C2

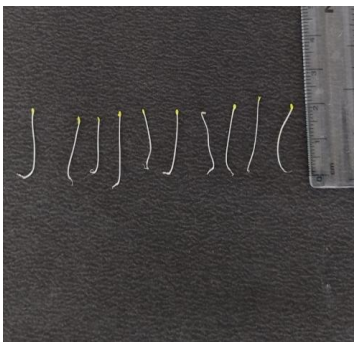


AG-1×C3

AG-1×C4



AG-1×C5



AG-1×C6

Plate -5 : An overview of seedling length (cm) for best altitudinal gradient

Double White' were taken from Dhaulakuan Farm and was statistically matchable with interaction AG-1 × C_3 (2.73 cm) . On another note, seedlings of the shortest length (2.02 cm) were observed in the interaction AG-3 × C_4 i.e. when seeds of cv. 'Pomponette Rose' were collected from floriculture farm and was found to be statistically at par with the seedling length of interactions AG-3 × C_5 (2.12 cm), AG-3 × C_6 (2.04 cm), AG-2 × C_4 (2.06 cm) and AG-2 × C_6 (2.09 cm).

The overall seedling length is function of root and shoot length. It indicates growth rate and growth habit of the genotypes. Seedling length has direct correlation with seed vigour during the germination process. The seed which produce taller seedling are considered to be more vigorous than those which produce shorter seedlings. Similar findings were also reported by Panwar *et al*. (2020) in pea. Increasing trend of seedling length in the cultivars was accompanied with good germination capacity of the seeds which in turn depends on the genetic make-up of the plant and is a varietal character. This variation in the length of seedlings might be due to inherent genotypic variation, which expressed suitably under favourable environmental conditions. Such observations were also recorded by Gowda (1990) and Mathad *et al.* (2008) in aster.

4.14 SEEDLING DRY WEIGHT (mg)

The data concerning to seedling dry weight revealed significant differences due to cultivars, altitudinal gradients and their interaction effects and have been presented in Table 4.14.

In concern with the influence of altitudinal gradients, maximum seedling dry weight (0.114 mg) was recorded in the seedlings of seed lot of Dhaulakuan farm. While, minimum value for the same parameter (0.104 mg) was recorded in the seeds of plants at the Floriculture (AG-3) conditions and was statistically at par with seeds of Khaltoo farm (0.108 mg).

Among different cultivars, 'Monstrosa Double Mix' produced seedlings with the highest dry weight (0.120 mg) and found to be statistically at par with cv. 'Monstrosa Double White' (0.119 mg). In contrast, cv. 'Pomponette Rose' produced seedlings with the minimum dry-weight (0.097 mg) which was at par with seedling dry-weight of cv. 'Pomponette Mix' (0.098 mg).

Table 4.14: Effect of altitudinal gradients on seedling dry weight (mg) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	0.120	0.129	0.127	0.100	0.105	0.101	**0.114**
AG-2 (Khaltoo farm,Nauni)	0.110	0.120	0.119	0.097	0.106	0.099	**0.108**
AG-3 (Floriculture farm, Nauni)	0.108	0.111	0.113	0.094	0.105	0.095	**0.104**
Mean	**0.112**	**0.120**	**0.119**	**0.097**	**0.105**	**0.098**	
$CD_{0.05}$: Altitudinal Gradients (AG) : 0.002							
Cultivars(C) : 0.003							
Altitudinal gradients × Cultivars : 0.005							

As regards interaction effects of altitudinal gradients and cultivars, maximum seedling dry weight (0.129 mg) was in the interaction, AG-1 × C_2 i.e. when seeds of cultivar 'Monstrosa Double White' were taken from Dhaulakuan farm and found to be statistically at par with the interaction, AG-1 × C_3 (0.127 mg). However, seedlings with least dry weight (0.094 mg) were observed in the interaction, AG-3 × C_4 i.e. when seeds of cultivar 'Pomponette Rose' were collected from Floriculture farm and was found to be statistically similar with the interactions AG-3 × C_6 (0.095 mg), AG-2 × C_4 (0.097 mg) and AG-2 × C_6 (0.099 mg) respectively.

Seedling dry weight is a measure of total accumulation of dry matter in the seedlings. Higher value of seedling dry weight might be attributed to more vigorous nature of the seeds. Seedling dry weight is an important attribute which determines vigour of the seedlings. Plants grown in the favourable conditions produce healthy and bold seeds which in turn resulted in higher value of dry weight. Hence, seedling dry weight is an important character as it is directly correlated to seed vigour (Raturi, 2013). Seed lot having higher seedling dry weight is considered to have higher vigour (Tirakannanavar *et al.*, 2004). Such type of variations might be due to genetic differences among different cultivars. Similar findings were also reported by Panwar *et al.* (2020) in pea.

4.15 SEED VIGOUR INDEX-I (Length)

The data presented in Table 4.12 reveal that there are significant differences among English daisy cultivars grown under three different altitudinal gradients namely, Dhaulakuan, Floriculture farm and Khaltoo farm, Nauni for seed vigour index-I (Appendix-II).

Among the different altitudinal gradients selected at different locations, significantly highest seed vigour index-I (203.20) was recorded for the seeds of plants grown under Dhaulakuan conditions. However, minimum seed vigour index-I (167.54) was recorded in the seeds collected from Floriculture farm and found to be significantly lowest.

Among the varieties evaluated, highest seed vigour index-I (222.06) was recorded for seeds of cv. 'Monstrosa Double White' and was detected to be statistically at par with cv. 'Monstrosa Double Mix' (216.84). However, lowest seed vigour index-I (152.88) was recorded for seeds of cv. 'Single Meadow' followed by cv. 'Pomponette Rose' (156.59).

Table 4.15: Effect of altitudinal gradients on seed vigour index-I (length) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	165.33	249.27	244.28	165.65	218.79	175.86	**203.20**
AG-2 (Khaltoo farm,Nauni)	150.87	211.84	217.43	156.43	188.74	158.36	**180.61**
AG-3 (Floriculture farm, Nauni)	142.45	205.08	188.81	147.69	166.44	154.79	**167.54**
Mean	**152.88**	**222.06**	**216.84**	**156.59**	**191.32**	**163.00**	
$CD_{0.05}$: Altitudinal Gradients (AG)			:	4.51			
Cultivars(C)			:	6.38			
Altitudinal gradients × Cultivars			:	11.05			

The interaction between altitudinal gradients of different locations and cultivars revealed that significantly higher seed vigour index–I (249.27) was recorded with the interactive effects of AG-1 × C_2 i.e. when cv. 'Monstrosa Double White' produce seeds at altitudinal gradient of Dhaulakuan farm which was at par with the interactive effects of AG-1 × C_3 (244.28) . However,

minimum seed vigour index-I (142.45) was observed in the interactions AG-3 × C_1 i.e. when seeds of cv. 'Single Meadow' were collected from Floriculture farm.

Seed vigour determines the potential for rapid and uniform emergence of plants under a wide range of field conditions. Increase in the seedling vigour index might be due to higher seed germination and more seedling length (i.e. more values for length of roots and shoots. The variation in the quality of parameters might be due to inherent genotypic variation and suitable favourable environmental conditions for growing of plants for seed parameters (Pramila *et al.*, 2011). Such observations were also recorded by Gowda (1990) and Mathad *et al.* (2008) in China aster.

4.16 SEED VIGOUR INDEX-II (mass)

The data in Table 4.16 concerning to seed vigour index-II (mass) revealed significant differences due to cultivars, altitudinal gradients namely Dhaulakuan farm, Floriculture farm, Nauni and Khaltoo farm, Nauni and their interaction effect (Appendix-II)**.**

Among the different altitudinal gradients selected at different locations, highest seed vigour index-II (9.39) was recorded in AG-1 (Dhaulakuan farm) which was detected to be significantly highest. In contrast, least seed vigour index-II (7.92) was recorded in the seeds of AG-I (Floriculture farm).

Among the different cultivars evaluated, maximum value for seed vigour index-II (10.28) was recorded in the seeds of cv. 'Monstrosa Double White' which was found to be statistically at par with the seed vigour index-II (10.14) of cv. 'Monstrosa Double Mix'. However, lowest value for seed vigour index-II (7.28) was recorded in the seeds of cv. 'Pomponette Rose' and found to be statistically at par with seed vigour index-II of cv. 'Single Meadow' (7.56) and cv. 'Pomponette Mix' (7.57), respectively.

The interaction between altitudinal gradients of different locations and varieties revealed that significantly higher seed vigour index–II (11.71) was recorded in the interaction, AG-1 × C_3 i.e. seeds of cv. 'Monstrosa Double White' obtained from altitudinal gradient of Dhaulakuan location, which was at par with the interactive effects of AG-1 × C_2 (11.39). However, lowest

seed vigour index-II (6.88) was observed in the interaction, AG-3 × C_4 i.e. when seeds of cv. 'Pomponette Rose' were produced at altitudinal gradient of Floriculture farm of Nauni and was found to be matchable with the interactions AG-2 × C_4 (7.39), AG-2 × C_6 (7.52) and AG-3 × C_6 (7.22).

Table 4.16: Effect of altitudinal gradients on seed vigour index-II (mass) of English daisy cultivars

Cultivars / Altitudinal Gradients	C_1 (Single Meadow)	C_2 (Monstrosa Double White)	C_3 (Monstrosa Double Mix)	C_4 (Pomponette Rose)	C_5 (Pomponette Red)	C_6 (Pomponette Mix)	Mean
AG-1 (RHR&TS, Dhaulakuan)	8.22	11.71	11.39	7.56	9.46	7.98	**9.39**
AG-2 (Khaltoo farm,Nauni)	7.47	10.00	9.96	7.39	9.11	7.52	**8.57**
AG-3 (Floriculture farm, Nauni)	7.00	9.13	9.06	6.88	8.20	7.22	**7.92**
Mean	**7.56**	**10.28**	**10.14**	**7.28**	**8.92**	**7.57**	
$CD_{0.05}$: Altitudinal Gradients (AG) : 0.27							
Cultivars(C) : 0.38							
Altitudinal gradients × Cultivars : 0.65							

Das et al. (2018) studied seed germination and seedling vigour index in *Bixa orellana* and *Clitoria ternatea* and concluded that the increase in vigour index shows a parallel relationship to the corresponding enhancement of germination percentage. The gradual increase in germination percentage and vigour index in seeds harvested from various farms can be attributed to intraspecific variations and physiological maturity of seeds. These results are in conformity with those results of Pramila *et al.*, 2011 obtained in marigold.

❖ SWOT (Strengths, Weakness, Opportunities and Threats) Analysis:

SWOT analysis of English daisy seed production is done on the basis of our experience during trial and interview of Mr. Kuljeet Singh who is currently farm manager of biocarve seeds (Biocarve seeds is a flower seeds company located at Sugar Mill Road, Village Dhablan, Patiala, Punjab 147-001). The details of interview are also discussed below. The questions asked in the

interview are mentioned in Appendix-III. Analysed SWOT results have been described as follows:

Strengths	**Weaknesses**
• Preferred winter season annual • Regular seed demand • Visible long term impact in terms of profit	• Highly labour intensive • Time consuming post harvest technology • Small seeded crop
Opportunities	**Threats**
• Elevated demand in market • Employment generation • International market	• Non suitable environment • Elevated market competition

Strengths:

English daisy is commonly used as edging plant in different gardens. It is one of the most common annuals grown in home gardens. Different cultivars are grown for their different colours as preferred by the growers. People grow English daisy in their home gardens as a winter season annual for beautification purpose. Another commercial aspect of English daisy cultivation is its seed production as there is high demand in the market for its seeds because it is mainly propagated by seeds in nurseries for raising seedlings which are further sold to customers. English daisy can be grown directly from seeds but due to small size of seeds nursery sowing is done for raising seedlings which are further transplanted in fields or gardens. Producers have visualized long term impact in terms of its seed production which can lead to huge profit in lesser area.

Weakness:

Cultivation of English daisy for seed production requires high labour. For better quality seed production skilled labour is required which is difficult to find. Seeds of English daisy are very minute and light requiring proper handling after harvesting. As seeds are very small it requires more time in post harvest operations such as cleaning. Small seeded crops are also not preferred by farmers to grow as their seeds are difficult to collect as they are prone to shattering.

Opportunities:

Ornamental annuals are commercially propagated through seeds. There is high demand of English daisy seeds as it is also one of the most commonly grown winter season annual grown in

gardens for beautification purpose. Cultivation of English daisy for seed production generates more employment because of its high labour requirement. People in developed countries like USA, Holland, Germany, Italy and Canada etc. prefer to grow annuals in their home gardens due to which there is high demand of ornamental annual seeds in foreign markets. This opens doors of Indian ornamental seed industry to international markets. Farmers can fetch high prices for seeds in international markets as compared to local markets which will make seed production of ornamental annuals a more profitable venture in coming days than it is now.

Threats:

English daisy is a seasonal crop. It is commonly grown in winter seasons and harvested from spring onwards. Environment plays an important role in production of better quality seeds. Unfavourable environment during cultivation period leads to less seed yield and poor quality seed production. Poor quality seeds will fetch low prices in market and will ultimately lead to losses or less profit. Increase in market competition will also lead to less profit.

To know about commercial marketing and cultivation aspect of English daisy flower and seed production in market we did a telephonic interview of Mr. Kuljeet Singh who is currently a farm manager of Biocarve seeds.The details of the company are as follows:

Biocarve seeds is a flower seeds company located at Sugar Mill Road, Village Dhablan, Patiala, Punjab 147-001. The company is producing high quality flower, vegetables and cereal crop seeds since 1993.

Following were the questions asked in the interview:

- We asked him in how much area do you cultivate English daisy for seed production?
  - He answered that they cultivate English daisy in about 30 acres of land. Contract farming is done by combining with farmers.
- Another question asked was that how much profit do you get from one acre land in a single season?
  - The respondent said that profit of about 1.5 lakh Rs can be easily obtained from one acre of land in a single season.
- We also asked him that how many varieties does the company grows?

- He responded that company grows six to eight varieties of English daisy for seed production.
- Next question asked was related to previous one, which among the grown varieties is sold maximum and minimum and what are the possible reasons for it?
- The respondent was of opinion that sale of all the varieties are equal. Different varieties have different colours and characters. Different consumers choose different varieties for growing based on their preferences and requirements.
- We also asked him that how do you collect and process seeds?
- The respondent told that labour collect seed heads from the field and cleaning and packaging of seeds is done with the help of machines. As the seeds are very small it takes more time as compared to bolder seeds.
- Question regarding challenges faced by the company in English daisy flower cultivation was asked.
- The respondent said that availability of labour is the only challenge faced by them.
- Another question asked was that do you export English daisy seeds to foreign countries? If yes then to which countries maximum seed is exported?
- The respondent said that yes seed is exported to various countries. USA and Holland are primary consumers of their seeds as there is more demand of ornamental annuals.
- Question about impact of corona on sales of company was also asked.
- The respondent answered that there was minor influence of corona on seed production of English daisy. He said that sales were affected during complete lockdown due to cessation of transport facilities. After that it came to normal.
- We asked him from his point of view what are strengths of English daisy seed production?
- He replied that according to him seed production of English daisy can make farmers earn more profits in small areas as compared to other agricultural crops.
- Next we asked him about the weaknesses of English daisy seed production?
- The respondent answered that labour requirement is the only drawback or weakness of English daisy seed production.

Chapter-5

SUMMARY AND CONCLUSION

The present investigation entitled, **"Evaluation of *Bellis perennis* L. cultivars under different altitudinal gradients in Himachal Pradesh"** was conducted at three altitudinal gradients selected at different locations in Himachal Pradesh during 2020-2021. The selected locations are as follows:

1. Regional Horticulture Training and Research Station, Dhaulakuan, Sirmaur (468 m amsl).
2. Experimental Farm at Khaltoo, Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (1060 m amsl).
3. Research Farm of the Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (1276 m amsl).

The experiment was carried out during the period December, 2020 to June, 2021 by growing six cultivars ('Single Meadow', 'Monstrosa Double White', 'Monstrosa Double Mix', 'Pomponette Rose', 'Pomponette Red' and 'Pomponette Mix') of English daisy under three different altitudinal gradients. The results obtained from the present investigation are summarized as under:

- Among three altitudinal gradients selected at different locations, planting of English daisy cultivars at altitudinal gradient of RHR&TS, Dhaulakuan farm (AG -1) resulted in earliest first flowering (53.94 days) and full blooming (96.46 days) and also showed superior results w.r.t. plant height (21.20 cm), flower head diameter (3.15 cm), flower heads per plant (67.92), number of seeded heads per plant (47.14), number of seeds per head (217.79), seed yield per plant (1.43 g), seed yield per plot /per hectare (22.83 g / 171.25 kg), 1000 seed weight (0.143 g), seed germination percentage (82.33%), seedling length (2.45 cm), seedling dry weight (0.114 mg), seed vigour index-I (203.20) and seed vigour index-II (9.39). However, planting of English daisy plants at altitudinal gradient of floriculture farm i.e. AG- 3 showed maximum duration of flowering (66 days).

- Among different cultivars evaluated cv. 'Pomponette Red' gave better results w.r.t. days taken to first flowering (54.27 days) and maximum duration of flowering (64.35 days) as well. Whereas, cv. 'Single Meadow' performed better w.r.t. days taken to full blooming (100.87 days), plant height (28.89 cm), number of flower heads per plant (143.25), number of seeded heads per plant (96.85), seed yield per plant (2.97 g) as well as seed yield per plot and per hectare (47.53 g and 356.51 kg) and cv. 'Monstrosa Double White' resulted in highest values w.r.t. flower head diameter (4.44 cm), number of seeds per head (296.55), seed germination percentage (85.50 %), seedling length (2.59 cm), seedling dry weight (0.120 mg), seed vigour index-I (222.06) and seed vigour index-II (10.28) and was statistically at par with cv. 'Monstrosa Double Mix'

- Results of interactions of different altitudinal gradients and cultivars of English daisy:
  - The interaction, AG-1 × C_1 i.e. growing of cv. 'Single Meadow' under Dhaulakuan farm exhibited best performance w.r.t. days for full blooming (92.73 days), plant height (30.76 cm), flower heads per plant (146.85), number of seeded heads per plant (100.03), seed yield per plant (3.18 g) and seed yield per plot and per hectare (50.87 g and 381.50 kg).
  - Interaction, AG-1 × C_5 i.e. growing of English daisy cv. 'Pomponette Red' at altitudinal gradient of Dhaulakuan farm took minimum days to first flowering (46.53 days).
  - Interaction, AG-3 × C_5 i.e. when cv. 'Pomponette Red' was grown at altitudinal gradient of Floriculture farm resulted in maximum duration of flowering (69.70 days) among all the interactions
  - Interaction AG – 1 × C_2 i.e. growing of cv. 'Monstrosa Double White' at Dhaulakuan farm resulted in production of better flower head diameter (4.62 cm), number of seeds per head (299.24), 1000 seed weight (0.158 g), seed germination percentage (90.75%), seedling length (2.75 cm), seedling dry weight (0.129 mg) seed vigour index-I (249.27) and seed vigour index-II (11.71) and these results were closely followed by the interaction, AG -1 × C_3 i.e. growing of cv. ' Monstrosa Double Mix' at altitudinal gradient of Dhaulakuan.

CONCLUSION

- From the study undertaken, it is concluded that among different altitudinal gradients selected at different locations, altitudinal gradient of Dhaulakuan (468 m amsl) was found better w.r.t. various parameters of growth, flowering, seed yield and quality of English daisy as compared to other altitudinal gradients. However, planting time of *Bellis perennis* L. should be standardized as per zones for better plant growth, flowering, seed production and seed quality at different locations.
- Among different cultivars evaluated, best performance was exhibited by cv. 'Single Meadow' w.r.t. various growth flowering and seed yield parameters. However, best seed quality was found in cv. 'Monstrosa Double White' closely followed by cv. 'Monstrosa Double Mix'.
- Among the interaction effects of Altitudinal gradients and English daisy cultivars evaluated, best performance was observed in AG-1 × C_1 i.e. growing of cv. 'Single Meadow' under Dhaulakuan farm w.r.t. plant growth, flowering and seed yield whereas best seed quality was reported in interaction AG-1 × C_2 i.e. growing of cv. 'Monstrosa Double White' at Dhaulakuan Farm.

LITERATURE CITED

Abdul-Baki A A and Anderson J D. 1973. Vigour determination in soyabean seed by multiple criteria. *Crop Science* **13**:630-633.

Agarwal R L. 2018. *Seed Technology*.2nd edition. Oxford and IBH Publishing Company Pvt. Limited, New Delhi. 536p.

Anonymous. 1985. ISTA (International Seed Testing Association). International rules for seed testing. *Seed Science and Technology* **13**:300-520.

Atal H L, Bairwa H L, Mahawer L N and Regar A L. 2019. Studies on performance of China aster[*Callistephus chinensis* (L.) Nees] varieties in southern Rajasthan agro-climatic conditions. *Journal of Ornamental Horticulture* **22**:33-37.

Bailey D A. (1998). Winter annual trial summary. *North Carolina Flower Growers' Bulletin*. **4**: 10-14.

Bajad A A, Sharma B P, Gupta Y C, Dilta B S and Gupta R K. 2018. Effect of different planting times and mulching materials on seed quality and yield of China aster cultivars . *Journal of Pharmacognosy and Phytochemistry* **1**:3106-12.

Behera T K, Sirohi P S and Pal A. 2002. Assessment of chrysanthemum germplasm for commercial cultivation under Delhi condition. *Journal of Ornamental Horticulture* **5:**11-14.

Bhargav V, Kumar R, Rao T M, Bharathi T U, Dhananjaya M V, Kumar S, Babu K R and Kumari P 2018. Evaluation of China aster [*Callistephus chinensis* (L.) Nees] F_1 hybrids and their parents for qualitative and quantitative traits. *International Journal of Current Microbiology and Applied Sciences* **7**:1654-61.

Bhattarai B, Maitra S and Thockchom R. 2019. Assessment of height, earliness and biomass production in selected winter flowering ornamental annuals for better utilization in landscaping. *The Pharma Innovation Journal* **8**:59-64.

Byadwal R K, Meena M K, Chauhan S and Rundla S K. Performance of different genotypes of gaillardia (*Gaillardia pulchella* Foug.) in respect to flowering, quality and yield parameter. *Journal of Pharmacognosy and Phytochemistry* **7**:2697-2700.

Chakraborty A, Bordolui S K, Mahati M K, Sadhukan R and Sri Veda D J M S N K. 2019. Variation in seed production potential of China aster genotypes in the new alluvial zone of West Bengal. *Journal of Crop and Weed.* **15**:201-04.

Chourasia A, Viradia R R, Ansar H and Madle S N. 2015. Evaluation of different gladiolus cultivars for growth, flowering, spike yield and corm yield under Sarashtra region of Gujarat. *The Bioscan* **10**:131-34.

Chowdhuri T K, Rout B, Sadhukan R and Mondal T. 2016. Performance evaluation of different varieties of China aster [*Callistephus chinensis* (L.) Nees] in sub-tropical belt of West Bengal. *International Journal of Pharmaceutical Science Invention* **5**:15-18.

Craufurd P Q and Wheeler T R. 2009. Climate change and the flowering time of annual crops. *Journal of Experimental Botany* **60**:2529-39.

Das A, Mandal S and Nag S. 2018. Seed germination of annatto (*Bixa orellana* L.)- A review . *International Journal of Recent Scientific Research.***9**:26257-60.

Desevedavy C, Amoros M, Girre L, Lavaud C and Massiot G. 1989. Antifungal agents: *in vitro* and *in vivo* antifungal extracts from the common daisy, *Bellis perennis. Journal of Natural Products.* **52**:184-185.

Dewan N, Kumar S, Sharma S and Chakraborty S. 2016. Evaluation of chrysanthemum (*Chrysanthemum morifolium* Ramat.) genotypes under West Garo Hills District, Meghalaya. *HortFlora Research Spectrum* **5**:189-94.

Dhatt K K and Kumar R. 2007. Effect of planting time and spacing on growth, flowering and seed yield in *Coreopsis lanceolata* and *Coreopsis tinctoria. Journal of Ornamental Horticulture.* **10**:105-9.

Dhatt K K and Kumar R. 2010. Effect of planting time and growth regulators on growth and seed quality parameters of Larkspur. *Journal of Ornamental Horticuture* **13**:50-54.

Dierig D A, Adam N R, Mackey B E, Dhalquist G A and Coffelt T A. 2005. Temperature and elevation effects on plant growth, development and seed production of two *Lesquerella* species. *Industrial Crops and Products* **24**:17–25.

Girange R R, Charjan S U, Jadhav G N, Bhaskarwar A C, Ghube N N and Lambat A P. 2016. Evaluation of different genotypes of Gaillardia for growth, flowering and yield parameters. *International Journal of Agriculture Science and Research* **6**:301-06.

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

Gowda J V N. 1990. Effect of time of planting on growth and flower production in China aster [*Callestephus chinensis* (L.) Nees]. *Mysore Journal of Agricultural Sciences* **24**:72-78.

Gupta A K, Jaiswal N K and Saravanan S. 2015. Varietal evaluation of different hybrids of Dahlia (*Dahlia variabilis* L.) under Allahbad agro-climatic conditions. *Indian Journal of Agricutural Science and Research* **5**:55-58.

Jangde T, Sharma G, Jangde B and Banjara N C. 2019. Evaluation of gerbera (*Gerbera jamesonii*) cultivars under naturally ventilated polyhouse in Chhattsigarh plain. *Jounal of Pharmacognosy and Phytochemistry* **8**:2112-14.

Jin-Bo, Wang Y X and Liu C.1995. Breeding and selection of annual and biennial ornamental plants. *Acta Horticulturae Sinica.* **22**:97-98.

Khanal B. 2014. Effects of growing conditions of marigold in Ilam District, Nepal. *American Journal of Plant Sciences*. **5**:3389-95.

Khanvilkar M H, Kokate K D, Mahalle S S. 2003. Performance of African marigold (*Tagetes erecta*) in North Konkan coastal Zone of Maharashtra. *Journal of Maharashtra Agricultural Universities* **2**:333- 34.

Kireeti A, Ravindrababu M, Prasad O J and Ramadevi P. 2017. Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev) varieties in humid coastal zone of Andhra Pradesh *International Journal of Chemical Studies* **5**:370-72.

Kumar R and Kaur K. 2000. Effect of planting time and cultivars on growth, flowering and seed yield in phlox (*Phlox drumondii*). *Seed Research* **28**:23–6.

Kumar R and Kaur K. 2001. Effect of time of planting and nitrogen on coreopsis. *Journal of Ornamental Horticulture* **4**:57–8.

Kumar R, Ahmed N, Lal S and Mahendiran G. 2014. Evaluation of gerbera genotypes for cutflower production for different growing conditions of Kashmir. *Indian Journal of Horticulture* **7**:138-141.

Kumar A, Dubey P, Patanwar M and Sharma R. 2015. Evaluation of chrysanthemum varieties for loose flower production in Chattisgarh plains. *Trends in Biosciences.***8**:175-77.

Kumar R, Thakur P, Gupta Y C, Joshi A K, Sharma P, Sharma A and Singh S. 2021. Evaluation of dahlia (*Dahlia variabilis* L.) cultivars for growth and flowering characteristics under sub-montane, sub-tropical low hill zone of Himachal Pradesh. *International Journal of Farm Sciences* **11**:19-23.

Kumar R. 2014. Evaluation of chrysanthemum genotypes for flowering traits under open grown conditions. *HortFlora Research Spectrum* **1**:24-28.

Kumar S V, Pandiyaraj P and Theresa K. 2017. Collection and evaluation of China aster (*Callistephus chinensis* L. Nees.) varieties for enhanced yield and quality under tropical condition of Tamil Nadu. *Research in Environment and Life Sciences* **10**:418-20.

Mahantesh K K, Prasanth P, Chandrashekhar R, Saidaih P, Siddappa and Umesh B C. 2018. Evaluation of different African marigold (*Tagetes species* Linn.) genotypes for vegetative, floral and yield attributes under Southern Telangana condition. *International Journal of Chemical Studies* **6**:3311-15.

Mahawer L N, Kumar L, Shukla A K and Bairwa H L. 2010. Evaluation of Dahlia cultivars under Aravalli hill conditions of Udaipur. *Indian Journal of Horticulture* **67**:234-37.

Manjula B S, Nataraj S K, Hegde P P, Anitha G and Ayesha N. 2017. Evaluation of Dahlia genotypes (*Dahlia variabilis* L.) for growth, yield and quality traits under hill zone of Karnataka. *Environment & Ecology* **35**:3158-61.

Mathad R C, Vyakaranahal B S and Deshpande V K. 2008. Influence of planting dates and picking stages on seed yield and quality in aster [*Callestephus chinensis* (L.) Nees] genotyopes. *Indian Journal of Agricultural Research* **42**:224-27.

Misra R L and Misra S (eds.). 2017. Commonly used ornamental plants. Kruger Brent Publishers UK. pp.113.

Morikawa T, Li X, Nishida E, Nakamura S, Ninomiya K, Matsuda H, Muraoka O, Hayakawa T and Yoshikawa M. 2011. Medicinal flower of *Bellis perennis. Chemical and Pharmaceutical Bulletin* **59**:889-95.

Munikrishnappa P M, Patil A A, Patil V S, Patil B N, Channappagoudar B B and Alloli T B. 2013. Studies on the growth and yield parameters of different genotypes of China aster (*Callistephus chinensis* Nees.). *Journal of Agricultural Science* **26**:107-10.

Munikrishnappa P M. 2011. Study on the standardization of production technology in China aster under transitional tract of North Karnatka. Ph. D Thesis, University of Agriculture Sciences, Dharwad.

Naik V P, Seetaramu G K, Tejaswani and Teggeli G R. 2019. Evaluation of marigold (*Tagetes erecta* L.) genotypes for flower yield and xanthophylls content under for North Eastern dry zone of Karnatka. *International Journal of Chemical Studies* **7**:1571-1573.

Narsude P B, Kadam A S and Patil V K. 2010. Studies on the growth and yield attributes of different African Marigold (*Tagetes erecta* L.) genotypes under Marathwada condition. *The Asian Journal of Horticulture* **5**:284-86.

Negi R, Dhiman S R, Dhiman M R, Gupta Y C, Dogra R K and Gupta R K. 2020. Performance and flower characterization of newly evolved genotypes of chrysanthemum (*Dendrenthema grandiflora* Tzvelev) for cut flower production. *International Journal of Chemical Studies* **8**: 2921-23.

Negi R, Jarial K, Kumar S and Dhiman S R. 2015. Evaluation of different cultivars of chrysanthemum suitable for low hill conditions of Himachal Pradesh. *Journal of Hill Agriculture* **6**:144-46.

Pandey R K, Bhat D J I, Dogra S, Singh A, Laishram N and Jamwal S. 2012. Evaluation of gladiolus cultivars under subtropical conditions of Jammu. *International Journal of Agricultural Sciences* **8**:518-22.

Pandey R, Singh B K, Singh R, Baksh H, Pandey P and Pandey M. 2018. Impact of climatic condition in horticultural crop production. *International Journal of Engineering Scence and Advanced Research* **4**:14-20.

Panwar A, Mishra A C, Negi S, Negi S and Sajwan P. 2020. Studies on seed quality parameters in different genotypes of vegetable Pea (*Pisum sativum* L.) in mid hills of Uttarakhand, India. *International Journal of Current Microbiology and Applied Sciences* **9**:243-252.

Patil S, Mishra A, Nagar K K and Kumar C. 2017. Evaluation of chrysanthemum (*Chrysanthemum morifolium* Ramat.) varieties for flowering traits under ecological conditions of sub-humid zone of Rajasthan. *Chemical Science Review and Letters* **6**:1338-42.

Pato J and Obeso J R. 2012. Growth and reproductive performance in Billberry (*Vaccinium myrtillus*) along an elevation gradient. *Eco Science* **19**:59-68.

Prabhu G, Thamaraiselvi S P, Aruna P, R Sudhakar R. 2018. Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev) genotypes for loose flower production under Coimbatore conditions. *International Journal of Chemical Studies* **6**:1618-21.

Pramila C K, Prasanna K P R, Jayanth R and Ramachandra R. 2011. Seed production in marigold with special reference to seasons. *International Journal of Agricultural Sciences* **7**: 400-03.

Raghupati B, Sarkar M M, Karim K B and Sil M.. 2017. Varietal evaluation of medium decorative Dahlia (*Dahlia variabilis* L.) under subtropical plains of West Bengal. *Environment & Ecology* **35**:2786-89.

Raghuvanshi A, Sharma B P. 2011. Varietal evaluation of French marigold (*Tagetes patula* L.) under mid- hill zone of Himachal Pradesh. *Progressive Agriculture* **11**:123-26.

Rai T S and Chaudhary S V S. 2016. Evaluation of China aster (*Callistephus chinensis* (L.) Nees) cultivars under mid hill conditions of Himachal Pradesh. *The Bioscan* **11**: 2367-70.

Randhawa G S and Mukopadhyay A. 1986. *Floriculture in India*. Allied Publishers Private Limited, New Delhi. 660 p.

Raturi H C.2013. *Studies on seed priming in cucumber* (*Cucumis sativus* L.). Ph. D Thesis Department of Vegetable Science, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan. 238p.

Roopa S , Chandrashekar S Y, Shivaprasad M, Hanumantharaya L and Kumar H. 2018. Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev) genotypes for floral and quality traits under hill zone of Karnataka, India. *International Journal of Current Microbiology and Applied Sciences* **7**:1874-79.

Salve S, Bhalekar S G, Gawade N and Nilwaran Y. 2019. Performance of promising genotypes of gaillardia (*Gaillardia pulchella* L.) for yield attributes and storage study. *Journal of Pharmacognosy and Phytochemistry* **8**:1032-34.

Sarkar A, Sadhukan R and Chowdhuri T K. 2020. Varietal evaluation of China aster (*Callistephus chinensis* Nees.) in sub-tropical region of West Bengal. *International Journal of Current Microbiology and Applied Sciences* **9**:3726-36.

Sarkar I, Chakravorty S and Maitra S. 2014. Evaluation of gladiolus cultivars with respect to flowering attributes in Darjeeling hills of West Bengal, India. *Indian Journal of Agricultural Research* **48**:360-66.

Sharma P, Gupta Y C, Dhiman S R, Sharma P and Bhargava B. 2017. Effect of different planting dates on growth, flowering and seed production of candytuft (*Iberis amara*). *Indian Journal of Agricutural Sciences* **87**:792-5.

Sharma P, Gupta Y C, Dhiman S R, Sharma P and Gupta R. 2015. Effect of planting dates on growth flowering and seed production of garland chrysanthemum (*Chrysanthemum coronarium*). *Indian Journal of Agricultural Sciences* **85**:912-6.

Sharma R. 2012. Effect of seed priming and planting dates on growth and flowering of pansy *(Viola × wittrockiana Gams.)*. M. Sc. thesis, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan.

Sil M, Sarkar M M, Raghupati B and Mondal S. 2017. Varietal evaluation of Gerbera(*Gerbera jamesonii.*) grown in a polyhouse. *International Journal of Current Microbiology and Applied Sciences* **7**:810-14.

Singh P, Bhardwaj A, Kumar R, and Singh D. 2017. Evaluation of gerbera varieties for yield and quality under protected environmental conditions in Bihar. *International Journal of Current Microbiology and Applied Sciences.* **6**:112-16.

Srilatha V, Kumar K S and Kiran Y D. 2015. Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev) varieties in southern zone of Andhra Pradesh. *Agriculture Science Digest* **35**:155-57.

Srinivas P T, Rajasekharam T. 2020. Evaluation of marigold genotypes under tropical conditions of Tirupati. *International Archive of Applied Sciences and Technology* **11**:85-89.

Sultan M and Nassour M. 2019. Evaluation of some genotypes of China aster [*Callistephus chinensis* (L.) Nees.] under conditions of Syrian coast-Lattakia. *International Journal of Agriculture and Environmental Science* **6**:24-27.

Thakur N, Nair S A, Kumar R, Bharathi T U, Dhananjaya M V and Venugopalan R. 2018. Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev) for desirable horticultural traits. *International Journal of Current Microbiology and Applied Sciences* **7**:565-74.

Tirakannanavar S, Chavan M, Reddy D V B S and Kukanoor L. 2004. A study on seed quality parameters in different genotypes of China aster (*Callistephus chinensis*). *Journal of Ornamental Horticulture* **7**:125-27.

Vrsek I, Zidovec V and Fistric N. (2000). Seed production of several genera of biannual flowers. *Sjemenarstvo* **17**:199-208.

Yadav A, Sharma G and Dubey P. 2014. Flowering attributes of chrysanthemum varieties for loose flower production. *Progressive Horticulture* **46**:168-70.

Zosiamliana, J H, Reddy G S N and Rymbai H. 2013. Study on the performance of some varieties of China aster (*Callistephus chinensis* Nees.) in Andhra Pradesh. *Progressive Horticulture* **45**:312-16.

Zosiamliana J H, Reddy G S N and Rymbai H. 2012. Growth, flowering and yield characters of some cultivars of China aster (*Callistephus chinensis* Nees.). *Journal of Natural Product and Plant Resources* **2**:302-05.

APPENDIX –I

Mean monthly meteorological data of Regional Horticultural Research and Training Station, Dhaulakuan, Distt. Sirmaur, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) w.e.f. November 2020 to April 2021

Months	Rainfall (mm)	Temperature (°C)		
		Maximum	Minimum	Mean
November, 2020	25.00	28.60	10.50	19.55
December, 2020	24.00	24.80	7.20	16.00
January, 2021	18.00	23.70	6.90	15.3
February, 2021	8.20	25.10	8.20	16.65
March, 2021	20.50	30.10	10.30	20.20
April, 2021	100.40	33.60	12.80	23.20

Mean monthly meteorological data of Khaltoo Experimental Farm of Department of Seed Science and Technology, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) w.e.f. November 2020 to April 2021

Months	Rainfall (mm)	Temperature (°C)		
		Maximum	Minimum	Mean
November, 2020	36.90	23.90	5.80	14.85
December, 2020	24.20	22.01	2.60	12.31
January, 2021	21.00	20.60	2.40	11.50
February, 2021	61.20	23.50	4.80	14.15
March, 2021	14.70	27.40	9.20	18.30
April, 2021	64.90	29.60	10.00	19.80

Mean monthly meteorological data of Nauni Experimental Farm of Department of Floriculture and Landscape Architecture,Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) w.e.f. November 2020 to April 2021

Months	Rainfall (mm)	Temperature (°C)		
		Maximum	Minimum	Mean
November, 2020	37.70	23.10	5.20	14.15
December, 2020	23.80	20.70	2.20	11.45
January, 2021	21.30	20.50	2.00	11.25
February, 2021	59.70	23.00	4.50	13.75
March, 2021	14.80	26.80	9.00	17.90
April, 2021	65.90	28.90	9.80	19.35

APPENDIX –II

4.1 Analysis of variance (ANOVA) table for effect of altitudinal gradients on days taken to first flowering of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	1.270			
Altitudinal gradients	2	1,772.045	886.023	1,180.135	0.00000
Cultivars	5	1,623.777	324.755	432.557	0.00000
Altitudinal gradients ×Cultivars	10	28.675	2.867	3.819	0.00159
Error	34	25.527	0.751		
Total	53	3,451.294			

4.2 Analysis of variance (ANOVA) table for effect of altitudinal gradients on days taken to full blooming of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	2.759			
Altitudinal gradients	2	2,530.482	1,265.241	3,375.994	0.00000
Cultivars	5	458.475	91.695	244.666	0.00000
Altitudinal gradients ×Cultivars	10	16.724	1.672	4.462	0.00048
Error	34	12.742	0.375		
Total	53	3,021.182			

4.3 Analysis of variance (ANOVA) table for effect of altitudinal gradients on plant height (cm) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.141			
Altitudinal gradients	2	30.890	15.445	103.755	0.00000
Cultivars	5	864.252	172.850	1,161.161	0.00000
Altitudinal gradients ×Cultivars	10	13.015	1.302	8.743	0.00000
Error	34	5.061	0.149		
Total	53	913.359			

4.4 Analysis of variance (ANOVA) table for effect of altitudinal gradients on flower head diameter (cm) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.001			
Altitudinal gradients	2	0.723	0.361	400.880	0.00000
Cultivars	5	55.383	11.077	12,289.339	0.00000
Altitudinal gradients ×Cultivars	10	0.019	0.002	2.138	0.04844
Error	34	0.031	0.001		
Total	53	56.156			

4.5 Analysis of variance (ANOVA) table for effect of altitudinal gradients on duration of flowering (days) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.830			
Altitudinal gradients	2	1,067.668	533.834	908.382	0.00000
Cultivars	5	164.400	32.880	55.949	0.00000
Altitudinal gradients ×Cultivars	10	14.606	1.461	2.485	0.02334
Error	34	19.981	0.588		
Total	53	1,267.485			

4.6 Analysis of variance (ANOVA) table for effect of altitudinal gradients on number of flower heads per plant of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	3.696			
Altitudinal gradients	2	156.976	78.488	64.447	0.00000
Cultivars	5	70,180.340	14,036.068	11,525.058	0.00000
Altitudinal gradients ×Cultivars	10	30.976	3.098	2.543	0.02067
Error	34	41.408	1.218		
Total	53	70,413.397			

4.7 Analysis of variance (ANOVA) table for effect of altitudinal gradients on number of seeded heads per plant of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.771			
Altitudinal gradients	2	81.994	40.997	45.523	0.00000
Cultivars	5	30,973.418	6,194.684	6,878.496	0.00000
Altitudinal gradients ×Cultivars	10	19.405	1.940	2.155	0.04679
Error	34	30.620	0.901		
Total	53	31,106.208			

4.8 Analysis of variance (ANOVA) table for effect of altitudinal gradients on number of seeds per head of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	3.661			
Altitudinal gradients	2	277.457	138.729	74.335	0.00000
Cultivars	5	210,301.055	42,060.211	22,537.210	0.00000
Altitudinal gradients ×Cultivars	10	15.543	1.554	0.833	0.60086
Error	34	63.453	1.866		
Total	53	210,661.169			

4.9 Analysis of variance (ANOVA) table for effect of altitudinal gradients on seed yield per plant (g) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.001			
Altitudinal gradients	2	0.310	0.155	143.919	0.00000
Cultivars	5	31.245	6.249	5,796.614	0.00000
Altitudinal gradients ×Cultivars	10	0.078	0.008	7.245	0.00001
Error	34	0.037	0.001		
Total	53	31.670			

4.10.1 Analysis of variance (ANOVA) table for effect of altitudinal gradients on seed yield per plot (g) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.176			
Altitudinal gradients	2	79.530	39.765	142.395	0.00000
Cultivars	5	8,008.942	1,601.788	5,735.864	0.00000
Altitudinal gradients ×Cultivars	10	20.349	2.035	7.287	0.00001
Error	34	9.495	0.279		
Total	53	8,118.491			

4.10.2 Analysis of variance (ANOVA) table for effect of altitudinal gradients on seed yield per hectare (kg) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	9.771			
Altitudinal gradients	2	4,471.633	2,235.817	142.060	0.00000
Cultivars	5	450,505.453	90,101.091	5,724.877	0.00000
Altitudinal gradients ×Cultivars	10	1,144.818	114.482	7.274	0.00001
Error	34	535.110	15.739		
Total	53	456,666.785			

4.11 Analysis of variance (ANOVA) table for effect of altitudinal gradients on 1000 seed weight (g) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Replication	2	0.000			
Altitudinal gradients	2	0.000	0.000	30.539	0.00000
Cultivars	5	0.006	0.001	192.132	0.00000
Altitudinal gradients ×Cultivars	10	0.000	0.000	0.442	0.91471
Error	34	0.000	0.000		
Total	53	0.006			

4.12 Analysis of variance (ANOVA) table for effect of altitudinal gradients on seed germination percentage (%) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Altitudinal gradients	2	309.538	154.769	40.615	0.00000
Cultivars	5	1,637.395	327.479	85.938	0.00000
Altitudinal gradients ×Cultivars	10	146.956	14.696	3.856	0.00056
Error	54	205.774	3.811		
Total	71	2,299.663			

4.13 Analysis of variance (ANOVA) table for effect of altitudinal gradients on seedling length (cm) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Altitudinal gradients	2	0.789	0.394	78.073	0.00000
Cultivars	5	2.769	0.554	109.616	0.00000
Altitudinal gradients ×Cultivars	10	0.105	0.010	2.076	0.04273
Error	54	0.273	0.005		
Total	71	3.936			

4.14 Analysis of variance (ANOVA) table for effect of altitudinal gradients on seedling dry weight (mg) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Altitudinal gradients	2	0.001	0.001	37.010	0.00000
Cultivars	5	0.006	0.001	86.236	0.00000
Altitudinal gradients ×Cultivars	10	0.000	0.000	3.416	0.00160
Error	54	0.001	0.000		
Total	71	0.008			

4.15 Analysis of variance (ANOVA) table for effect of altitudinal gradients on seed vigour index-I (Length) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Altitudinal gradients	2	15,615.502	7,807.751	129.334	-0.00000
Cultivars	5	56,896.976	11,379.395	188.497	0.00000
Altitudinal gradients ×Cultivars	10	3,327.017	332.702	5.511	0.00001
Error	54	3,259.931	60.369		
Total	71	79,099.425			

4.16 Analysis of variance (ANOVA) table for effect of altitudinal gradients on seed vigour index-II (Mass) of English daisy cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Signficance
Altitudinal gradients	2	26.047	13.023	62.027	0.00000
Cultivars	5	110.092	22.018	104.869	0.00000
Altitudinal gradients ×Cultivars	10	7.333	0.733	3.492	0.00134
Error	54	11.338	0.210		
Total	71	154.810			

APPENDIX –III

QUESTIONNAIRE

Questions asked from Mr. Kuljeet Singh (farm manager of biocarve seeds) in the telephonic interview:

Q1. In how much area do you cultivate English daisy?

Q2. How much profit do you earn from one acre by seed production of English daisy?

Q3. How many varieties of English daisy do you cultivate commercially?

Q4. Among the cultivated varieties which variety has maximum sale and why?

Q5. How do you collect and process seeds?

Q6. What are the challenges faced in the cultivation and seed production of English daisy?

Q7. Do you export seeds to foreign countries also? If yes then to which countries maximum seed is exported?

Q8. Did corona affected sales of company?

Q9. In your opinion what are strengths of English daisy cultivation for seeds?

Q10. In your opinion what are weakness of English daisy cultivation for seeds?

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Title of Thesis	:	**Evaluation of *Bellis perennis* L. cultivars under different altitudinal gradients in Himachal Pradesh**
Name of the Student	:	Vikrant Singh Parmar
Admission Number	:	H-2019-24-M
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Major Advisor	:	Dr HS Baweja

ABSTRACT

The present investigation entitled, **"Evaluation of *Bellis perennis* L. cultivars under different altitudinal gradients in Himachal Pradesh"** was carried out at three locations based on altitudinal gradients *viz.* AG- 1 i.e. Regional Horticultural Research and Training Station, Dhaulakuan (468 m amsl) , AG – 2 i.e. Experimetal Farm at Khaltoo, Department of Seed Science and Technology of Dr. YS Parmar University of Horticulture and Forestry, Nauni (1060 m amsl) and AG – 3 i.e. Experimental Farm, Department of Floriculture and Landscape Architecture of Dr. YS Parmar University of Horticulture and Forestry, Nauni (1276 m amsl) by growing six cultivars of English daisy namely 'Single Meadow', 'Monstrosa Double White', 'Monstrosa Double Mix', 'Pomponette Rose', 'Pomponette Red' and 'Pomponette Mix' during 2020-21. The experiment was laid out in RBD (factorial) with 18 treatment combinations replicated thrice. Among different altitudinal gradients, Dhaulakuan farm (AG -1) gave best results for plant growth, flowering, seed yield and seed quality parameters while, altitudinal gradient of floriculture farm (i.e. AG – 3) exhibited maximum duration of flowering. Among different cultivars, the plants of cv. 'Pomponette Red' took minimum days for first flowering and showed maximum duration of flowering. However, minimum time for full blooming was taken by the plants of cv. 'Single Meadow'. This cultivar also registered maximum values for plant height, number of flower heads per plant, number of seeded heads per plant, seed yield per plant as well as seed yield per plot and per hectare too. Whereas, cv. 'Monstrosa Double White' exhibited superior results w.r.t. flower head diameter, number of seeds per head, seed germination, seedling length, seedling dry weight, seed vigour index-I and seed vigour index-II. Among the interactions, best results for plant growth, flowering and seed yield parameters were obtained in AG-1 × C_1 i.e. growing of cv. 'Single Meadow' at altitudinal gradient of Dhaulakuan farm. While, better seed quality was observed in the interaction, AG-1× C_2 i.e. growing of cv. 'Monstrosa Double White' at altitudinal gradient of Dhaulakuan farm and closely followed by the interaction, AG-1× C_3 i.e. growing of cv. 'Monstrosa Double Mix' at altitudinal gradient of Dhaulakuan farm. From the present study, it is concluded that among different altitudinal gradients, superior results for plant growth, flowering, seed yield and seed quality were obtained at altitudinal gradient of Dhaulakuan farm (468 m amsl). Among different cultivars evaluated, best performance was exhibited by cv. 'Single Meadow' w.r.t. various growth, flowering and seed yield parameters. However, best seed quality was found in cv. 'Monstrosa Double White' followed by cv. 'Monstrosa Double Mix'.

Signature of the Major Advisor **Signature of the Student**

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