GENETIC STUDIES AND DUS CHARACTERIZATION IN *Lilium*

Thesis

by

SANGEETA KUMARI
(H-2015-05-D)

submitted to

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

in

partial fulfilment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY
FLORICULTURE AND LANDSCAPE ARCHITECTURE
DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE
COLLEGE OF HORTICULTURE

2019

Dr Sita Ram Dhiman
(Sr. Floriculturist)

Department of Floriculture and Landscape Architecture
Dr YS Parmar University of Horticulture and Forestry,
Nauni-173 230, Solan (HP)

CERTIFICATE - I

This is to certify that the thesis titled **"Genetic studies and DUS characterization in *Lilium*"** submitted in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY FLORICULTURE AND LANDSCAPE ARCHITECTURE** in the discipline of **HORTICULTURAL SCIENCES** to Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP)-173 230 India is a record of bonafide research work carried out by **Ms Sangeeta Kumari (H-2015-05-D)** daughter of Sh. Shiv 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 investigations have been fully acknowledged.

Place: Nauni, Solan
Dated: 15.01.2019

Dr Sita Ram Dhiman
Chairman, Advisory Committee

CERTIFICATE - II

This is to certify that the thesis entitled, **"Genetic studies and DUS characterization in *Lilium*"** submitted by **Ms Sangeeta Kumari (H-2015-05-D)** daughter of Sh. Shiv Kumar to the Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP)-173 230 India in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY FLORICULTURE AND LANDSCAPE ARCHITECTURE** in the discipline of **HORTICULTURAL SCIENCES** has been approved by the student's advisory committee after an oral examination of the same in collaboration with the external examiner.

Dr Sita Ram Dhiman 20/4/19
(Sr. Floriculturist)
Chairman, Advisory Committee

20/04/19
External Examiner
Dr Desh Raj
Professor (Floriculture)
CSK, HPKV, Palampur

20.4.19
Dean's Nominee
Dr SC Verma
Deptt of Entomology

Members of Advisory Committee

1. **Dr RK Gupta**
   (Professor)
2. **Dr Puja Sharma** 20/4/19
   (Assistant Professor)
3. **Dr RK Dogra** 20.4.19
   (Assistant Professor)

Professor and Head
Department of Floriculture and Landscape Architecture

Dean
College of Horticulture
UHF, Nauni, Solan (HP)

ACKNOWLEDGEMENTS

First and foremost, I would like to express my profound sense of gratitude to the "LORD RUDRA" for showering immense blessings upon me and for giving me patience, understanding and strength enough in every ups and down moments due to which I could be able to accomplish this academic endeavor.

Thank You is all I can say to "MOTHER NATURE", for healing whenever I was distressed, ill, exhausted. I am sending gratitude your way in the most humble way.

Family is nature's one of masterpieces. I humbly offer my salutations at the lotus feet of my affectionate parents Smt. SHANTI DEVI JI and Sh. SHIV KUMAR JI, who always supported, encouraged and stood by me during whole course of time. Words fail to express my gratitude to my mother for her sacrifices, prayers and heartfelt blessings who always believed in giving a strong education wings to her daughter. The love and affection of my beloved brother Virender and sister–in-law Pooja need not to be acknowledged but to be kept in my heart. I will always be grateful to my sister-in-law for her immense help during transformation of this manuscript.

Every effort is motivated by an ambition and all ambitions have inspiration behind, with the great reverence and esteemed pride, I express my warmest feeling with deep sense of gratitude to the chairperson of my advisory committee Dr. SR DHIMAN (Sr. Floriculturist, Department of Floriculture and Landscape Architecture). I have no words to express my heartfelt thanks for his unique supervision, critical analysis, painstaking efforts, selfless acts and sympathetic attitude. I learnt a lot from him than I learnt from any other books I referred. I dedicate this piece of work to him and will always be thankful for shaping my work ethics.

I owe profound debt to Dr. MR DHIMAN (Principal Scientist, ICAR-IARI, Regional Station, Katrain, Kullu) for his invaluable help, vital suggestions, constant encouragement, unending benevolence, and debonair discussions throughout this course of investigation right from the initiation of the work to the ship-shaping of the manuscript. It is my profound privilege to express my earnest thanks to Siddharth Moudgil (SRF, Katrain), Negi bhaiya and entire field staff of Katrain station for their selfless help during the course of investigation.

I herewith express gratitude to my advisory committee Dr. RK Dogra (Assistant Professor, Department of Fruit Sciences) and Dr. RK Gupta (Professor, Department of Basic Sciences) for their cordial and invaluable help. Help extended by Dr Bharati Kashyap and Dr YC Gupta is thankfully acknowledged.

Words are inadequate to express my illimitable, veneration, adoration, indebtness towards Pratibha di, Reshma Mam, Dr. Ajab Sir. My heartfelt thanks to Gaurav for his valuable help in field works. Technical help provided by Dejen (PhD Scholar, Deptt of Basic Sciences) is dully acknowledged.

I'll always remain beholden to my juniors Deepthi, Nikhitha, Rishu, Rahul and Paras for their affection and help. I also express my thanks to Hitesh for his moral support.

My in-depth thankfulness is expressed to Kamlesh massy and Sooraj Maussa ji and sweet company of my cousins for their valuable help extended during my stay at Katrain station.

Facilities and co-operation extended by all the technical and field staff members of Department of Floriculture and Landscape Architecture is thankfully acknowledged. Valuable help extended by Parvesh Uncle is dully acknowledged.

Last but not the least, I wish to thank DPT Computers Nauni especially Sohan Bhaiya Ji for their promptness and care while making this manuscript in its present form.

To err is human. I solely claim the responsibility for the shortcomings and limitations in this work.

Place:
Date: **(Sangeeta Kumari)**

CONTENTS

ABBREVIATIONS

%	:	Percentage
@	:	At the rate of
>	:	Less than
<	:	Greater than
ANOVA	:	Analysis of variance
CD	:	Critical difference
cm	:	Centimeter
d.f.	:	Degrees of freedom
et al.	:	*et alli* (and others)
etc.	:	*et cetera*
FYM	:	Farm Yard Manure
g	:	Gram
g/m^2	:	Gram per meter square
ha	:	Hectare
i.e.	:	*id est* (that is to say)
m	:	Meter
°C	:	Degree Celsius
RBD	:	Randomized Block Design
RH	:	Relative humidity
RHS	:	Royal Horticultural Society
sp.	:	Species
viz.	:	*videlicet* (namely)
/	:	Per
UPOV	:	International Union for the Protection of New Varieties of Plants
UPGMA	:	Unweighted Pair Group Method with Arithmetic Mean

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Chapter-1

INTRODUCTION

Lilium is one of the most economically important and popular bulbous ornamental plant. It belongs to the family Liliaceae and is native to Northern Hemisphere, centred around in Asia, North America and Europe. The Far East is the home of almost half of the world's lilies and the majority of garden lilies originated there. The genus *Lilium* comprises around 100 species and more than 9,400 cultivars. The species of this genus are taxonomically classified into seven sections based on 13 morphological and two germination characteristics. They are available in wide range of colours, forms and are commonly used as cut flower, pot plant and in landscape. Some of the cultivars are highly fragrant and possess medicinal properties. *Lilium* occupy an important place in international flower market ranking 4th position among the top ten cut flowers of the world (Anon, 2017).

Today, the largest cultivation areas of *Lilium* are European countries especially the Netherlands. They are also grown on a large scale in Japan, Israel, Korea and China. India too has the potential for growing good quality *Lilium*. The major production areas are located in hilly states of the country like Himachal Pradesh, Uttarakhand and Jammu and Kashmir *etc*.

In past few years, Haryana state is emerging as a leading and potential hub for *Lilium* cultivation. During 2012-13, area under *Lilium* cultivation was 2.00 hectares with a production of 2,40,000 sticks however, during 2016-17, this area has increased to 46.50 hectares with a production of 1,90,37,200 sticks per annum (Anon, 2016).

Lilium hybrids are now being commercially grown in Lahaul & Spiti, Kullu and Chamba districts of Himachal Pradesh. As per the estimates of Directorate of Horticulture-Himachal Pradesh, *Lilium* occupied 21.92 hectares out of total area of 708.61 hectare under floriculture in the state during 2016-17 (Anon, 2017). However, the acreage of *Lilium* cultivation is still expected to increase because of the favourable climatic conditions for its cultivation in different parts of Himachal Pradesh and other hilly states of the country. Considering the significance and popularity of cultivating this crop, there is prime need for improvement and to develop varieties suitable for cultivation under Indian conditions. Due to the occurrence of diverse geographical conditions in India, *Lilium* cultivation has immense potential for cultivating both under protected as well as under open field conditions.

Lilies have a wide variety of valuable characters such as flower colour, size, flowering time and resistance to different pathogens. Combining these vital horticultural traits into one cultivar by crossing is almost the only way to obtain introgression of traits. Information on variability and heritability of plant characters and association among yield and quality characters are of vital importance in effectiveness of breeding programme. Present day cultivars of *Lilium* have been evolved as a result of cross between complex of hybrids and depending upon specific features they have been categorized into different groups like; Asiatic (A), Orientals (O), LA (*Lilium longiflorum* × Asiatic), LO (*Lilium longiflorum* × Oriental), OT (Oriental × Trumpet), OA (Oriental × Asiatic) *etc*.

There are different major groups of *Lilium* hybrids (Grassotti and Gimmeli, 2011) *viz*., Asiatic hybrid lilies, derived from species native to Japan, Korea, China and Europe, were the first commercially successful group of hybrid lilies introduced around 1950 by the famous breeder Jan de Graaff from Oregon, USA. These groups of cultivars were derived from species such as *Lilium bulbiferum, Lilium dauricum*, *Lilium concolor*, *Lilium davidii, Lilium hollandicum, Lilium maculatum, Lilium leichtlinii*, *Lilium pumilum* and *Lilium tigrinum*. These hybrids were excellent cut flowers with upright flowers with good post-harvest longevity, shorter, sturdier than their parental species and easy to force. The range of colours varies from yellow, orange, pink, red, white and also bicoloured flowers with or without spots.

The second important group is *Lilium longiflorum* with large, white, and trumpet shaped flowers. They are known as the Easter lily in the USA and are mainly used for pot plant production whereas in other countries like; The Netherlands, Israel, Japan, Korea and China these are primarily used for cut-flower production.

Another significant group is Oriental hybrids, derived from *Lilium auratum*, *Lilium speciosum*, *Lilium japonicum* and *Lilium rubellum*, all native of Japan. Oriental lilies are famous for their large flowers, pleasant fragrance and beautiful white, pink, and cream colours. The bloom sizes are the largest and most spectacular among all the lilies. The Oriental lily has a waxy texture that extends their vase life.

Efforts by breeders were devoted to create interspecific hybrids with new characteristics such as LA hybrids, the first interspecific hybrids introduced in the late 1990s, are a colourful group, and are produced from crosses between Longiflorum and Asiatic (LA). These cultivars combined the full colour range of the Asiatic groups, with the elegance of flower form and fragrance of the Longiflorum group. They are brightly-coloured trumpet type lilies and LA hybrids gets a trumpet shape, a great strength and a long vase life from the Longiflorum, while from the Asiatic they derive warmer colours and an upright calyx.

But the absolute novelty hybrids are the OT hybrids, derived from a cross between Orientals and Trumpets, commonly known as Orienpet. The colours range of the OT is much broader than the pink and white colour commonly associated with the Oriental types. A sweet fragrance is generally less than the Oriental hybrids.

Present goals of breeders are to breed a four-way cross between Longiflorum, Asiatic, Oriental and Trumpet, to obtain a new LAOT hybrid flower form, with a mix of vigorous habit, unexpected and unusual colours and fragrant upright flowers to combine the best characteristics of all the four parental groups (Lim *et al.*, 2000 & Barba-Gonzalez *et al.*, 2014).

In nature, the occurrence of genotype × environment interaction has long provided a major challenge for obtaining complete understanding of the genetic control of variability, which plays important role, related to production problems of agriculture in general and plant breeding in particular. Phenotypic diversity has the advantages of simple, convenient, rapid and cost-saving use of the traits of stable, less susceptible to the environment impact to study the genetic diversity, such as plant height, leaves, flowers etc. In order to sustain the availability of new prominent cultivars, genetic variability is necessary. Growers are keeping on looking for novel and improved agronomic and desirable traits. Variability information about the different characters present among the individual cultivars belonging to single species or different species is important for the future breeding programme. Exploitation of naturally existing variability is of great importance for the screening of superior genotypes. These elite genotypes can be used for further various hybridization programmes. Since genus *Lilium* consists of highly heterozygous group of ornamental bulbous plant, it is crucial to evaluate the wide germplasm available before adopting hybridization programmes to exploit the diversity in growth and flowering traits.

Correlation studies determine as how far two variables are associated with each other. The yield component is the most important aspiration of plant as it is expressed with function of many components traits and their interaction with the environment. Thus, it is essential to study the mutual associations between various plant characters so as to define the component traits which may be capitalized as reliable selection criteria for genetic improvement of yield and other desirable traits. Heritability estimates helps in determining the relative amount of heritable portion of variation.

Genetic diversity present in a population is used as a source of elite genes in crop improvement for the production of high yielding varieties. The more diverse the parents, greater is the chances of increased variability in the population. Earlier, ecological divergence was considered as an index of genetic diversity in the past and varieties from different localities have usually been included in hybridization programme. Study of genetic divergence is helpful as in estimating the relative contribution of different quantitative characters towards the expression of genetic divergence.

Phenotypically stable genotypes are of great importance, because the environmental conditions vary from year to year or region to region. Wider adaptation to the particular environment and consistent performance of recommended genotypes is one of the main objectives in breeding programme. Genotype × Environment interaction compels the breeder to choose between developing widely adaptable cultivars or cultivars adapted to limited subsets of environment and in identifying traits and environments for better cultivar evaluation. Thus, evaluation of genotypes for stability of performance under varying environmental conditions for yield has become an essential part of any breeding programme.

Characterization, systematic documentation and conservation of germplasm are important for its utilization in crop improvement programmes. Critical evaluation of the genotypes through parameters of variability and genetic divergence studies gives a fair idea of the extent of improvement in a character under study. Multivariate statistical methods have been successfully used to assess the extent of genetic diversity in available genotypes. Besides variability and genetic divergence, characterization of *Lilium* germplasm for morphological traits through DUS technique is also important in which there is considerable breeding activity and production of new varieties. Testing for DUS of genotypes of *Lilium* involves comparison of candidate and existing variety by recording of a number of phenotypic characters in tests in which all genotypes are grown side by side.

However, there is dearth of information available regarding this aspect, so present study is planned to evaluate the performance of different genotypes of *Lilium* with the following objectives:

i) To assess the genetic variability and association in *Lilium* genotypes

ii) To study the genetic divergence of different genotypes in *Lilium*

iii) To find out the stable *Lilium* genotype for commercial cultivation

iv) Morphological characterization of *Lilium* genotypes for Distinctness, Uniformity and Stability (DUS)

Chapter-2

REVIEW OF LITERATURE

Lilium is one of the important flower crop owing to its commercial value worldwide. Among bulbous crops, it occupies second place after Tulip in international flower market. Performance of any genotypes depends upon genetic constitution, whereas, expression of genotypes depends upon climatic conditions of the region under which they are grown. Information on nature and magnitude of variability existing in the plant material and association among the various characters is a pre-requisite for improvement in the yield. Besides varietal evaluation, variability studies helps in crop improvement programme. For a sound breeding programme, critical assessment of the nature and the extent of genetic variability available in the germplasm, heritability and genetic advance of the important characters in a crop are essential. Hence, an attempt was made to generate basic information on qualitative and quantitative characters of different genotypes of *Lilium* and to study the morphological variation among the genotypes, stability of genotypes over the environments, yield attributing components and its related characters, their heritability and genetic advance.

The information available in the literature for yield and quality traits have been reviewed here under the following sub heads:

2.1 Varietal evaluation
2.2 Genetic variability and association studies
2.3 Genetic divergence studies
2.4 Stability studies
2.5 DUS characterization studies

2.1. VARIETAL EVALUATION

Dhiman (2003) evaluated seven cultivars of Asiatic hybrids and six cultivars of Oriental hybrids at IARI, Regional Station, Katrain, Kullu and reported that among Asiatic hybrids maximum bud length (6.90 cm), minimum days to visible bud formation (173.60 days) and days to full flowering (185.60 days) reported in cultivar ‘Jollanda’ while ‘Grand Care’ (215.00 days) was late blooming, maximum number of leaves per plant (91.00) in cv. ‘Pollyana’, maximum leaf length (7.90 cm) in cv. ‘Grand Care’ while plant height, leaf width, number of flowers and flower diameter were found to be non-significant. In case of Oriental hybrids, minimum days for bud formation (186.60 days), maximum leaf length (10.20 cm), number of leaves (43.30) and plant height (57.00 cm) observed in cv. 'Meditterrannae' and maximum flower diameter (15.58 cm) in cv. 'Cascade'. However non-significant differences were found among cultivars with respect to number of flowers per plant and flower bud length.

Sloan and Harkness (2005) evaluated seventeen Asiatic, seven Oriental and two LA hybrid lily cultivars based on growth characteristics important for cut flower production. Cultivars 'Avignon' and 'Loreto' required the fewest days for Asiatic cultivars from planting to harvest i.e. 49.50 days and 49.20 days, respectively, cv. 'Cannes' had the largest stem diameter (1.20 cm), cvs 'Chianti' (35.30 cm) 'Sunray' (34.10 cm) and 'Navona' (33.10 cm) belonging to Asiatic group had the shortest stem length while cvs 'Ibarra'(4.90), 'Toro'(2.50) and 'Pollyana' (2.30) had the fewest flowers per stem while cv. 'Cordelia' had the highest number of flowers per stem (7.40). In case of Oriental hybrids, 'Barbaresco' (68.50 days) required the fewest days to produce a marketable stem. 'Noblesse' produced stem with the smallest diameter (0.54 cm) of all Oriental hybrid and produced the shortest stem (31.20 cm) among the Oriental lilies and cultivars 'Acapulco' (5.30), 'Stargazer' (5.30) and 'Golden Torch' (5.60) produced maximum flowers per stem.

Similarly in another study conducted by Sloan and Harkness (2006) on different *Lilium* hybrids revealed the stem diameters of the OT hybrid cultivars greater than other cultivars. The basal stem diameter of 'Alusta' was the largest (1.96 cm) while Oriental hybrids such as 'Caruso' (0.83 cm), 'May Tay' (0.83 cm), and 'Cornas' (0.81 cm) produced the smallest stem diameters. The OT hybrid 'Alusta' produced ten blooms per stem while Asiatic cultivars on an average produced four blooms per stem. The number of blooms among the LA hybrid cultivars ranged from 2.80 – 7.00 blooms per stem. 'Pantanal' (7.00) produced the most blooms of the LA hybrid cultivars while for Oriental hybrids, it ranged from 1.70 to 7.50.

Findings of Kumar *et al*. (2011) on evaluation studies in 8 Asiatic *Lilium* cultivars *viz*., 'Avelino', 'Botticelli', 'Farfalla', 'Brunello', 'Detroit', 'Gironde', 'Navona' and 'Vermeer' for cut flower production in Meghalaya indicated plant height (52.86 cm), leaf length (8.64 cm), bud diameter (2.70 cm), petal breadth (5.12 cm), bulb diameter (5.40 cm) maximum in cv. 'Avelino'. Whereas, maximum number of leaves per plant (104.53), pedicel length (7.84 cm), bulb height (4.43 cm), number of scales per bulb (63.66) were higher in cv. ‘Botticelli’. The flower diameter (17.36 cm), bud length before opening (10.07 cm), petal length (10.59 cm), bulb weight (56.66 g) was maximum in cv. ‘Detroit’. However, flowers per plant (4.93) were higher in cv. ‘Gironde’, while maximum plant girth (6.19 mm) and leaf breadth (1.74 cm) in cv. ‘Brunello’ and ‘Vermeer’, respectively.

Study conducted by Sindhu and Singh (2012) revealed that all the *Lilium* hybrids included in the study had shown good percentage of sprout emergence. Cultivar ‘Yellow Giant’ took minimum number of days to sprout emergence (5.00 days) and bud initiation (37.00 days) and flowering (96.66 days) since planting whereas cultivars ‘Alaska’ and ‘Vivaldi’ took the maximum number of days to sprout emergence (8.00 days). Out of six cultivars evaluated, plant height recorded maximum in ‘Yellow Giant’ (66.25 cm) followed by ‘Vivaldi’ (60.41 cm). ‘Yellow Giant’ and ‘Corrida’ showed maximum flower size and number of bulbs produced per plant whereas maximum diameter of bulb recorded in cultivars ‘Vivaldi’ and ‘Alaska’. The maximum number of bulblets per plant recorded in cultivars ‘Yellow Giant’ and ‘Vivaldi’.

Dhiman *et al*. (2014) conducted an experiment in Lahaul Valley of Himachal Pradesh in North Western Himalayas with the objective to know the influence of different sites on cut flower and bulb production among different groups of *Lilium* hybrids. During the study an intensive survey was conducted and data were collected on existing genotypes from different sites located at different altitudes *viz*., Kuthvihal (10302 feet), Gondhla (10726 feet), Dalang (9781 feet) and Phura (9600 feet). The results showed that bulbs grown at Dalang site had shorter growing cycle than those grown at other sites. Plant height and number of flowers per stem were comparable except for Asiatic hybrid ‘Navona’ at Dalang and Gondhla; Oriental hybrids ‘Rubato’, ‘Tiara’ and ‘Mother Choice’ showed a lower number of flowers per stem at Dalang site. The three main hybrid groups behaved differently according to temperature conditions. Asiatic and Oriental hybrids were better adapted to cooler climates. Fresh weight of Asiatic hybrids ‘Navona’ and ‘Brunello’ were higher at Dalang, Kuthvihal and Phura. In Oriental hybrids fresh weight and size of harvested bulbs were higher at Kuthvihal. Moreover, the results indicated that dry temperate regions of Himachal Pradesh are suitable for quality cut flower and bulb production of *Lilium*.

Variation in performance with respect to growth, flowering and bulb production among five Asiatic cultivars *viz*., ‘Mount Negro’, ‘Alaska’, ‘Orange Matrix’ and ‘Nov Cento’ under Bhubaneswar conditions may be due to genetic and environmental interaction and the selected cultivars can be used for both cut flower as well as pot plant production (Barik and Mohanty, 2015).

Sarvade *et al*. (2015) evaluated eight cultivars of *Lilium viz*., ‘Elite’, ‘Serrada’, ‘Brunello’, ‘Tresor’, ‘Latoya’, ‘Novano’, ‘Brindisii’ and ‘Courier’ at the Hi-tech Floriculture Project, College of Agriculture, Pune, Maharashtra during the year 2009. All the cultivars differed significantly with respect to flowering and flower quality parameters. Cultivar ‘Tresor’ showed earliness in flower bud initiation, first flowering and short period for complete harvesting (42.69 days, 56.31 days and 62.13 days, respectively) and longer flower stalk (96.06 cm) while delayed bud initiation, flowering and days for complete harvesting was noticed in cv. ‘Serrada’.

Balode (2016) while working with ten *Lilium* species, 72 Asiatic hybrids, 6 LA hybrids (*Lilium longiflorum* × Asiatic), 7 Trumpet hybrids and 5 OT (Oriental × Trumpet) hybrids for flowering time and grey mould disease resistance under open environment conditions with the objective to select the most suitable lilies for garden as well as landscape design reported that Caucasus and Martagons species were early-flowering, the LA hybrids and Asiatic hybrids were medium-flowering but Trumpet hybrids, OT hybrids and *Lilium henryi* required longest time from emergence of shoots to flowering. She further concluded that five of evaluated Trumpet hybrids ‘Aurelija’, ‘Elegija’, ‘Ekzotika’, ‘Varsma’ and ‘White Henryi’ as well five Oriental hybrids ‘Black Beauty’, ‘Erfordia, ‘Leslie Woodriff’, ‘Shocking’ and ‘Silk Road’ showed significant resistance to grey mould and considerably exceeded the Asiatic hybrids ‘Aphrodite’, ‘Electric’, ‘Magic Eye’, ‘Lolly Pop’, ‘Monte Rosa’, ‘Mont Blanc’ and ‘Roma’ and were not recommended for growing under open environmental conditions and selecting for garden design.

Evaluation studies on four *Lilium* cultivars for finding out the suitability of their cultivation under low hills of Himachal Pradesh revealed ‘Pollyana’ as best performer in terms of growth and flowering followed by ‘Alliana’ and found to be suitable for cultivation under low hills of Himachal Pradesh state (Negi *et al*., 2016).

Bhandari *et al*. (2017) conducted an experiment on performance of 18 exotic *Lilium* hybrids in order to assess their suitability for commercial cultivation in the hilly regions of Jilling Floritech Farm, Uttrakhand during 2014-15 under protected conditions. All the 18 hybrids showed significant variation for vegetative, flowering and bulb attributes. Results indicated that among the cultivars studied, earliest sprout emergence (4.66 days) was recorded in 'Yellow Diamond'. Earliest flower-bud initiation (30.33 days) in 'Bach', flower-bud colour break stage (46.33 days) and flowering (50.00 days) in 'Detroit'. Maximum number of flower buds per plant (8.66) recorded in 'Pollyana', longest inflorescence (25.23 cm) in 'Indian Summerset', maximum flower diameter (17.66 cm) in 'Creil', maximum plant height (145.13 cm) in 'Bright Diamond', and maximum stem thickness (1.86 cm) in 'Novana'. However, maximum number of bulblets (6.66) per plant was recorded in 'Ceb Dazzle'.

Chandrashekar *et al*. (2018) carried out an investigation in the Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, Chikmagalur, Karnataka to characterize the Asiatic lily genotypes for flowering and quality of cut flowers under naturally ventilated polyhouse. The days taken for flower bud emergence were significantly differed among all the genotypes. The cultivar 'Telisker' was the earliest to show colour (35.00 days) whereas cv. 'Ercolano' (48.67 days) was late. The cv. 'Pirandeu' was the earliest to show colour by taking minimum number of days followed by 'Telisker'. The cultivar 'Merluza' (19.51 cm) followed by 'Courier' (19.34 cm) produced significantly bigger sized flowers than any other genotypes whereas, cultivars 'Pirandeu', 'Ceb Dazzle', 'Courier', 'Pavia' and 'Tresor' recorded maximum number of spikes per square meter (24.00) while, 'Batistero' recorded the minimum number (16.67). The cultivar 'Pirandeu' showed its vase life maximum up to (12.37 days) and found significantly superior over other genotypes and found to be at par with 'Pavia' (12.17 days) whereas, the minimum vase life recorded in 'Navona' (7.73 days).

A study on appraisal of *Lilium* cultivars namely, 'Nashville', 'Eyeliner' and 'Hyde Park' was carried out at Centre for Quality Planting Material, CCS Haryana Agricultural University, Hisar (Haryana) during winter season of 2017- 18 to identify the suitable cultivar for successful cultivation and flower production under polyhouse conditions. Based on the overall results cultivar 'Nashville' showed better performance for vegetative, flowering and quality characters under polyhouse growing condition of Western Haryana, Hisar district and recommended for its commercial cultivation (Kumar *et al*. 2018).

Sharma and co-workers (2018) evaluated nine cultivars of *Lilium viz*., 'Brindisi', 'Litouwen', 'Pavia', 'Sulpice', 'Tresor', 'Eyeliner', 'Indian Diamond', 'Yellow Diamond' and ‘Indian Summerset’ for their growth and flowering performance at Precision Farming Development Centre, Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana). It was found that ‘Pavia’ (5.70) produced maximum number of flowers; ‘Yellow Diamond’ (69.20 days) was early flowering while maximum flower diameter was observed in cv. ‘Indian Summerset’ (19.30 cm). Based on the study they concluded that the variation in cultivars may be due to genetic and environmental interaction. Among evaluated cultivars, performance of plants in respect of several parameters was found better under polyhouse condition. The selected cultivars can be used for cut flower production under Hisar condition with proper management practices.

2.2. GENETIC VARIABILITY AND ASSOCIATION STUDIES

Genetic variability forms the bases for crop improvement. Genotypic and phenotypic coefficients of variation are useful in detecting the amount of variability present in the available genotypes. The main purpose of estimating heritability and the genetic parameters that compose the heritability estimate is to compare the expected gains from selection based on alternative selection strategies.

Fisher (1918) partitioned the continued variation exploited by quantitative traits into heritable and non-heritable components which are attributed due to the genotype of the crop and environmental factors in which crop is being grown; respectively.

Vavilov (1951) discovered the genetic variability for the first time and advocated that the wide range of variability provide better scope of selecting desirable genotypes. Effective selection is dependent upon the existence of genetic variability in the population and availability of broad based germplasm resource is essential for sound and successful crop improvement programme.

Syamal and Kumar (2002) carried out an investigation on the genetic variability of dahlia. Variability analysis revealed high genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for plant height, flower diameter, durability and number of flowers whereas it showed lower value for the internodal length, number of branches and number of leaves.

Nair and Shiva (2003) studied the genetic variability, correlation and path coefficient analysis among the 25 genotypes of gerbera at IIHR, Hessarghatta, Bangalore during 1998-

2001. Variability estimates revealed that the phenotypic coefficient of variation or PCV was higher than genotypic coefficient of variation (GCV) for all the characters indicating the role of environmental factors in the expression of particular genotype. However, estimate of GCV was recorded high for leaf area followed by flower yield.

Nazir *et al*. (2004) studied the genetic variability among 22 diverse genotypes of gladiolus for 20 characters at two locations, i.e., Baraut (Meerut) and Jammu during 1998-99 and 1999-2000. They observed that the PCV were higher than GCV for all the characters studied, indicating high degree of environmental influence. Higher GCV and PCV estimates were found for number of cormels produced per plant and average weight of cormels per plant. Heritability estimates were high (>80 %) for days for 50 % heading, first floret colour showing and complete opening of first floret. Whereas, number of cormels per plant, average weight of cormels per plant and propagation coefficient showed moderate to high heritability along with genetic advance as percentage of mean showing additive gene effects.

Patil and co-workers (2004) studied the coefficient of variation, heritability and genetic advance in gladiolus hybrids at Floriculture Unit, Department of Horticulture, University of Agricultural Sciences, Dharwad during 2003-04. The estimates of variability revealed that the PCV and GCV were found high for average weight of corm, weight of the spike, weight of the daughter corm and number of cormels per plant. The characters with low PCV and GCV were plant height, number of leaves, number of days taken for first floret to open, length of floret and number of days taken for spike initiation. However, high heritability with medium genetic gain was observed for number of days taken for spike initiation, days taken for first floret to open, number of florets per spike, spike length and rachis length.

Radhakrishna and co-workers (2004) carried out the correlation analysis among eight tuberose single genotypes and six double genotypes for 10 quantitative characters at IIHR, Bangalore during 2001-02. Analysis of variances in case of single genotypes revealed loose flower yield exhibiting positively significant response at genotypic and phenotypic levels with spike length, number of flower per spike, flower length, flower diameter, 100 flower weight and spike weight. Number of flowers per spike showed significant positive correlation with loose flower yield, spike length, rachis length at both levels. In double genotypes, spike yield showed positive and significant correlation with number of leaves per plant, rachis length, flower length and flower diameter. Rachis length also showed positively significant correlation with plant height, spike length, flower length, spike weight and spike yield at both genotypic and phenotypic levels.

Investigation on 40 genotypes of tulip under two different environments *viz*., open field and polyhouse revealed that phenotypic coefficients of variation were higher than genotypic coefficients of variation for all characters studied under both the environmental conditions. All the characters showed high heritability, except bulb sprout and bulb number per plant. High heritability with high genetic gain was observed for plant height, scape length and bulblet weight per plant under both the growing environments (Jhon *et al*., 2006).

An experiment on assessment and variability studies was carried out among 10 genotypes of gladiolus at AICRPF, Rajendranagar, Hyderabad during 2003-04 and 2004-05 and exhibited that the PCV was higher than GCV for all the characters studied indicating the apparent variance was not only due to genotypes but also due to the influence of environment in the expression of genotype. The GCV was recorded maximum for the characters like, plant height, number of florets/spike, followed by days to flowering and number of florets/spike, whereas, it was low for vase life and spike length (Pratap and Rao, 2006).

Sheela *et al.* (2006) studied the association between various characters and the direction and magnitude of different characters among 12 genotypes of heliconia. Correlation studies revealed that number of flowering shoots per year had a strong positive correlation with vase life, number of flowers/bract and size both at genotypic and phenotypic levels. Plant height was positively correlated with days to first flowering, duration of flowering, spike length, bract number, number of flowers/bract, leaf area and bract size.

Balaram and Janakiram (2009) studied the genetic variability among thirty five gladiolus genotypes (eleven Indian and twenty four exotic) for seven corm characters at the Indian Institute of Horticultural Research, Hessaraghatta, Bangalore. The study revealed that all the genotypes exhibited wide range of number of cormels per corm. For all the seven characters studied, the differences between phenotypic and genotypic coefficient of variation were narrow indicating less environmental influences on their expression. High phenotypic and genotypic co-efficients of variations, heritability and genetic advance recorded for number of daughter corm, number of cormels per corm and cormel weight and therefore, suggested the selection of genotypes based on these traits for further improvement through effective breeding programmes.

Bihari *et al.* (2009) carried out an investigation to study the variability among fifty genotypes of canna at CSA University of Agriculture and Technology, Kanpur. The study revealed a considerable variation among vegetative parameters. Duration of flowering, flower length and diameters were found to have considerable variation which indicated potential for making improvement through breeding.

Vijaylaxami and co-workers (2010) conducted an experiment under Hyderabad conditions of Andhra Pradesh to evaluate variability among seven single cultivars of tuberose (*Polianthes tuberosa* L.) during the year 2008-09. The estimates of PCV and GCV were recorded high in case of leaf area, yield of flowers per plant and the weight of bulb in decreasing order of their magnitude, whereas, low estimates were recorded for plant height, number of leaves per plant, duration of flowering and number of florets per spike.

An experiment was conducted to estimate genetic variability, heritability and genetic advance of fifteen quantitative characters in forty four gladiolus cultivars which revealed that the estimated phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV). The characters like days to 50 % sprouting, number of leaves per plant, length of leaves, number of florets per spike, diameter of corm, weight of corms per plant, number of cormels and weight per plant exhibited high heritability along with high genetic advance which indicated that there was additive gene action in expression of these traits and thereby further improvement could be made by selection (Kumar *et al*., 2011).

Twelve genotypes of gladiolus were evaluated to determine genetic variability, heritability, genetic advance and genetic gain for twenty six contributing characters. Significant variations were recorded for the various characters studied. Phenotypic and genotypic coefficients of variation were highest for number of cormels and weight of cormels produced per plant, indicating presence of sufficient genetic variability for selection in these traits. High heritability and high genetic advance for number of cormels per plant, weight of cormels per plant, leaf area, number of spikes per plot, number of corms per plot, number of florets remaining open at a time, number of spikes per plant, leaf width, spike diameter, weight of corm, rachis length, vase life of spike, number of corms per plant and plant height indicated the presence of additive gene effects in these traits and their amicability for direct selection. The non additive gene effects were evident in spike length, size index of corms, number of florets per spike, number of days to slipping thus warranting use of heterosis breeding for these characters they further concluded that the selection on the basis of cormels per plant could be more effective for further breeding programme (Choudhary *et al*., 2012).

Kumar and co-workers (2012) carried out an experiment to assess the extent of correlation coefficient and path analysis in twelve gladiolus genotypes, *i.e.*, ‘True Love’, ‘Pacifica’, ‘Rigency’, ‘Yellow Stone’, ‘Sagun’, ‘Tiger Flame’, ‘Praha’, ‘Snow Princess’, ‘Picardy’, ‘Eurovision’, ‘Aldebran’ and ‘Promise’. The experiment was conducted at the Horticulture Research Farm, Department of Applied Plant Science (Horticulture), Lucknow during 2009-10. Analysis of data, revealed that maximum phenotypic variation was recorded for corm weight per plant (180.75) followed by number of days taken for full spike emergence (117.18). Significant positive correlation of corm weight per plot was recorded with corm size (0.91), spike length (0.76) and plant height (0.67).

Bhatia *et al*. (2017) estimated the genetic variability, heritability, genetic advance and correlation in twenty one genotypes of tulip (*Tulipa gesneriana* L.). Tulip germplasm were evaluated for various vegetative, floral and bulb quality related traits. The maximum value of PCV and GCV was recorded for number of bulbs per plant. High heritability coupled with high genetic advance was observed for spike length, plant height, and wrapper leaf area indicating selection on the basis of these characters would be more effective for the improvement of tulip. Scape length, the economically important trait in tulip, revealed a highly significant and positive correlation with plant height and bulb size. Highly significant and positive correlation of number of bulbs was observed with number of leaves per plant and wrapper leaf area. Hence, direct selection from germplasm lines may be effective for improvement in closely associated traits.

Kumar (2013) carried out genetic studies on eight Asiatic lilium genotypes for identifying the promising quantitative traits and observed high phenotypic and genotypic coefficient of variation for leaf length, leaf width, plant spread, number of flowers/plant, pedicel length, petal length, bulb weight, number of bulblets/bulb, scales/bulb indicating high genetic variability in these traits. Flower diameter was positive and significantly associated with number of flowers/plant, bud diameter, petal length, petal breadth, bulb weight, bulb diameter, bulb height and propagation coefficient. He also concluded that to improve flower yield/plant in Asiatic lilium, focus should be given on number of leaves/plant as it has positive correlation with number of flowers per plant.

Kadam *et al*. (2014) conducted an experiment with 26 gladiolus cultivars at Research Farm of Directorate of Floricultural Research, New Delhi and reported that higher values of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded for cormel weight, *i.e.* 104.36 and 67.26 and number of cormels per plant (99.82 and 71.58; respectively). Maximum heritability was recorded for days to first floret opening (87.23%) followed by rachis length (82.07%) and days to spike initiation (78.26%). Highest values for genetic advance were also recorded for plant height (26.35) and spike length (23.36). However, low genetic advance was observed for days to sprouting (0.04) followed by number of corms (0.32) and number of leaves per plant (0.59).

Dhiman *et al*. (2015) evaluated nine diverse genotypes of alstroemeria to assess the nature and magnitude of variability and genetic advance for different floricultural traits. The coefficient of variation found highest for number of shoots per plant (GCV=46.86, PCV=50.51) and minimum for days taken to flowering (GCV=9.02, PCV=9.40). In the present study, estimates of high heritability coupled with high genetic advance were observed in all the traits studied except leaf length, leaf width, flower diameter and flower bud length, in which high heritability was combined with moderate genetic advance. Plant height gave the highest positive significant genotypic and phenotypic association with the spike length. On the contrary, days to flowering had strong negative correlation with spike length, plant height and number of shoots per plant. The character leaf width was found to have a direct significant effect on the number of shoots per plant, while a negative and direct relationship was found between leaf length and number of shoots per plant.

Kumar *et al*. (2015) evaluated ten gladiolus cultivars for eighteen characters to estimate the genetic variability, heritability, genetic advance and correlation to identify suitable gladiolus cultivar for mid-hill conditions of Arunachal Pradesh and found that magnitude of phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV). The high value of PCV along with GCV observed for plant height, leaf length, florets/spike, vase life, corm weight and cormels/plant indicated that there is variability in these characters. High heritability coupled with high genetic advance as per cent of mean was recorded for plant height, leaf length, florets/spike, corm diameter, corm weight and number of cormels/plant. Spike length was also significant and positively correlated with flower diameter and number of cormels/plant.

Kumar (2015) estimated the correlation and path coefficient analysis among 10 genotypes of gerbera for 13 quantitative traits to identify potential economic traits for selection. The experiment was carried out in randomized block design with three replications under naturally ventilated polyhouse at the Division of Ornamental Crops, IIHR, Hessaraghatta, Bengaluru during 2011-13. They reported that the number of leaves per plant was highly significant and positively correlated with number of suckers per plant, whereas, leaf length was highly significant and positively correlated with leaf width, plant spread, days to bud burst, days to first flower opening, flower stalk length, flower stalk diameter and number of flowers per plant. Days to first flower opening were positive and highly significant with leaf length, days to bud burst and number of flowers per plant. Flower diameter was positive and highly significant with number of suckers per plant and flower stalk length.

Vanlalruati *et al*. (2016) conducted an experiment to study the genetic variability, character association and path coefficient analysis in different *Orchid* spp for various quantitative traits. The maximum phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded for floret diameter. High heritability coupled with high genetic advance was observed for plant height, leaves/pseudobulb, florets/spike, floret diameter and pedicel length. Spike length showed positive and highly significant association with spike longevity and number of florets/spike at genotypic and phenotypic level. The study revealed wide variation for all the characters indicating sufficient genetic variability to be exploited in breeding programme.

Anitha *et al*. (2017) carried out an experiment with 12 cultivars of lisianthus which exhibited significant differences in all the characters studied. The coefficient of variation found to be highest for number of buds per plant (GCV = 43.24, PCV = 43.60) and minimum for bud diameter (GCV = 6.62, PCV = 8.27). Highest heritability was noticed for number of buds per plant (h^2 = 98.35) while high heritability coupled with high genetic advance was noted for days taken for bud initiation (h^2 = 98.20, GA = 39.86) and number of buds per plant (h^2 = 98.35, GA = 25.03). High genetic advance as per cent mean was exhibited by number of buds per plant (88.35) while the minimum of 10.43 was noticed in bud diameter.

Kispotta *et al*. (2017) carried out an experiment with ten gladiolus cultivars at the Department of Horticulture, Birsa Agricultural University, Ranchi during the period from December, 2009 to May, 2014 in order to estimate genetic variability, heritability, genetic advance and genetic advance as per cent of mean for 11 contributing characters. Phenotypic and genotypic coefficients of variation were highest for the spike length (34.16 and 34.18; respectively) followed by number of floret per spike (33.02 and 33.25; respectively) indicated the presence of sufficient genetic variability for selection in these traits. Days taken for the spike emergence was positively and highly significant with the days taken for bud initiation, days taken for first floret to show colour and to open, number of floret open at a time, diameter of the floret and spike length. Days taken for spike emergence were however, negatively and significantly correlated with number of floret per spike, number of shoot per plant and vase life. High heritability and high genetic advance in spike length (1.00 and 70.33; respectively), indicated the presence of additive gene effects in these traits and their amicability for direct selection on the basis of spike length, number of floret per spike and vase life will be more effective for further breeding programme.

Manoj (2016) studied genetic variability among 22 diverse gladiolus genotypes for 20 characters at Floriculture Research Farm, Jammu for two years during 2010-2011. The PCV were higher than GCV for all the characters studied, indicating thereby high degree of environmental influence. Higher GCV and PCV estimates were found for number of cormels per plant and average weight of cormels per plant. Heritability estimates were high (>80 %) for days to 50 per cent heading, days to first floret opening and days to last floret opening whereas propagation coefficient, number of cormels per plant showed moderate to high heritability along with genetic advance showing additive gene effects.

Phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) for all the characters included in study ranged from 4.73 to 56.94 per cent and 3.84 to 56.64 per cent; respectively indicated high degree of environmental influences in twenty genotypes of gladiolus. The heritability of different quantitative characters varied from 32.00 per cent (diameter of corms) to 99.1 per cent (cormels per plant). The high heritability coupled with high genetic advance (percentage of mean) for cormels per plant (99.1 and 116.29; respectively) advocated high genetic progress for this character (Verty *et al*., 2017).

2.3. GENETIC DIVERGENCE STUDIES

The genetic diversity of species is a valuable natural resource and the basis for survival. The greater the genetic diversity of a species and the more complex its genetic background, the stronger its evolutionary potential and ability to withstand adversity, and the more easily it will expand its distribution range and adapt to new environments.

The genetic divergence analysis of sixty cultivars of gladiolus for twenty developmental characters illustrated grouping of cultivars into 12 clusters. Based on cluster means, characters such as spike length, number of florets per spike, number of florets opening at first, number of florets remaining open at a time, number of capsules forming per spike and the seeds set per capsule, number of daughter corms & cormels produced per plant, and diameter of foremost floret were major factors of differentiation among these 60 cultivars. The cultivars producing more number of corms and cormels, spike length and number of florets per spike can thus be utilized for hybridization for making improvement in these characters (Misra and Saini, 1997).

Deshraj and Misra (2000) studied genetic divergence for 20 quantitative characters in 25 cultivars of gladiolus under three different environment conditions. Based on cluster means, characters like days to 50 % heading, first floret colour showing, first floret opening, last floret opening, number of florets per spike, average weight of a corm and propagation coefficient were the major factors for differentiation among all the cultivars. Maximum genetic distance was observed between clusters IV & V (E1 and E3), II & V (E2) and III and IV (pooled). The study also revealed that clustering behaviour and mean performance of cultivars of individual cluster were not consistent over the environments because of larger genotype x environment interaction.

Mishra and Mohanty (2003) assessed genetic divergence among 18 dahlia varieties through multivariate analysis following Mahalanobis D^2 statistic, canonical analysis and numerical taxonomic approach. Analysis of variance showed significant differences among the test entries for all the characters except flowering duration and number of tuber per plant. The characters having major contribution to genetic divergence were stalk diameter of secondary flower, number of ray florets in main flower, petal length and number of ray florets in secondary flower in order of merits.

Twenty five genotypes of dahlia were assessed for genetic diversity and variability studies. The genotypes were studied and grouped into 10 clusters in which cluster I, II and III were largest with five genotypes in each cluster, followed by cluster IV, V and VI having two genotypes in each cluster. The cluster VII, VIII, IX and X were mono genotypic clusters. The maximum intra-cluster distance was exhibited by genotypes of the cluster VI, while the lowest by the genotypes of the cluster IV. The inter-cluster distance was highest between the cluster VI, while the lowest between the cluster I and II (Nimbalkar *et al.*, 2006).

Pal *et al*. (2006) employed Mahalanobis D^2 analysis to study the genetic diversity of thirty gladiolus genotypes. The clustering pattern indicated that the geographic diversity need not necessarily be related to the genetic diversity. Genotypes from different eco-geographic regions were identified in one cluster. The inter-cluster distance was found maximum between cluster III and VIII followed by VI and VII. They further concluded that the genotypes in these clusters may possibly be utilized for hybridization through suitable breeding system for the successful exploitation of heterosis in gladiolus.

Bihari *et al.* (2009) evaluated the fifty genotypes of gladiolus to assess the nature and magnitude of genetic divergence using Mahalanobis D^2 statistics in the Department of Botany, D.A.V. College, Kanpur, during 2004-2005. The population was grouped into six clusters in which, cluster I was the largest one with twenty six genotypes followed by cluster V with seven and cluster-Ill and VI with five genotypes, whereas, cluster-II had four and cluster-IV had three genotypes. The cluster-I recorded maximum intra-cluster distance (16431.619) followed by cluster-V (1986.137), III (1754.896) and II (1114.541). With respect to inter cluster distance, it was found maximum between cluster-IV & V (1239.864) followed by I & IV (887.138), IV and VI (768.188) and I & V (725.470). Cluster-I retained maximum number of treatments which showed genetic similarities. Remaining clusters retained four or three cultivars which had considerable differences in their parents. Therefore, selection for divergent parents based on these traits is recommended for getting desirable hybrids or segregates in gladiolus.

Swaroop and Janakiram (2010) carried out an investigation with twenty eight genotypes of gladiolus (*Gladiolus hybrida*) which were evaluated to assess the genetic diversity at the Research Farm of Floriculture and Landscaping, IARI, New Delhi during 2006-07 to 2009-10 for three years in a completely randomized block design with three replications. Studies revealed that the mean performance of gladiolus data were highly significant for all the twelve traits for growth, flowering and corms parameters studied indicating the presence of variability. The genotypes were grouped into eight clusters, among which, cluster VIII was largest with twelve genotypes, followed by cluster I having four genotypes and the remaining cluster had two genotypes each. The maximum intra cluster distance was exhibited by genotypes of cluster VIII, whereas, lowest by the genotypes of cluster II. The inter-cluster distance was highest between the cluster VI and VIII and lowest between cluster I and VI, and II and V. The different clusters have higher mean values for different traits, the genotypes ‘Anjali’ from cluster I, ‘Dhanvantari’ and ‘Her Majesty’ from cluster VIII, ‘American Beauty’ from cluster III and ‘Sylvia’ from cluster VI deserve to be considerably to divergence.

In an experiment seven kinds of phenotype characteristics were studied to analyze the genetic diversity of giant, large, medium and small flower type of dahlia population. The result indicated that the difference of stem diameter, leaf length, leaf width, flower diameter, and pedicel were significant among different flower type population. The mean phenotypic differentiation coefficient out of dahlia population showed that variation among population (51.43%) was slightly higher than that within population (48.57%) (Feng *et al*., 2012).

A study conducted by Bhajantri (2013) indicated that among the 17 characters studied in gladiolus genotypes most of the flower characters contributed towards diversity. Floret diameter contributed maximum towards genetic divergence followed by number of florets per spike, vase life, spike length and plant height. Thirty genotypes were grouped into 8 clusters and among them, cluster I was the largest with 9 genotypes followed by cluster II (7) and IV (6) and cluster III with 3 genotypes. Rest of the clusters was of (clusters V, VII and VIII) solitary type. Divergence values (D^2 value) ranged from zero to 7.97 indicating considerable amount of moderate variability in the material studied. It is desirable to select genotypes from clusters having high cluster means and also with high flower character like spike length as parents for future recombination breeding programmes.

Malik and Pal (2015) studied genetic divergence among 22 gladiolus genotypes using Mahalanobis D^2 analysis and concluded that four clusters were formed and inter-cluster distance was found maximum between cluster II and cluster IV. The characters which contributed maximum in genetic divergence were leaf area (24.67 %), number of cormels per plant (17.75 %), spike length (9.09 %) and number of florets per spike (8.65 %) which can further be used in selecting diverse parent for hybridization programme. Therefore, selection should be based on leaf area, number of florets per spike, spike length and number of cormels per plant for better genotypes.

Naresh *et al*. (2015) evaluated eight gladiolus hybrids along with one check variety in order to study the genetic variability, heritability, genetic advance and correlation for identifying suitable gladiolus cultivar for coastal conditions of Andhra Pradesh, India. The magnitude of phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV). High heritability coupled with high genetic advance as per cent of mean was noticed in plant height at maturity, number of cormels per plant, number of corms per plant, days taken to sprouting of corm and weight of corm and cormels per plant thereby implying that these characters could be considered as guide parameters in order to make selections for improvement in gladiolus germplasm.

Gantait *et al*. (2016) studied genetic variability, heritability, genetic advance, correlation coefficient and path coefficient analysis for different traits were studied in 20 gladiolus genotypes. The results showed significant differences for all the traits studied among the genotypes. The high genotypic co-efficient of variation was recorded for floret diameter (20.38 %), flower stalk girth (25.01 %), number of corms per plant (41.35 %), corm weight (69.19 %), number of cormels per plant (41.35 %) and cormels weight (47.55 %) coupled with narrow difference between the genotypic and phenotypic co-efficient of variation. Genetic advance as per cent mean ranged from 0.13 to 141.47 % among the various traits. High heritability coupled with high genetic advance was also observed for plant height (89.40 %), leaf length (65.77 %), spike length (88.01 %), spike weight (97.46 %), number of corms per plant (74.75 %) and cormels per plant (95.60 %) indicating additive gene action, which suggested that improvement of these traits would be effective for further selection of superior genotypes. The plant height exhibited positive significant correlation at genotypic and phenotypic levels with number of florets per spike, spike length and spike weight. The path coefficient analysis based on spike weight, as responsible variable showed that the traits, namely, plant height (1.347), number of leaves (0.006), number of florets per spike (0.072) and spike length (0.265) exhibited significantly positive direct effect. Spike weight imparted maximum positive direct effect on the plant height followed by spike length. Hence, traits like spike weight, plant height and spike length may be considered for further improvement.

Wang *et al*. (2016) carried out the experiment with a sample of 49 individuals including 40 cultivars (Asiatic hybrids, Oriental hybrids, Longiflorum hybrids, LA hybrids, LO hybrids, and OT hybrids), nine species of wild lily, and their variants in order to assess the genetic variability and diversity of the main resources of lily via phenotypic characters, pollen morphology, and ISSR markers. The experiment revealed the positive correlations between pedicel length and both plant height and petiole length. In contrast, leaf shape demonstrated significant negative correlations with petiole length and pedicel length. Flower fragrance and anther length were significantly negatively correlated. Overall, data indicated that the selection of nutritional traits (plant height, ground diameter, pedicel length, petiole length and leaf shape) benefited the development of lily cultivars with larger flowers. Specifically, the genetic diversity of wild lily was higher than the cultivars.

Ranchana *et al*. (2013) conducted an experiment to evaluate the performance of five tuberose genotypes *viz*., ‘Calcutta Double’, ‘Hyderabad Double’, ‘Pearl Double’, ‘Suvasini’ and ‘Vaibhav’ under tropical conditions during 2011–2012. Results revealed that number of florets per spike recorded high phenotypic and genotypic coefficient of variation. High heritability coupled with high genetic advance as per cent of mean was observed for number of florets per spike, number of spikes per meter square, rachis length, yield of florets per plot, spike length, flowering duration, days taken for sprouting and plant height.

Sharma and co-workers (2017) conducted an experiment to evaluate the genetic variability in gladiolus at Horticultural Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during 2014-2015. A total of 53 varieties were evaluated for twenty seven characters in genetic diversity on the basis of Mahalanobis D^2 results of Cluster and D^2 analysis indicated the distribution patterns of gladiolus genotypes into 8 clusters. Cluster IV contained maximum number of genotypes (13). The grouping pattern of the genotypes suggested no parallelisms between genetic divergence and geographical distribution of genotypes while intra-cluster was maximum in cluster VII (D^2=372.85) revealing maximum genetic diversity followed by cluster II (D^2=343.39) and cluster V (D^2 =150.90) and maximum inter-cluster generalized distance (D^2=1855.02) was between cluster VII and cluster VIII thus exhibited maximum divergence followed by cluster II and VIII (D^2=1568.48). They further suggested that selection of genotypes based upon large cluster distance from all the clusters may lead to favorable broad spectrum genetic variability for corm yield improvement. The cluster VII had highest mean values number of corms per plant and genotypes in cluster VIII had highest mean values of weight of corm, weight of corms per plant indicating that by crossing between these clusters may be helpful in genetic improvement of gladiolus germplasm.

Bhatia *et al*. (2017) assessed twenty one tulip genotypes for their genetic divergence based on sixteen agro-morphological traits following Mahalanobis D^2 -statistic. On the basis of D^2 values, the 21 genotypes were grouped into five clusters, of which cluster II accommodated six genotypes, while cluster IV had single genotype. The highest inter cluster D^2 value was recorded between clusters III and V (11005.75) indicating that crosses may be attempted between the genotypes of cluster III (‘Character’, ‘Christian Dream’, ‘Hamilton’ and ‘Horizon’) and cluster V (‘Apeldoorn’, ‘Blushing Apeldoorn’, ‘Golden Apeldoorn’, ‘Strong Gold’ and ‘Tulip Hb’) to obtain new desirable recombinants in tulip. The study of cluster mean value of five clusters indicated high range of variation for days to sprout, days to flower, wrapper leaf area, percent sprouting & flowering, plant height and scape length among the different clusters. The cluster V includes genotypes with earliness and exhibited longest duration of flowering, highest wrapper leaf area and bulb weight. Genotypes of this cluster also possessed desirable floral traits (scape length, floral size and scape thickness) and bulb traits (number of bulbs per plant and bulb weight). Hence, genotypes from this cluster could serve as valuable parents to develop superior cultivars.

2.4. STABILITY ANALYSIS

The performance of a genotype is highly influenced by the genotype × environment interaction. Nature of genotype × environment interactions are extremely complex (Allard and Hansche, 1964). Despite the varieties being pure lines, single cross, double cross hybrids, test crosses, segregating populations or any other materials with which the breeder may be working, genotype × environment interaction play a major role in their phenotypic expression over particular environment.

At the beginning, the analytical approach had been to estimate genotype × environment interaction from the pooled analysis of variance (Horner and Frey, 1957 and Sandison and Bartlett, 1958). Later on an alternate method for analyzing the genotype × environment interaction, mainly based on regression technique came to existence. The most essential feature in developing this technique was to quantify the environment on the basis of the mean performance of the material and was originally suggested by Yates and Cochran (1938). It was modified by different workers such as Finlay and Wilkinson (1963), Eberhart and Russell (1966), Perkins and Jinks (1968) and Freeman and Perkins (1971). The regression of genotypes on environment provides two simple measures of genotypic changes to environments namely regression coefficient and deviation from regression. For measuring the genotype × environment interaction through linear regression technique, Yates and Cochran (1938), Finlay and Wilkinson (1963), Eberhart and Russell (1966) and Perkins and Jinks (1968) used the mean obtained by calculating the average of all the characters or a particular character where each location was taken as the environmental index.

Even though different stability models are available, the regression analysis of Eberhart and Russell (1966) has been widely used by many workers. According to this model, parameters like b_i (slope of regression line) and s^2_{di} (sum of square deviation from regression) provide the criteria necessary to rank varieties for stability in performance.

Among crop plants, little work has been done on ornamentals with regard to stability and adaptability trials. The observable difference in the behaviour of 18 varieties of gladiolus grown simultaneously at Leningrad (latitude 59°44 North) and Kransnodar (latitude 45°36 North) with respect to the characters like plant growth and flowering was studied. The gladioli planted at Leningrad were found to be fast growing, but flowering was late. At the same time the gladioli grown at Kransnodar, growth started little late but flowering was advanced by 20-25 days (Tamberg and Chirva, 1978).

Arora and Sharma (1991) selected seven cultivars of gladiolus, *viz.*, ‘Snow Princess’, ‘Melody’, ‘Aldebaran’, ‘Suchitra’, ‘Mayur’, ‘G-55’ and ‘CPG-6’ for stability performance in six environments by planting the corms on first of each month from July to December. On the basis of mean performance, cv. ‘Snow Princess’ took minimum number of days for basal floret to open. ‘Melody’ was a good performer and had average stability for most of the traits whereas ‘Mayur’ produced maximum number of florets. Though, ‘Mayur’ produced less number of cormels per plant than ‘Melody’, yet it had better stability performance. These cultivars, therefore, exhibited great promise for hybridization programmes.

Desh Raj and Misra (1998a) studied three locations (Palampur, Shimla and Katrain) for 2 years (1993 and 1994) on 25 varieties of gladiolus. Singificant mean squares due to genotype × environment interactions (linear) were observed for propagation coefficient, whereas, for all the other characters mean squares due to pooled deviation were significant. Among the varieties screened for stability for all vegetative characters, three genotypes (‘Dhanvantari’, ‘Legend’ and ‘American Beauty’) were identified as being the most suitable across all the six environments. The cultivars ‘Dhanvantari’, ‘Red Softglow’, ‘Australian Fair’, ‘Rose Memento’ and ‘Viola’ were found best under Palampur conditions. ‘Red Softglow’, ‘Viola’, ‘Dhanvantari’, ‘Melody’ and ‘Little Fawn’ were found to be best under Shimla conditions. Whereas, at Katrain, cultivars like ‘American Beauty’, ‘Spring Song’, ‘Snow Princess’, ‘Australian Fair’ and ‘Rose Memento’ were found to be ideal.

Study conducted with various gladiolus cultivars at UP hills by Pant and Lal (1998) revealed that the morphological traits like spike length was the longest for cultivars ‘Apple Blossom’, ‘Picardy’ (87.44 cm) and ‘Oscar’ and number of flowers was highest in ‘Friendship’ followed by ‘Oscar’.

Findings of Desh Raj and Misra (1998b) indicated significant linear component of genotype × environment interaction for characters such as number of florets per spike and rachis length when 25 cultivars were subjected for stability analysis over six environments. Among these cultivars, ‘Red Softglow’ and ‘Viola’ showed high mean performance, unit regression coefficient and least deviation from regression coefficient for most of the economic characters under all the six environments.

Misra (2002) while conducting studies on variability and stability estimates in carnation concluded that stability for characters like number of flower buds per plant, plant height, stem length and days to flower bud opening are very important as these had a strong positive association with number of flowering stems per plant. Genotypes for further breeding programme may be selected based on this criterion.

Naik (2003) concluded that tall genotype ‘AMO’ and dwarf ‘Orange Boy’ could be considered most stable for xanthophyll yield, flower yield, petal meal yield per hectare and most of the vegetative and floral characteristics as they were well adapted to all of the environments as indicated by their mean value higher than general mean and significantly superior over local checks *viz.*, ‘Orange Double’ and ‘Local Dwarf’ and also their regression coefficient was nearer to unity and non-significant deviation from regression mean square.

Vaidya (2006) conducted an experiment to find out the stable genotype for cut flower, loose flower, pot plant and bedding purposes under Nauni, Mashobra and Bhota locations of Himachal Pradesh. Based upon the growth and flowering performance, Sel. 43 and Sel. 83 have been suggested for cultivation as loose flowers and Sel. 21, Sel. 44 and Sel. 56 as pot plant. For their cultivation as cut flower, Sel. 29, Sel. 31, Sel. 33, Sel. 34, Sel. 37, Sel. 39, Sel. 41, Sel. 43, Sel. 58, Sel. 61, Sel. 63, Sel. 64, Sel. 69, Sel. 76, Sel. 77, Sel. 81, Sel. 82, Sel. 83 and Sel. 98 have been recommended for all the three locations.

Stability analysis performed in different marigold genotype revealed that genotype ‘AMC-19’ was most stable with relatively better yield and quality parameters *viz.*, flower diameter, shelf life and xanthophyll content as indicated by its high mean value with stable and predictable performance followed by ‘AMC-8’ and ‘AMC-20’. The genotype ‘AMC-6’ was found suitable for favourable environmental conditions. The genotypes ‘AMC-6’, ‘AMC-7’, ‘AMC-20’, ‘AMC-14’ and ‘AMC-8’ were stable with high mean values and predictable performance for flower diameter while genotypes ‘AMC-6’, ‘Marigold African Giant’ and ‘AMC-17’ were stable with higher mean values and performance for individual flower weight. The genotypes ‘AMC-6’, ‘AMC-7’, ‘AMC-13’, ‘AMC-17’ and ‘AMC-19’ had maximum shelf life with higher mean values and predictable performance (Patil *et al*., 2011).

Fifteen genotypes of spray chrysanthemum were evaluated for stability parameters with respect to plant height, total leaf area per plant, number of flowers per plant and flower yield (weight) over two successive years under greenhouse and open field conditions. Cultivars ‘Tata Red’ and ‘Aditi’ could be considered as widely adapted varieties for flower yield and number of flower per plant; respectively. ‘Red Gold’ and ‘Jaya’, showing their wide adaptability for plant height, were suitable for adverse and favourable environments, respectively, in case of flower yield (Gantait *et al*., 2012).

The result of AMMI (Additive main effects and multiplicative interaction) revealed that chrysanthemum genotypes ‘Dundi’, ‘Statesman’ and ‘Raja’ were the most stable genotypes because their interaction with the environment was not enough to hinder yield as indicated by their IPCA scores of zero and near zero suggesting that these genotypes can be cultivated in any of the three environments included in the study. Genotype ‘Garden Beauty’, ‘Karnool’ and ‘Winter Queen’ were generally high yielding and had high interactions, indicating that they were unstable and responsive to changes in the environment. The best genotypes with respect to open condition environment were ‘Dundi’ and ‘Accession No. 2’; ‘Statesman’, ‘Raja’, ‘Autumn Joy’ and ‘Accession No. 1’ for shade house; whereas ‘Chitradurga Local’, ‘Garden Beauty’ and ‘Winter Queen’ were best for polyhouse condition. Overall results indicated that genotype ‘Dundi’ could be the best choice as a suitable genotype with desirable flower diameter and flower weight (more than average), good shelf life, relatively higher yield as well as stability for Northern dry zone of Karnataka (Priyanka, 2012).

Investigation on stability analysis in chrysanthemum (*Dendranthema grandiflora* Tzvelev) was carried out at College of Horticulture, Venkataramannagudem, West Godavari district of Andhra Pradesh during 2017-2018. The genotype × environment interaction was significant for all the characters except number of flowers per plant. The genotype 'Pusa Aditya' and 'Scent Chamanthi' showed stability for yield per plot and 'Scent Chamanthi' for yield per hectare with regression coefficient near to unity with non-significant deviation from linearity (S^2_{di}) and therefore considered as well adopted to all environments (Kumar *et al*., 2018).

2.5. DUS CHARACTERIZATION STUDIES

Under the provision of UPOV 1991 Act, a plant variety must satisfy the criteria for protection *viz*., distinctness, uniformity and stability (DUS). The requirement of distinctness, uniformity and stability are assessed on the basis of morphological characteristics. These characteristics are a feature of whole plant or part of plant. The testing of DUS characters is useful in four main ways, (i) identification of varieties, (ii) for registration of varieties and plant variety protection (PVP) Act, (iii) for varietal information system and classification of varieties into different groups and (iv) for creating the database for plant viz., for genetic resources (Singh *et al*., 2005).

Arens *et al.* (2009) carried out an investigation to study the identification of carnation varieties using microsatellite markers for the characterization of carnation varieties as well as the construction and evaluation of a molecular database. In total, 172 samples were analysed of which 133 samples were sent in by breeding companies and 12 samples were reference varieties from the carnation DUS test of 2005. The 15 polymorphic microsatellite markers available were supplemented with 28 newly developed markers. The set of 12 reference varieties was used for pattern quality assessment. Thirteen markers were selected on the basis of pattern quality (quality 1 or 2), using the standards described by Smulders *et al.* (1997). The selected markers were used for fingerprinting the set of 172 samples. The numbers of allelic marker phenotypes varied from 3 to 20 and, in total, 163 marker phenotypes were found.

In order to promote the encouragement for the development of new varieties of ornamental crops and to protect the farmers and breeders rights, the PPV and FR Authority (2010) has proposed the DUS testing guidelines applied to all varieties, parental lines of *Chrysanthemum* × *morifolium* Ramat (*Chrysanthemum* × *grandiflorum* Ramat), *Chrysanthemum pacificum* Nakai and the hybrids between these. The main aim of these guidelines to different crops is to provide comprehensive practical guidance for the corresponding examination of DUS of the candidate variety and, in particular, to identify appropriate characteristics for the examination of DUS.

Preceding to registering a variety as a cultivar and /or granted Plant Breeder's Rights, its distinctness, uniformity and stability (DUS) is tested using morphological characters which are recognized as 'descriptors'. In India, PPV and FR Authority (Protection of Plant Varieties and Farmers' right Authority) conducted evaluation trials for identifying the DUS descriptors for rose (PPV and FR Authority, 2011a) and orchids namely *Cymbidium* Sw., *Dendrobium* Sw. and *Vanda* Jones ex R.Br (PPV and FR Authority, 2011b). Under this act, a new cultivar will be registered based on its DUS test.

Banerji and his coworkers (2012) evaluated ten large flowered chrysanthemum cultivars, viz., 'Beat Rice May', 'Beauty', 'Casa Grande', 'Jet Snow', 'John Weber' , 'Miss Maud Jeffries', 'Penny Lane', 'Shanker Dayal', 'Snow Ball' and 'S.S. Arnold' for morphological and biochemical characterization at National Botanical Research Institute (NBRI), Lucknow. Morphological data were recorded on vegetative and floral characters. Biochemical characterization included analysis of anthocyanins, carotenoides, chlorophyll content (chlorophyll a, b and total) and flavonoids. Results on morphological and biochemical parameters clearly indicated distinctness among cultivars with reference to differences in morphological characters and chemical composition of pigments.

Panwar *et al.* (2012) characterised thirty two Indian roses using DUS based morphological descriptors. Plant growth type was divided into six categories and the maximum twenty four genotypes were covered under bed rose category. Similarly, flower colour was divided into thirteen categories based on colour groups mentioned in the DUS guidelines. The study concluded that the existence of wide variation for various vegetative and floral traits in all the genotypes provides good scope for selecting suitable genotypes for all the economic traits.

Choudhary and his co-workers (2014) conducted an expriment on the characterizarion of marigold genotypes using morphological characters at the Research Farm of Department of Horticulture, CCS Haryana Agricultural University, Hisar during the years 2011-12 and 2012-13. Thirty genotypes of marigold were slected and their different morphological characters both at vegetative and flowering stages were studied and the categorization was done on the basis of their plant characters. The results revealed the significant variations for different growth, flowering and yield parameters among all the genotypes.

De *et al.* (2014a) studied the morphological characterization of eight species of *Paphiopedilum* viz., *Paphiopedilum concolor, P. fairrieanum, P. godefroyae, P. hirsutissimum, P. insigne, P. spicerianum, P. venustum* and *P. villosum* for the development of morphological descriptors based upon UPOV guidelines and accordingly total 76 morphological descriptor of *Paphiopedilum* were developed. The morphological characterizations were done used for all vegetatively propagated species of *Paphiopedilum* and alliance of the family *Orchidaceae*.

De and co-workers (2014b) evaluated 40 hybrids of *Oncidium* for development of DUS test guidelines using common descriptors. Out of 60 common descriptors developed, plant type, basal leaf number/ pseudobulb, flower width in front view, petal predominant colour, petal colour pattern, lip predominant colour and lip colour pattern were used for grouping of hybrids.

De and co-workers (2015a) carried out an investigation on morphological characterization of thirty *Dendrobium* spp. for the development of morphological descriptor of *Dendrobium* based on UPOV guidelines and accordingly total 62 morphological descriptors were developed. Out of 62 descriptors, plant height, internode number, inflorescence number per shoot per year, flower width, flower predominant colour, lip main colour, lip ornamentation and flowering time were used for grouping characteristics of species.

De *et al*. (2015b) studied the morphological characterization of all vegetatively propagated species of *Vanda* of family Orchidaceae. They studied 11 *Vanda* species viz. *Vanda alpina, V. cristata, V. coerulea, V. parviflora, V. coerulescens, V. stangeana, Papilionanthe (Vanda) teres, V. bicolor, V. tassellata, V. pumila*, and *V. parishii* for the development of morphological descriptors based upon UPOV guidelines and accordingly total 65 morphological descriptors of *Vanda* were developed.

Distinction of cultivars based on morphological characters is the criterion being followed internationally for assigning Plant Breeders Rights. However, the time and environmental influence being constant problems in morphological evaluation has forced for looking at feasible alternative. Keeping in view the inherent problem of the morphological characters related to their limited number, the precision required in recording, and high genotype × environment interaction, the use of biochemical and molecular markers for DUS testing of varieties has been suggested (Law *et al.*, 1999; Wouters and Booy, 2000; Jones *et al.*, 2003; Cook *et al.*, 2003). Of the physiological, biochemical and molecular methods; molecular method had always emerged as time saving and most reliable alternative. Therefore, complementary approaches, such as the use of microsatellite markers, are being evaluated and molecular databases are being constructed. Among several molecular markers, microsatellites are highly polymorphic and preferred for their co-dominant nature, and for abundance.

Tejaswini and co-workers (2012) carried out an investigation to identify a potential set of microsatellite markers for discrimination of carnation cultivars. Microsatellite markers extracted genetic differences between clones indicating the problem of uniformity criterion that is considered as fundamental in DUS testing. On the contrary the set of primers that expressed uniformity across clones failed to extract the maximum difference between cultivars required to establish the distinctness. Primers with high value of power of discrimination were found to be more appropriate for establishing the distinctness of cultivars. Microsatellite markers were to able cluster genetically similar genotypes together that are morphologically separated into distant clusters.

Asha *et al*. (2016) conducted an experiment on characterization and establishment of distinctiveness among thirty chrysanthemum genotypes for 41 essential characters among which six characters were monomorphic, five dimorphic and thirty were polymorphic. Out of thirty genotypes studied, eight were found to be distinctive on the basis of ten essential characters while the rest of twenty two genotypes remained in groups of two or three without being differentiated for similar traits, therefore it is suggested to use other biological markers/DNA fingerprinting.

Chapter-3

MATERIALS AND METHODS

The present investigation on **“Genetic studies and DUS characterization in *Lilium*’’** were carried out at the experimental farm of Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan and Indian Council of Agriculture Research, Indian Agricultural Research Institute, Regional Station, Katrain, Kullu (HP). The experimental farm of Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan is located 1276 m above mean sea level at the latitude of 32°5'10" North and longitude of 77°11'30" East. The prevalent climate of Nauni is sub-temperate characterized by mild summers and cool winters. The maximum temperature during the study period ranged between 16.40 ^{o}C to 30.50 ^{o}C and minimum 3.10 ^{o}C to 20.40 ^{o}C during the first year of cultivation. During second year (2017-18) maximum temperature ranged between 19.10 ^{o}C to 30.70 ^{o}C and minimum 2.10 ^{o}C to 18.90 ^{o}C. The meteorological data of the experimental period of both the years has been presented in Appendices-I.

As far as climatic conditions of Regional Station Katrain are concerned, the experimental farm is situated at an altitude of 1688 m above mean sea level at the latitude of 32°10'49" North and 77°11'42" East. The maximum temperature during the study period ranged between 13.90 ^{o}C to 27.13 ^{o}C and minimum 3.40 ^{o}C to 20.93 ^{o}C during the first year of cultivation. During second year (2017-18) maximum temperature ranged between 13.65 ^{o}C to 28.10 ^{o}C and minimum 3.90 ^{o}C to 20.61 ^{o}C. The meteorological data of the experimental period of both the years has been presented in Appendices-II.

3.1 PLANT MATERIAL

Eighteen cultivars of *Lilium* belonging to four different groups *viz*., seven Asiatic hybrids (‘Navona’, ‘Prato’, ‘Tresor’, ‘Shiraj’, ‘Brunello’, ‘Pollyana’, and ‘Elite’), seven LA hybrids (‘Eyeliner’, ‘Ercolano’, Ceb Dazzle’, ‘Best Seller’, ‘Pavia’, ‘Salmon Classic’ and ‘Cilesta’), two OT hybrids (‘Yelloween’ and ‘Montego Bay’) and two Oriental hybrids (‘Viviana’ and ‘Sapporo’) were selected for the present investigation (Plate 1a). The planting material of these cultivars was procured from ICAR-IARI, Regional Station, Katrain, Kullu Valley (Himachal Pradesh). The bulbs were produced under the prevailing condition of Kullu

Valley. The meteorological data of the bulb production period of Katrain, Kullu Valley is given in the Appendix-III.

For planting at Nauni, freshly harvested bulbs of uniform size (12/14) (Plate 2a) of all the cultivars were selected and were stored at 4 ^{o}C in the cool chamber of the department of Floriculture and Landscape Architecture for 9 weeks before planting and subsequently planting was done in the month of December. For second year crop, harvesting of first year planted crop was done and bulbs of all the genotypes were vernalized for 9 weeks at 4 ^{o}C in the cool chamber and further planting was done. However under Katrain conditions, no such artificial vernalizations of bulbs were performed and after harvesting bulbs were planted accordingly in the month of October during both the years.

3.2 GENERAL PROCEDURES

3.2.1 Preparation of growing medium

Growing medium was prepared by mixing soil, well rotten farm yard manure (FYM), sand and vermicompost in the ratio of 2:1:1:1 (v/v). Before mixing of these components thoroughly, soil as well as FYM was sieved to keep the stones, grass roots and other unwanted materials away from the growing mixture.

3.2.2 Bed preparation and application of chemical fertilizers

The thoroughly mixed medium was spread in the shade net house/field to make raised (20 cm) beds of 60 cm length and 60 cm width with a path of 30 cm width between the beds. All unwanted material *viz*., crop residues, stones, weeds were removed from the beds and the soil was brought to a fine tilth. A basal dose of nitrogen (6.52 g/m^2), phosphorus (18.75 g/m^2) and potassium (5.0 g/m^2) was applied by mixing urea (3.9 g/0.6 m^2), single super phosphate (11.25 g/0.6 m^2) and muriate of potash (3.0 g/0.6 m^2) in the medium thoroughly. Thereafter, planting of different varieties was done in a Randomized Block Design (RBD).

3.2.3 Planting

Planting of bulb was done after one week of mixing the fertilizers in soil to avoid direct contact of fertilizer granules with the bulb. The depth of bulb planting was kept at 8-10 cm deep in lines separated by 30 cm distance from line to line (Plate 2b). The bulbs were planted carefully so as to avoid any damage to bulbs. After planting, beds were drenched with solution comprising of Bavistin (0.1 %) and Dithane M-45 (0.2 %).

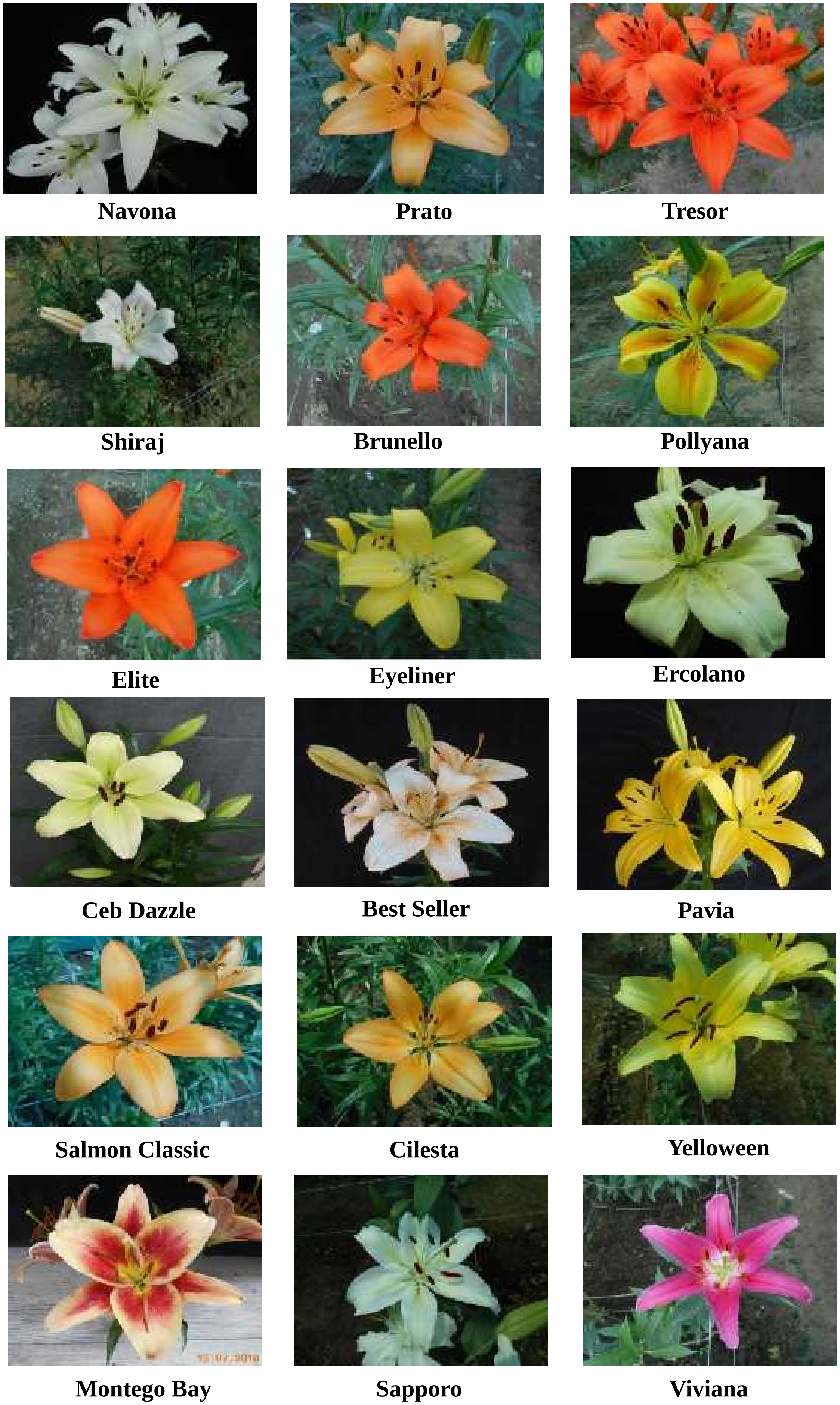


Plate 1(a): *Lilium* genotype selected for experiment

3.2.4 Intercultural operations

Routine intercultural operations like; watering, weeding, hoeing and control of insect-pest and diseases *etc* were done as per the requirement. Irrigation was given at an interval of 5-6 days during the winter season, whereas, during summer months irrigation was done in 3-4 days interval.

Initially after planting drenching with Bavistin (0.1 %) and Dithane M-45 (0.2 %) was done at weekly interval in order to avoid bulb or scale rotting. When plants attained about 50 cm height, staking with bamboo sticks was also done in order to avoid breakage of stems.

The predominant weed population of *Oxalis latifolia* and *Galinsoga parviflora* was controlled by manual weeding with the help of hand hoe which indirectly also helped in providing better aeration to the roots of the crop plants.

3.3 EXPERIMENTAL DETAILS

The present study was done in two locations for two years in a Randomized Block Design with three replications, one at the experimental farm of Department of Floriculture and Landscape Architecture, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP) under shade net house (50 %) conditions and another at Indian Council of Agricultural Research, Indian Agriculture Research Institute, Regional Station, Katrain, Kullu, (HP) under open field conditions during 2016-17 and 2017-18.

The details of study were given as under:

Genotypes : 18

Replications : 3

Design : Randomized Block Design (Factorial)

Locations : 2

(i) Experimental Farm, Department of Floriculture and Landscape Architecture

(ii) ICAR-IARI, Regional Station, Katrain, Kullu

Each location in each year was considered as different environment, making four different environments designated as follows:

Environment 1 (E_1) : Experimental Farm, FLA, Nauni, 2016-17

Environment 2 (E_2) : Experimental Farm, FLA, Nauni, 2017-18

Environment 3 (E_3) : ICAR-IARI, Regional Station, Katrain, Kullu, 2016-17

Environment 4 (E_4) : ICAR-IARI, Regional Station Katrain-Kullu, 2017-18

3.4 OBSERVATIONS RECORDED

To evaluate variability, genetic divergence and stability analysis, the following observations were recorded:

1. Days taken for bulb sprout emergence

Days taken for bulb sprout emergence were recorded from the date of planting of bulb to the appearance of sprouts above growing medium.

2. Per cent bulb sprouting

Per cent bulb sprouting was calculated by counting the number of bulbs sprouted out of total numbers of bulbs planted.

3. Plant height (cm)

Plant height was measured from the surface of soil to the top of inflorescence with the help of meter rod at the time of flowering.

4. Number of leaves/plant

Number of leaves was counted from the ground level to the pedicel of the lower most flower bud.

5. Leaf length (cm)

The length of longest leaf from ten randomly selected plants was measured with the help of measuring scale and expressed in centimeters.

6. Leaf width (cm)

The leaf used for measuring the length was also used for recording width. The widest part of the leaf was measured to determine the leaf width and expressed in centimeters.

7. Stem length (cm)

Stem length was measured by leaving 20 cm from the surface of soil to the top of inflorescence with the help of meter rod at the stage of harvesting of stems.

8. Days to flower bud formation

Days taken to flower bud formation were recorded by counting the days from the date of sprouting till the visibility of first flower bud inside the folded leaves.

9. Bud length (cm)

Bud length was measured at harvesting stage with the help of measuring scale.

10. Days to first flower

Days to first flowering were recorded from the date of sprouting of planted bulbs to the day when first flower of the plant was fully opened.

11. Stem diameter (cm)

Basal stem diameter was measured with the help of digital vernier caliper at the time of harvesting.

12. Size of the flower (cm)

Size of flower was recorded as an average of distance between apices of petals in East to West direction and the distance between apices of petals in North to South direction.

13. Number of flowers per plant

The total number of flowers per plant were recorded at the time of peak flowering.

14. Tepal length (cm)

The length of outermost tepal from base to the tip was measured with the help of measuring scale and expressed in centimeters.

15. Tepal width (cm)

The widest part of the tepal was measured to determine the width with the help of measuring scale.

16. Duration of flowering (days)

Duration of flowering was recorded by counting the number of days from the first opening of the flower till the fading of last flower.

17. Bulb diameter (cm)

Bulb diameter was recorded with the help of digital vernier caliper as an average of the diameter of bulb from the middle in length and width wise.

18. Weight of bulb (g)

Average weight of ten bulbs was calculated with the help of electronic weighing machine.

19. Number of bulblets/plant

The total number of bulblets produced per plant just above the mother bulb on the stem was counted after harvesting of each plant.

20. Weight of bulblets (g)

Total weight of bulblets was recorded first, then total weight of bulblets was divided by the number of bulblets produced per stem, and then the weight of individual bulblet was recorded.

21. Axillary bulbils/stem (particular to variety)

Number of bulbils per stem were counted after flowering.

22. Vase life (days)

Vase life was determined as the number of days taken from placing of cut stem in distilled water till wilting and falling of petals.

23. Stem strength (%)

Stem sturdiness was recorded by holding cut flower stem horizontally at a point 3 cm above the cut end and the deviation of flower head below the horizontal plane with the natural curvature of the stem was recorded by making the angles on chart. Stem sturdiness was graded in three ranks on the basis of following characters and angle of deviation.

Characters	Deviation	Rank
Sturdy	$10\text{-}20^{o}$	1
Fairly sturdy	$>20\text{-}30^{o}$	2
Fairly limp	$>30^{o}$	3

24. Grading of cut flowers (%)

Grading of cut flower was done on the basis of stem length and number of flowers per stem. The stem length was calculated by subtracting twenty from the actual plant height. The following grades were designated: (Anon, 1996)

Grades	**1**	**2**	**3**	**4**	**5**
Stem length	>60 cm	>55-60 cm	>50-55 cm	>40-50 cm	<40 cm
Number of flowers/plant	>6	5-6	4-5	3-4	1

25. Incidence of insect-pest and diseases

The plants were investigated throughout growing period for appearance of any insect-pest and disease symptoms. Per cent incidence of insect-pest and diseases was computed as follows:

$$\text{Per cent incidence} = \frac{\text{Number of plants infected}}{\text{Total number of plants}} \times 100$$

Plate 2(a): View of *Lilium* bulbs selected for planting

Plate 2(b): View of planting of *Lilium* bulb

(a): At flower bud formation stage

(b): At flowering stage

Plate 3: Overview of experimental trial at Nauni location

(a): At bulb sprouting stage

(b): At peak flowering stage

Plate 4: Overview of experimental field of *Lilium* genotypes at ICAR-IARI, Regional Station, Katrain, Kullu

3.5 STATISTICAL ANALYSIS

The data in respect of different characters studied were subjected to the following analysis:

3.5.1 Analysis of variance

Analysis of variance was done as per design of experiment as suggested by Gomez and Gomez (1984). For estimation of different statistical parameters, following procedure and formulae were adopted:

3.5.2 Analysis of variance

Source of variance	Degree of freedom	Sum of squares	Mean sum of squares	Variance ratio (V.R.)
Replication (r)	r-1	Sr	Sr/(r-1) = Mr	Mr/Me
Genotypes (g)	g-1	Sg	Sg/(g-1) = Mg	Mg/Me
Error (e)	(r-1) (g-1)	Se	Se/(r-1) (g-1) = Me	

Where,

r = Number of replications

g = Number of genotypes

Sr = Sum of squares due to replications

Sg = Sum of squares due to genotypes

Se = Sum of squares due to error

Mr = Mean sum of squares due to replications

Mg = Mean sum of squares due to genotypes

Me = Mean sum of squares due to error

The calculated F-value was compared with tabulated F-value. When F-test was found significant, critical difference was calculated to find out the superiority of one entry over the others.

The standard error and critical differences were calculated as follows:

$$SE(m) \pm = \sqrt{Me/r}$$

$$SE(d) \pm = \sqrt{2\,Me/r}$$

$$CD_{0.05} = S.E.(d) \times t_{(0.05)}\ (r-1)\ (g-1)\ df$$

Where,

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

All the traits, which differed significantly, were utilized further for estimation of following genetic parameters:

3.5.2 Mean performance and genetic variability

The extent of variability is measured by genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) which provides information about relative amount of variation in different characters. The genotypic and phenotypic coefficients of variation were calculated as per formulae given by Burton and De-Vane (1953).

A) Genotypic Coefficient of variability (GCV)

$$\text{GCV (\%)} = \frac{\sqrt{\text{Genotypic variance (Vg)}}}{\text{General mean of population } (\bar{x})} \times 100$$

B) Phenotypic Coefficient of variability (PCV)

$$\text{PCV (\%)} = \frac{\sqrt{\text{Phenotypic variance (Vp)}}}{\text{General mean of population } (\bar{x})} \times 100$$

3.5.3 Heritability (in broad sense)

Heritability in broad sense was calculated by the formula as suggested by Allard (1960).

$$\text{Heritability (\%)} = \frac{Vg}{Vp} \times 100$$

Where,

Vg	=	Genotypic variance [Vg = (Mg - Me) / r]
Vp	=	Phenotypic variance [Vg + Ve]

3.5.4 Genetic advance (GA)

The expected genetic advance (GA) resulting from selection of five per cent superior individuals was worked out as suggested by Allard (1960).

Genetic advance = H x σ p x K

Where,

K	=	2.06 (Selection differential at 5 per cent selection index)
Σp	=	Phenotypic standard deviation
H	=	Heritability in broad sense

3.5.5 Genetic gain (GG)

Genetic gain expressed as per cent ratio of genetic advance and population mean was calculated by the method given by Johanson *et al.* (1955).

$$\text{Genetic gain (\%)} = \frac{\text{Genetic advance}}{\text{General mean of population}\,(\bar{x})} \times 100$$

For categorizing the magnitude of different of different parameters, the following limits were used:

For PCV and GCV:

>30% - High

15-30%- moderate

<15% - low

For heritability:

>80% - High

50-80%- moderate

< 50% - low

Genetic advance:

> 50 % - High

25-50 %- moderate

<25 % - low

3.5.6 Genetic divergence (D^2 analysis)

The genetic divergence among genotypes was computed by following Mahalanobis D^2 technique (1936) and the grouping of genotypes into different clusters was done by following Tochers method (Singh and Chaudhary, 1979). The calculation of D^2 analysis involved following steps:

i) A set of uncorrelated linear combination linear (y's) was obtained by pivotal condensation of the common dispersion matrix Rao (1952) of the set of correlated variable (x's).

ii) Using the relationship between y's and x's the mean value of different genotypes for different characters (x_1 to x_{15}) were transformed into the mean values of an uncorrelated linear combination (y_1 to y_{15}).

iii) The D^2 values between i^{th} and j^{th} genotype for K characters were calculated as:

$$D^2 ij = \sum_{i=1}^{K} (yit - yjt)$$

Group constellation

Treating D^2 as the generalized statistical distance between a pair of populations (genotypes), all populations were grouped into number of clusters according to method described by Rao (1952). The criterion used in clustering by this method was that, any two genotypes belonging to the same cluster, at least on an average, show a small D^2 value than those belonging to two different clusters. In other words, if genotypes V_1 and V_2 are close together and genotypes V_3 is distant from both as shown by their generalized distance then V_1 and V_2 will be grouped, in same the cluster.

3.5.7 Correlations

The genotypic and phenotypic correlations were calculated as per Al-Jibouri *et al.* (1958) by using analysis of variance and covariance matrix in which total variability has splited into replications, genotypes and errors. All the components of variance were estimated from the analysis of covariance as given below:

3.5.7.1 Analysis of Variance and Covariance

Source of variance	Degree of freedom	Mean sum of squares		Mean sum of products	Variance
		X	Y		
Replications (r)	r-1				
Genotypes (g)	g-1	Mg X	Mg Y	Mg XY = MP_1	MP_1/MP_2
Error (e)	(r-1) (g-1)	Me X	Me Y	Me XY = MP_2	

Genotypic, phenotypic and environmental co-variances between X and Y characters were worked out as under:

$$Ve\ XY = MP_2$$

$$Vg\ XY = (MP_1 - MP_2) / r$$

$$Vp\ XY = Vg\ XY + Ve\ XY$$

Where,

Ve XY	=	Environmental covariance between X and Y
Vg XY	=	Genetic covariance between X and Y
Vp XY	=	Phenotypic covariance between X and Y

3.5.7.2 Coefficients of correlation

a) Genotypic correlation coefficient between X and Y

$$r_g = \frac{Vg\ XY}{\sqrt{Vg\ X \times Vg\ Y}}$$

Where,

Vg XY	=	Genotypic covariance between X and Y
Vg X	=	Genotypic variance of X
Vg Y	=	Genotypic variance of Y

b) Phenotypic correlation coefficient between X and Y

$$r_p = \frac{Vp\ XY}{\sqrt{Vp\ X \times Vp\ Y}}$$

Where,

Vp XY	=	Phenotypic covariance between X and Y
Vp X	=	Phenotypic variance of X
Vp Y	=	Phenotypic variance of Y

Genotypic variance (Vg) = (Mg-Me) / r

Phenotypic variance (Vp) = (Vg+ve)

The calculated correlation coefficients (r) values were compared with ‘r’ tabulated values as given by Fisher and Yates (1963) at (n-2) degrees of freedom to test their significance, where ‘n’ denotes number of genotypes. If calculated ‘r’ value at 5 per cent level of significance was greater than tabulated value of ‘r’, the correlation was said to be significant.

3.5.8 Path coefficient analysis

The genotypic and phenotypic correlation coefficients were used in finding out their direct and indirect contribution towards yield per plot.

The direct and indirect paths were obtained by following Dewey and Lu (1959). The path coefficients were obtained by simultaneous selection of the following equations, which expresses the basic relationship between genotypic correlation ‘r’ and path coefficients (P).

$r_{14} : P_{14} + P_{24}\, r_{12} + P_{34}\, r_{13}$

$r_{24} : P_{14}\, r_{21} + P_{24} + P_{34}\, r_{23}$

$r_{34} : P_{14}\, r_{31} + P_{24}\, r_{32} + P_{34}$

where,

r_{14}, r_{24} and r_{34} are genotypic correlations of component characters with yield (dependent variable) and r_{12}, r_{13} and r_{23} are the genotypic correlations among component characters (independent variables).

The direct effects were calculated by the following set of equations:

$P_{14} = C_{11}\, r_{14} + C_{12}\, r_{24} + C_{13}\, r_{34}$

$P_{24} = C_{21}\, r_{14} + C_{22}\, r_{24} + C_{23}\, r_{34}$

$P_{34} = C_{31}\, r_{14} + C_{32}\, r_{24} + C_{33}\, r_{34}$

Where,

C_{11}, C_{22}, C_{23} and C_{33} are constants derived by using abbreviated Doulittle’s technique as explained by Goulden (1959).

$r_{12}\, P_{24}$, $r_{13}\, P_{34}$, $r_{21}\, P_{14}$, $r_{23}\, P_{34}$, $r_{31}\, P_{14}$, $r_{32}\, P_{24}$ are indirect effects.

Residual effect

The variation in the dependent variable which remained undetermined by including all the variables was assumed to be due to variable (s) not included in the present investigation. The degree of determination of such variable (s) on dependent variable was calculated as follows:

$$1 = P^2x_4 + P_{14}^2 + P_{24}^2 + P_{34}^2 + 2P_{14}\, r_{12}\, P_{24} + 2P_{14}\, r_{13}\, P_{34} + 2P_{24}\, r_{23}\, P_{34}$$

3.5.8 Stability analysis

For estimating stability among genotypes for different parameters, Eberhart and Russell's model was used.

Eberhart and Russell's model: In 1966, Eberhart and Russell presented an improved version of previously used stability models by partitioning the genotype × environment interaction of each variety into two parts:

i) Slope of the regression line,

ii) Deviation from the regression line.

Eberhart and Russell (1966) used the following model to study the stability of 'g' genotypes under 'e' environments:

$$xij = \mu + b_iI_j + \delta ij$$

where,

xij = mean of ith genotypes in jth environment, (i=1,2,..,g and j=1,2,…,e)

μ = mean of all the genotypes over all the environments,

b_i = the regression coefficient,

Ij = the environmental index

and δij = the deviation from regression of the i^{th} genotype at j^{th} environment.

The environmental index (Ij), calculated as the mean of all the genotypes in j^{th} environment minus the grand mean.

$$I_j = \frac{\sum_i^g xij}{g} - \frac{\sum_i^g \sum_j^e xij}{ge}$$

and $\sum_j^g Ij = 0$

Three parameters of stability were calculated by using following formula:

a) Phenotypic index (Pi)

$$P_i = \frac{\sum_j^e xij}{e} - \frac{\sum_i^g \sum_j^e xij}{ge}$$

and $\sum_{j}^{g} Pi = 0$

b) The regression coefficient (bi)

$$b_i = \frac{\Sigma_j^e x_{ij} I_j}{\Sigma_j^e I_j^2}$$

c) Mean square deviations (σ^2_{di}) from linear regression.

$$\sigma^2_{di} = \frac{\delta}{(e-2)} - \text{EMS}$$

Where,

$$\delta_i = \left(\Sigma_j^2 x_{ij}^2 - \frac{T^2_{gi}}{e} \right) - \frac{(\Sigma_j^e x_{ij} I_j)^2}{\Sigma_j^e I_j^2})$$

EMS = pooled mean sum of square due to error

3.5.8.1: ANOVA table for stability based on Eberhart and Russell's model (1966):

Sources of variation	Degree of freedom	Sum of squares
Genotype (g)	g-1	GSS = [illegible] - c.f.
Environment (e)	e-1	EnSS = [illegible] - c.f.
Genotype × Environment (g × e)	(g-1) (e-1)	GESS = TSS - GSS - EnSS
e + (g × e)	g(e-1)	EnSS + GESS
e(linear)	1	ELSS = [illegible]
g × e (linear)	(g-1)	GELSS = [illegible] ELSS
Pooled deviation	g(e-2)	EnSS - ELSS – GELSS
g_1	(e-2)	$\Sigma x^2_{1j} - \frac{T^2_{1}}{e}) - \frac{(\Sigma x_{1j} I_j)^2}{\Sigma I^2_j}$
g_2	(e-2)	$\Sigma x^2_{2j} - \frac{T^2_{2}}{e}) - \frac{(\Sigma x_{2j} I_j)^2}{\Sigma I^2_j}$
g_g	(e-2)	$\Sigma x^2_{gj} - \frac{T^2_{g}}{e}) - \frac{(\Sigma x_{gj} I_j)^2}{\Sigma I^2_j}$
Pooled error	e(g-1) (r-1)	

The following inferences can be drawn from the following adaptive specificity for various environments:

i) **Rich environment:** Genotypic mean $(\overline{G})$ more than overall mean, regression coefficient (b_i) >1 and high value of s^2_{di}.

ii) **Poor environment:** Genotypic mean $(\overline{G})$ more than overall mean, regression coefficient (b_i) < 1 and low value of s^2_{di} .

iii) **Average environment:** Genotypic mean $(\overline{G})$ less than overall mean, regression coefficient (b_i) > 1 and low value of s^2_{di}.

iv) **Overall environment:** Genotypic mean $(\overline{G})$ more than overall mean, regression coefficient (b_i) ≅1 and low value of s^2_{di}.

A stable genotype is one which confirms to the following three conditions of stability parameters i.e. $P_i > 0$; $b_i \cong 1$ and s^2_{di} is low.

3.6 MORPHOLOGICAL CHARACTERIZATION OF GENOTYPES

The morphological features are the key points for identification of plants among different plant species. The knowledge of morphological characters of genotypes is also helpful in maintaining the genetic purity of the plants. In order to ascertain the morphological description and their classes that can be reliable used for DUS testing of *Lilium* genotypes, the present study was under taken wherein 18 genotypes of *Lilium* hybrids belonging to four different groups were evaluated for 40 morphological characters. The evaluation for DUS testing was done as per the description prescribed by the UPOV guidelines for DUS testing in *Lilium* (UPOV, 2010). Among 40 morphological characters, 5 characters for stem, 6 characters for leaf, 2 characters for bud and 27 characters of flowers were studied. The characteristics were again classified into two groups *viz*., (i) essential characters, and (ii) optional characters. Observations have always to be recorded on essential traits. In *Lilium*, 21 characters were considered as essential characteristics and rest of 19 characters as optional characteristics. The observations were recorded on 10 plants in each replication at specified stages of crop growth period when the characters under study had full expression. Unless otherwise indicated, all observations were made at the time of anther dehiscence of the first flower bud characters which were taken just after the colour showing stage of the bud.

3.6.1 Methods and observations

- The characteristics described in the Table of Characteristics were used for the testing of varieties for DUS.

- For the assessment of Distinctiveness and Stability, observations were made on 30 plants or parts of plants selected randomly, which were divided among 3 replications (10 plants in each replication)**.**
- For the assessment of Uniformity of characteristics in the plot as a whole (visual assessment by a single observation of a group of plants or parts of plants), a population standard of 1% with an acceptance probability of at least 95% were applied.
- Because daylight varies, colour determinations made using a colour chart were made in the middle of the day in a room without direct sunlight. These determinations were made with the plant part placed against a contrasting background.
- The morphological characteristics were classified into two groups *viz*., essential and optional characters. The essential characters are to be recorded always, whereas, optional characters may or may not be recorded.

3.6.2 Characteristics and symbols:

1. States of expression are given for each characteristic to define the characteristic and to harmonize descriptions. Each state of expression is allocated a corresponding numerical note (1-24) for ease of recording of data and for the production and exchange of the description.
2. Legends:
   (*) Asterisked characteristics are used for those characters which are important for the international harmonization of variety descriptions and should always be examined in every growing season on all the varieties and shall always be included in the description of the variety, except when the states of expression of any of these characters is rendered impossible by a preceding characteristic or by the environmental conditions of the testing region.
   (+) Diagrammatic and photographical explanation of the characters.
3. Characteristics denoted with symbols QL, QN and PQ in first column of the Table of Characteristics are indicated as:
   i) **QL:** Qualitative characteristic
   ii) **QN:** Quantitative characteristic
   iii) **PQ:** Psuedo-qualitative characteristic

3.6.3 Explanations for individual characteristics

- Explanation covering several characteristics:

Unless otherwise indicated below, all observations should be made at the time of anther dehiscence of the first flower. Characteristics containing the following key in the first column of the Table of Characteristics were examined as indicated below:

Symbols	Plant part used	Methodology used
(a)	Stem	Examined on middle third of the stem.
(b)	Tepal	Observations were made on outer tepals.
(c)	Tepal	Observations on color were made on the inner side of the inner tepal, excluding papillae, spots and nectar furrow.
(d)	Tepal	Observations on papillae and/or spots and ribbing should be made on the inner side of the inner tepal.

Flower bud: main colour	The main color is the color with the largest surface area. The main color should be observed just before the opening of the flower.
Inflorescence: type of branching	In the case of varieties with umbellate and racemose branching, the first (lowest) branches are umbellate and the upper (higher) branches are racemose.
Flower type	1-6 tepals were described as single. 7-11 tepals were classified as semi-double. >12 tepals were described as double.
Stigma/stamen: main colour	The main color of a part or zone is the color with the largest surface area on the part or zone concerned.

Chapter-4

RESULTS AND DISCUSSION

The results of **"Genetic studies and DUS characterization in *Lilium*"** conducted during 2016-17 and 2017-18 are presented in this chapter under the following headings:

4.1 Variability studies
- 4.1.1 Mean performance of genotypes
- 4.1.2 Parameters of variability

4.2 Correlation studies
- 4.2.1 Phenotypic correlations
- 4.2.2 Genotypic correlations

4.3 Path co-efficient analysis

4.4 Genetic divergence

4.5 Stability analysis

4.6 DUS characterization of genotypes

4.1 VARIABILITY STUDIES

4.1.1 Mean performance of genotypes

As the study was conducted at two locations for two years, for statistical analysis of data, each location in each year was considered as a different environment, making as a whole four environments, designated as follows:

Environment 1 (E_1)	:	Experimental Farm, FLA, Nauni, 2016-17
Environment 2 (E_2)	:	Experimental Farm, FLA, Nauni, 2017-18
Environment 3 (E_3)	:	ICAR-IARI, Regional Station, Katrain, Kullu, 2016-17
Environment 4 (E_4)	:	ICAR-IARI, Regional Station, Katrain, Kullu, 2017-18

4.1.1.1 Days taken for bulb sprout emergence

Days taken for bulb sprout emergence were recorded from the date of planting of bulb to the appearance of sprouts above growing medium**.** The results pertaining to variation in days taken for bulb sprout emergence among different *Lilium* genotypes has been presented in Table 4.1.1.1.

In general, during 2016-17, genotype 'Best Seller' (38.17 days) took minimum days for bulb sprout emergence while 'Montego Bay (70.27 days) took the maximum when grown under Nauni conditions (E_1). During 2017-18, also same genotypes (28.83 days and 63.51 days, respectively) took minimum and maximum days to sprouting when grown at same location (E_2).

During 2016-17, 'Best Seller' (157.36 days) took minimum days to sprouting while 'Montego Bay' (193.50 days) took maximum days for sprout emergence when grown under Katrain conditions (E_3). Similarly during 2017-18, same genotypes (158.37 days and 193.83 days, respectively) took minimum and maximum days for bulb sprout emergence when grown at same location (E_4).

Table 4.1.1.1: Mean performance of *Lilium* genotypes for days taken for bulb sprout emergence

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	44.47	36.02	164.80	169.00	103.57
Prato	41.16	33.99	166.35	164.00	101.37
Tresor	46.06	33.60	175.27	178.51	108.36
Shiraj	45.17	37.17	167.90	171.10	105.33
Brunello	46.83	35.67	186.23	185.22	113.49
Pollyana	46.20	38.20	163.58	161.30	102.32
Elite	57.26	48.87	164.79	164.50	108.86
Eyeliner	55.65	45.82	172.83	173.77	112.02
Ercolano	52.78	44.82	166.55	168.47	108.16
Ceb Dazzle	46.08	38.08	174.36	175.50	108.51
Best Seller	38.17	28.83	157.36	158.37	95.68
Pavia	49.77	41.60	171.79	172.52	108.92
Salmon Classic	60.35	53.54	160.27	160.82	108.74
Yelloween	62.28	51.30	175.71	176.15	116.36
Cilesta	49.43	41.43	159.66	158.93	102.37
Montego Bay	70.27	63.51	193.50	193.83	130.28
Viviana	68.14	58.93	192.47	193.51	128.26
Sapporo	67.28	58.65	192.45	190.52	127.23
Mean	52.63	43.89	172.55	173.11	-
$CD_{0.05}$	**2.42**	**1.65**	**1.48**	**1.13**	-

$CD_{0.05}$ for pooled mean : Environments = 0.38
Genotypes = 0.81
Environments × Genotypes = 1.62

Pooled analysis of environments revealed that genotypes grown at Nauni location during 2017-18 (E_2) took minimum days (43.89 days) for bulb sprout emergence while maximum days (173.11 days) were recorded in genotypes grown at Katrain conditions during 2017-18 (E_4).

Pooled analysis of genotypes over different environments indicated that genotype 'Best Seller' (95.68 days) took minimum days for bulb sprout emergence while in contrast 'Montego Bay' (130.28 days) took maximum days for sprout emergence.

Table 4.1.1.2: Mean performance of *Lilium* genotypes for per cent bulb sprouting (%)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	100.00 (10.05)*	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Prato	96.67 (9.88)	96.67 (9.88)	100.00 (10.05)	96.67 (9.88)	97.50 (9.92)
Tresor	93.33 (9.71)	100.00 (10.05)	96.67 (9.88)	100.00 (10.05)	97.50 (9.92)
Shiraj	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Brunello	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Pollyana	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Elite	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Eyeliner	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Ercolano	93.33 (9.71)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	98.33 (9.97)
Ceb Dazzle	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Best Seller	100.00(10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Pavia	90.00 (9.53)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	97.50 (9.92)
Salmon Classic	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Yelloween	93.33 (9.71)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	98.33 (9.97)
Cilesta	96.67 (9.88)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	99.17 (10.01)
Montego Bay	96.67 (9.88)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	99.17 (10.01)
Viviana	93.33 (9.71)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	98.33 (9.97)
Sapporo	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)	100.00 (10.05)
Mean	97.41 (9.92)	99.82 (10.04)	99.82 (10.04)	99.82 (10.04)	-
$CD_{0.05}$	**NS**	**NS**	**NS**	**NS**	**-**

* Figure in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = 0.05
Genotypes = 0.10
Environments × Genotypes = 0.20

Interaction effects of environments and genotypes revealed that genotype 'Best Seller' (28.83 days) grown at Nauni conditions during 2017-18 (E_2) resulted in early sprout emergence whereas 'Montego Bay' (193.83 days) grown at Katrain conditions during 2017-18 (E_4) took maximum days for sprouting.

Variation in days taken to sprouting among genotypes might be due to their genetic make up of different *Lilium* genotypes. Generally, Oriental and OT group genotypes are late flowering as compared to Asiatic and LA group. Furthermore, variation in sprouting over different environments could be attributed to the fact that under Nauni conditions during both the years prior to planting, bulbs were vernalized at 4° C for 9 weeks which lead to the early sprouting of bulbs. However no such pre planting vernalization treatments were applied to the bulbs grown under Katrain conditions which added to the variation in sprouting among genotypes over environments. During storage at low temperature carbohydrates are mobilized and sugars accumulated which serves as a photosynthetic source for leaf growth and development. The effect of low temperature treatment on sprouting, leaf emergence and subsequent flowering has been pointed out by De Hertogh & Wilkins (1971), Le Nard (1983), Merel *et al*. (2003) and Malik (2014).

4.1.1.2 Per cent bulb sprouting

Per cent bulb sprouting was calculated by counting the number of bulbs sprouted out of total numbers of bulbs planted.

The individual effect of different environments on variation in per cent sprouting of bulbs of different genotypes was found to be non-significant (Appendices-IV & Appendices-V). However among different environments, maximum per cent bulb sprouting (99.82 %) recorded during 2017-18 at Nauni conditions (E_2) and Katrain conditions during both the years (E_3) & (E_4) (99.82 % & 99.82 %, respectively). In contrast, minimum per cent bulb sprouting (97.41 %) was noted in genotypes grown at Nauni conditions during 2016-17 (E_1).

Pooled analysis revealed that most of the genotypes showed 100 % sprouting while minimum per cent sprouting was noted in genotype ‘Prato’ (97.50 %), ‘Tresor’ (97.50 %) and ‘Pavia’ (97.50 %) as presented in Table 4.1.1.2.

Interaction effects of environments and genotypes depicted most of the genotypes grown during 2017-18 at Nauni conditions (E_2) and under Katrain conditions during 2016-17 and 2017-18 (E_3 and E_4, respectively) (Plate 4a) recorded 100 per cent bulb sprouting whereas minimum (90.00 %) recorded in ‘Pavia’ during 2016-17 at Nauni conditions (E_1).

In present investigation, most of the genotypes exhibited 100 per cent bulb sprouting. However, both genetic as well as environmental factors play significant role in sprouting of bulbs.

4.1.1.3 Plant height (cm)

Plant height was measured from the surface of soil to the top of inflorescence with the help of meter rod at the time of flowering. The results with respect to variation in plant height among different *Lilium* genotypes over different environments have been presented in Table 4.1.1.3.

In general, under both Nauni as well as Katrain conditions during both the year i.e. 2016-17 and 2017-18 (E_1, E_2, E_3 and E_4), maximum plant height recorded in genotype 'Yelloween' (96.89 cm, 92.71 cm, 103.07 cm and 98.24 cm, respectively). In contrast, minimum plant height recorded in 'Best Seller' (52.72 cm, 51.34 cm and 53.77 cm, respectively) during 2016-17 and 2017-18 at Nauni location (E_1 and E_2) and during 2017-18 at Katrain conditions (E_3), respectively. However during 2017-18 at Katrain conditions (E_4) minimum plant height recorded in 'Shiraj' (55.39 cm) which was found to be at par with 'Navona' (55.91 cm) grown in same location (E_4).

Table 4.1.1.3: Mean performance of *Lilium* genotypes for plant height (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	57.58	55.98	56.90	55.91	56.59
Prato	79.80	76.02	81.83	85.24	80.72
Tresor	59.47	53.65	56.39	60.90	57.60
Shiraj	62.65	55.77	58.70	55.39	58.13
Brunello	76.23	79.95	74.47	84.20	78.71
Pollyana	82.03	84.83	78.20	84.55	82.40
Elite	82.64	81.22	90.17	85.03	84.77
Eyeliner	89.53	86.89	90.50	85.34	88.07
Ercolano	63.17	71.46	62.30	68.57	66.37
Ceb Dazzle	65.48	71.28	66.47	63.29	66.63
Best Seller	52.72	51.34	53.77	56.77	53.65
Pavia	64.77	60.93	67.60	70.47	65.94
Salmon Classic	76.70	69.20	74.47	78.64	74.75
Yelloween	96.89	92.71	103.07	98.24	97.73
Cilesta	84.29	84.19	92.40	88.29	87.29
Montego Bay	67.69	77.97	73.13	68.47	71.82
Viviana	64.05	68.85	65.55	63.92	65.59
Sapporo	62.62	64.99	66.78	65.49	64.97
Mean	71.57	71.51	72.93	73.26	-
$CD_{0.05}$	**2.15**	**2.98**	**1.93**	**1.18**	**-**

$CD_{0.05}$ for pooled mean : Environments = 0.49
Genotypes = 1.03
Environments × Genotypes = 2.00

Pooled analysis of environments elucidated maximum plant height (73.26 cm) during 2017-18 at Katrain conditions (E_4) and found to be at par with the plant height (72.93 cm) during 2016-17 at same location (E_3). In contrast, minimum plant height (71.51 cm) observed during 2017-18 at Nauni conditions (E_2) and was at par with plant height (71.57 cm) observed during 2016-17 at same location (E_1).

On pooling of genotypes over environments revealed 'Yelloween' (97.73 cm) and 'Best Seller' (53.65 cm) recorded maximum and minimum plant height, respectively.

Interaction between environments and genotypes revealed that maximum plant height recorded in 'Yelloween' (103.07 cm) during 2016-17 at Katrain condition (E_3) and minimum in 'Best Seller' (51.34 cm) during 2017-18 at Nauni conditions (E_2).

Variation in plant height among different genotypes of *Lilium* could be attributed to their genetic make up. Genotypes grown at Katrain location reported more plant height as compared to Nauni location indicating the more influence of environment in expression of the character. Similar variations were also reported by Dhiman (2003), Sindhu and Singh (2012) and Barik & Mohanty (2015) in *Lilium*.

4.1.1.4 Number of leaves per plant

Number of leaves per plant was counted from the ground level to the pedicel of the lower most flower bud. Results pertaining to number of leaves per plant have been presented in Table 4.1.1.4.

In general, maximum number of leaves per plant was recorded in genotype 'Eyeliner' (86.97, 74.87, 83.20 and 89.43, respectively) under E_1, E_2, E_3 and E_4, respectively while minimum in 'Viviana' (20.30, 16.01, 18.40 and 17.57, respectively) and found to be at par with 'Sapporo' (20.73, 16.50, 19.54 and 18.15, respectively) under same environments.

Pooled analysis of environments depicted during 2017-18 at Katrain conditions (E_4) maximum number of leaves per plant (54.04) were produced whereas minimum during 2017-18 at Nauni conditions (E_4) (47.16).

Among different genotypes 'Eyeliner' (83.62) observed maximum number of leaves/plant while 'Viviana' (18.07) noted minimum and was at par with 'Sapporo' (18.73).

Interaction effect between genotypes and environments further revealed that during 2017-18 at Katrain location (E_4), 'Eyeliner' (89.43) recorded maximum number of leaves per plant and found to be at par with same genotype ('Eyeliner'; 86.97) during 2016-17 at Nauni conditions (E_1). In contrast minimum numbers of leaves per plant observed during 2017-18 at Nauni conditions (E_2) in 'Viviana' (16.01) was at par with same genotype during 2016-17 and 2017-18 at Katrain conditions (E_3 and E_4) i.e. 18.40 and 17.57, respectively, and with 'Sapporo' (16.50 and 18.15, respectively) during 2017-18 at Nauni condition (E_2) and Katrain conditions (E_4), respectively.

Table 4.1.1.4: Mean performance of *Lilium* genotypes for number of leaves per plant

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	57.37	44.13	39.43	43.50	46.11
Prato	48.40	48.20	69.67	69.67	58.98
Tresor	50.58	51.20	61.33	63.29	56.60
Shiraj	52.13	39.20	53.17	50.23	48.68
Brunello	63.43	71.80	57.72	62.26	63.80
Pollyana	64.50	42.13	80.11	85.50	68.06
Elite	65.07	65.90	66.67	63.25	65.22
Eyeliner	86.97	74.87	83.20	89.43	83.62
Ercolano	33.53	37.17	63.83	67.27	50.45
Ceb Dazzle	40.90	43.47	41.47	43.23	42.27
Best Seller	38.00	36.00	45.10	45.32	41.11
Pavia	42.87	46.77	39.30	45.54	43.62
Salmon Classic	61.80	59.57	66.97	68.53	64.22
Yelloween	58.37	58.47	44.40	38.33	49.89
Cilesta	75.40	71.03	68.53	67.26	70.56
Montego Bay	27.57	26.45	36.93	34.39	31.33
Viviana	20.30	16.01	18.40	17.57	18.07
Sapporo	20.73	16.50	19.54	18.15	18.73
Mean	50.44	47.16	53.10	54.04	-
$CD_{0.05}$	**3.21**	**3.59**	**2.78**	**1.42**	-

$CD_{0.05}$ for pooled mean : Environments = 0.67
: Genotypes = 1.40
: Environments × Genotypes = 2.81

More number of leaves indicates more photo-assimilates to the plant essential for the growth and flowering of cut stems. Variation in number of leaves per plant could be attributed to the varied genetic make up of different genotypes. In general it was found that Asiatic and LA hybrids showed more leaves as compared to OT and Oriental genotypes. Studies further revealed that minimum number of leaves in Oriental genotypes could be attributed to the short stature of plants.

Similar variations in number of leaves per plant have also been reported by Dhiman (2003), Kumar *et al*. (2011) and Barik & Mohanty (2015) among different genotypes of *Lilium*.

4.1.1.5 Leaf length (cm)

The length of longest leaf from ten randomly selected plants was measured with the help of measuring scale and expressed in centimeters. Data pertaining to variation in leaf length among different genotypes has been presented in Table 4.1.1.5 (Plate 5).

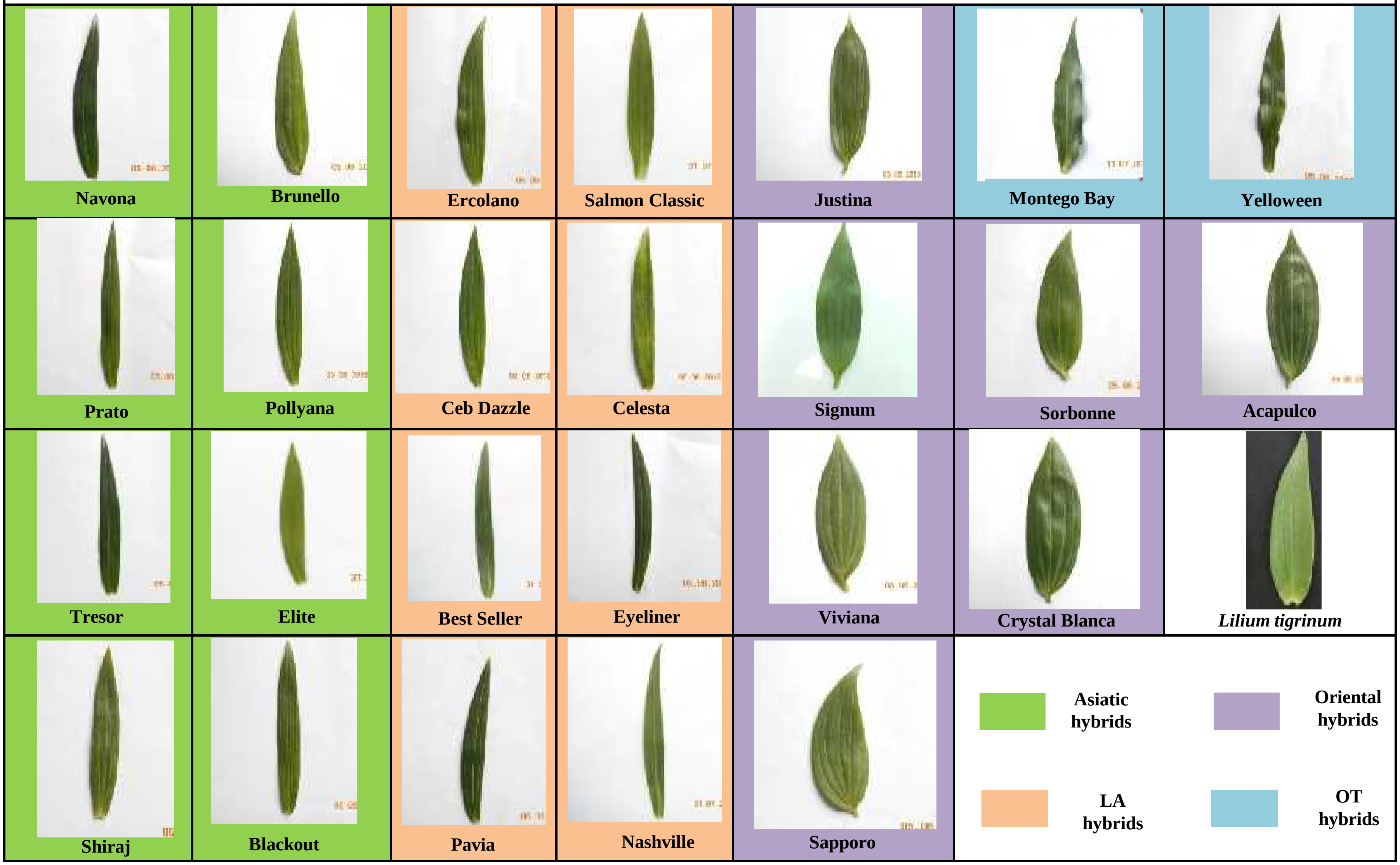
During 2016-17, maximum leaf length observed in 'Prato' (13.49 cm) under Nauni conditions (E_1) found to be at par with 'Eyeliner' (13.17 cm) whereas minimum in 'Sapporo' (6.71 cm) and was at par with 'Viviana' (6.64 cm) and 'Montego Bay' (6.80 cm). Similarly during 2017-18 under same location (E_2), maximum leaf length observed in 'Prato' (14.13 cm) while minimum in 'Sapporo' (6.38 cm) and found to be at par with 'Viviana' (6.91 cm) and 'Montego Bay' (6.70 cm).

Table 4.1.1.5: Mean performance of *Lilium* genotypes for leaf length (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	10.32	8.88	7.70	7.64	8.64
Prato	13.49	14.13	15.37	15.44	14.61
Tresor	8.76	8.81	13.37	11.37	10.58
Shiraj	7.70	11.32	6.60	6.95	8.14
Brunello	10.70	11.63	11.43	10.59	11.09
Pollyana	11.36	11.64	10.24	10.56	10.95
Elite	11.97	10.70	11.53	10.24	11.11
Eyeliner	13.17	12.26	14.26	14.18	13.47
Ercolano	10.81	11.24	10.40	10.24	10.67
Ceb Dazzle	11.12	10.79	11.94	11.21	11.27
Best Seller	11.52	11.05	14.47	14.64	12.92
Pavia	9.24	8.47	7.53	9.77	8.75
Salmon Classic	11.08	12.07	11.46	12.37	11.74
Yelloween	12.04	10.62	11.68	11.68	11.51
Cilesta	11.55	11.00	12.67	11.45	11.67
Montego Bay	6.80	6.70	7.51	7.08	7.02
Viviana	6.64	6.91	7.30	6.91	6.94
Sapporo	6.71	6.38	6.63	6.34	6.59
Mean	10.28	10.26	10.67	10.48	-
$CD_{0.05}$	**0.73**	**0.58**	**0.33**	**0.40**	-

$CD_{0.05}$ for pooled mean : Environments = 0.12
Genotypes = 0.26
Environments × Genotypes = 0.51

Plate 5: Variation in leaf length and width among different *Lilium* genotypes



During 2016-17 at Katrain location (E_3), 'Prato' (15.37 cm) recorded maximum leaf length whereas 'Shiraj' (6.60 cm) recorded minimum and was at par with 'Sapporo' (6.63 cm). Similarly, during 2017-18 at same location (E_4), 'Prato' and 'Sapporo' (14.61 cm and 6.34 cm, respectively) recorded maximum and minimum leaf length.

Pooled analysis of environments depicted maximum (10.67 cm) leaf length during 2016-17 at Katrain location (E_3) whereas minimum (10.26 cm) during 2017-18 under Nauni conditions (E_2) and was found to be at par with same location during 2016-17 (E_1).

Among different genotypes, 'Prato' (14.61 cm) recorded maximum leaf length whereas 'Sapporo' (6.59 cm) the minimum.

Interaction between environments and genotypes revealed maximum leaf length in 'Prato' (15.44 cm) during 2017-18 under Katrain conditions (E_4) which was at par with same genotype (15.37 cm) during 2016-17 under same location (E_3). However 'Sapporo' (6.34 cm) recorded minimum leaf length during 2017-18 at Katrain location (E_4) and found to be at par with same genotype (6.63 cm and 6.38 cm, respectively) under same location during 2016-17 (E_3) and during 2017-18 under Nauni location (E_2) and with 'Montego Bay', 'Viviana' and 'Sapporo' (6.80 cm, 6.64 cm and 6.71 cm, respectively) during 2016-17 under Nauni location (E_1).

Variation in leaf length among *Lilium* genotypes could be attributed to the inherent genetic factors along with interaction with favourable environmental factors which led to the variation in phenotypic expression. Earlier findings of Kumar *et al*. (2018) and Dhiman (2003) revealed the similar results.

4.1.1.6 Leaf width (cm)

The widest part of the leaf was measured to determine the leaf width and expressed in centimeters.

Data pertaining to leaf width as presented in Table 4.1.1.6 reveals that in general genotype 'Sapporo' (3.45 cm and 3.51 cm, respectively) showed maximum leaf width during both the years under Nauni conditions (E_1 and E_2, respectively) which was found to be at par with 'Viviana' (3.32 cm and 3.38 cm, respectively) under same conditions. In contrast during

2016-17 under Nauni conditions (E_1), minimum leaf width recorded in 'Tresor' (1.44 cm) followed by 'Navona' (1.58 cm), 'Pollyana' (1.46 cm) and 'Ercolano' (1.71 cm). Similarly during 2017-18 under same location, minimum leaf width observed in 'Tresor' (1.28 cm) found to be at par with 'Navona' (1.45 cm) and 'Cilesta' (1.40 cm). Furthermore data also revealed that during 2016-17 under Katrain location (E_3), maximum leaf width recorded in 'Viviana' (3.57 cm) whereas minimum in 'Shiraj' (1.48 cm) found to be at par with 'Tresor' (1.60 cm), 'Elite' (1.60 cm) and 'Yelloween' (1.51 cm). Under same location during 2017-18 (E_4), maximum leaf width recorded in 'Viviana' (3.76 cm) while minimum in 'Shiraj' (1.10 cm).

Table 4.1.1.6. Mean performance of *Lilium* genotypes for leaf width (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	1.58	1.45	1.73	1.74	1.63
Prato	1.95	1.71	2.60	1.71	1.99
Tresor	1.44	1.28	1.60	1.35	1.42
Shiraj	2.13	1.62	1.48	1.10	1.58
Brunello	2.03	1.97	2.30	2.51	2.20
Pollyana	1.46	1.60	2.27	2.15	1.87
Elite	2.29	1.75	1.60	1.79	1.86
Eyeliner	2.57	1.59	2.07	2.87	2.28
Ercolano	1.71	1.76	2.47	2.38	2.08
Ceb Dazzle	2.17	1.80	2.20	1.54	1.93
Best Seller	1.87	2.00	2.51	1.98	2.09
Pavia	2.25	2.08	2.21	2.51	2.26
Salmon Classic	2.14	1.87	2.07	2.54	2.16
Yelloween	2.03	1.95	1.51	2.16	1.91
Cilesta	2.21	1.40	2.10	1.98	1.92
Montego Bay	2.72	2.64	2.12	2.21	2.42
Viviana	3.32	3.38	3.57	3.76	3.51
Sapporo	3.45	3.51	3.41	3.40	3.44
Mean	1.58	1.45	1.73	1.74	-
$CD_{0.05}$	**0.32**	**0.28**	**0.12**	**0.06**	-

$CD_{0.05}$ for pooled mean : Environments = 0.05
Genotypes = 0.11
Environments × Genotypes = 0.21

On pooling of environments it was revealed that genotypes performed better with respect to leaf width under Katrain condition during 2017-18 (E_4) (1.74 cm) and was at par during 2016-17 under same location (E_3) (1.73 cm). However minimum leaf width (1.45 cm) recorded during 2017-18 under Nauni conditions (E_2).

Among different genotypes, maximum leaf width observed in 'Viviana' (3.51 cm) was at par with 'Sapporo' (3.44 cm) whereas minimum in 'Tresor' (1.42 cm).

Interaction between environments and genotypes revealed maximum leaf width in 'Viviana' (3.76 cm) during 2017-18 under Katrain location (E_4) was at par with same genotype (3.57 cm) during 2016-17 at same location (E_3). Minimum leaf width observed in 'Shiraj' (1.10 cm) during 2017-18 at Katrain location (E_4) found to be at par with same genotype (1.28 cm) during 2017-18 under Nauni location (E_2).

Differences in vegetative characters in different genotype of *Lilium* may be due to varied growth rates and their genetic potential resulted in variation in phenotypic expression. It was observed that Oriental hybrids produced broader leaves as compared to leaves produced by Asiatic, LA and OT hybrids which could be attributed to the genetic factors. Earlier findings of Kumar *et al*. (2018) and Dhiman (2003) in *Lilium* revealed the similar results.

4.1.1.7 Stem length (cm)

Stem length is a very important character which is decisive of the quality of cut flowers. Stem length was measured by leaving 20 cm from the surface of soil to the top of inflorescence with the help of meter rod at the stage of harvesting of stems. Data presented in Table 4.1.1.7 shows variation in lengths of cut flower stem as influenced under different environments.

In general, maximum stem length recorded in 'Yelloween' (76.89 cm, 72.71 cm, 83.07 cm and 78.24 cm, respectively) at both Nauni as well as Katrain conditions during both the year i.e. 2016-17 and 2017-18 (E_1, E_2, E_3 and E_4, respectively). In contrast, minimum stem length recorded in genotype 'Best Seller' (32.72 cm, 31.34 cm and 33.77 cm, respectively) during 2016-17 and 2017-18 at Nauni location (E_1 and E_2) and during 2017-18 at Katrain conditions (E_3), respectively. However during 2017-18 at Katrain conditions (E_4) minimum stem length observed in 'Shiraj' (35.39 cm) found to be at par with 'Navona' (35.91 cm) under same location (E_4).

Pooled analysis of environments elucidated maximum stem length (53.26 cm and 52.93 cm, respectively) during 2017-18 and 2016-17 at Katrain location (E_4 and E_3). In contrast, minimum stem length (51.19 cm) recorded during 2016-17 at Nauni location (E_1).

On pooling of genotypes over environments revealed maximum stem length in 'Yelloween' (77.73 cm) while minimum in 'Best Seller' (33.65 cm).

Table 4.1.1.7: Mean performance of *Lilium* genotypes for stem length (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	37.58	35.98	36.90	35.91	36.59
Prato	59.80	56.02	61.83	65.24	60.72
Tresor	39.47	33.65	36.39	40.90	37.60
Shiraj	35.77	42.65	38.70	35.39	38.13
Brunello	56.23	59.95	54.47	64.20	58.71
Pollyana	62.03	64.83	58.20	64.55	62.40
Elite	62.64	61.22	70.17	65.03	64.77
Eyeliner	69.53	66.89	70.50	65.34	68.07
Ercolano	43.17	51.46	42.30	48.57	46.37
Ceb Dazzle	45.48	51.28	46.47	43.29	46.63
Best Seller	32.72	31.34	33.77	36.77	33.65
Pavia	44.77	40.93	47.60	50.47	45.94
Salmon Classic	56.70	49.20	54.47	58.64	54.75
Yelloween	76.89	72.71	83.07	78.24	77.73
Cilesta	64.29	64.19	72.40	68.29	67.29
Montego Bay	47.69	57.97	53.13	48.47	51.82
Viviana	44.05	48.85	45.55	43.92	45.59
Sapporo	42.62	44.99	46.78	45.49	44.97
Mean	51.19	51.90	52.93	53.26	-
$CD_{0.05}$	**2.15**	**0.58**	**1.93**	**1.18**	-

$CD_{0.05}$ for pooled mean : Environments = 0.49
Genotypes = 1.03
Environments × Genotypes = 2.07

Interaction between environments and genotypes revealed maximum stem length in genotype 'Yelloween' (83.07 cm) during 2016-17 at Katrain condition (E_3) whereas minimum in 'Best Seller' (31.34 cm) during 2017-18 at Nauni conditions (E_2) which was at par with same genotype during 2016-17 under same location (E_1) i.e. 32.72 cm.

Stem length is directly correlated with plant height of the plants and variation in stem length could be attributed to the inherent genetic factors and prevailing climatic conditions. Similar variations were also reported by Dhiman (2003), Sindhu and Singh (2012) and Barik & Mohanty (2015) in among different *Lilium* genotypes.

4.1.1.8 Days to flower bud formation

Days taken to flower bud formation were recorded by counting the days from the date of sprouting till the visibility of first flower bud inside the folded leaves (Plate 3a). Variation among genotypes with respect to days to flower bud formation over different environments has been presented in Table 4.1.1.8.

In general, during 2016-17 & 2017-18, 'Best Seller' (55.71 days & 52.32 days, respectively) took minimum days for flower bud formation while 'Montego Bay (87.67 days & 86.57 days, respectively) took the maximum under Nauni conditions (E_1 & E_2), respectively.

During 2016-17, 'Best Seller' (28.53 days) took minimum days for flower bud formation while 'Montego Bay' (58.83 days) took maximum days under Katrain conditions (E_3) and found to be at par with genotype 'Viviana' (58.53 days) under same conditions. Similarly during 2017-18, same genotypes ('Best Seller'; 29.83 days and 'Montego Bay'; 60.83 days) took minimum and maximum days, respectively for flower bud formation grown at same location (E_4).

Table 4.1.1.8: Mean performance of *Lilium* genotypes for days to flower bud formation

Genotypes	**E_1 (FLA, Nauni 2016-17)**	**E_2 (FLA, Nauni 2017-18)**	**E_3 (IARI, RS – Katrain 2016-17)**	**E_4 (IARI, RS – Katrain 2017-18)**	**Pooled Mean**
Navona	68.55	67.23	42.25	44.73	55.69
Prato	72.50	67.42	43.07	45.77	57.19
Tresor	75.86	70.50	36.87	39.84	55.77
Shiraj	73.66	71.82	48.41	46.63	60.13
Brunello	73.75	71.58	43.17	44.13	58.16
Pollyana	73.48	73.17	46.35	48.65	60.41
Elite	68.83	64.20	41.74	44.17	54.74
Eyeliner	73.10	68.59	48.71	48.47	59.72
Ercolano	71.76	65.57	42.70	43.60	55.91
Ceb Dazzle	67.55	67.33	45.47	47.70	57.01
Best Seller	55.71	52.32	28.53	29.83	41.60
Pavia	66.37	68.40	38.53	39.22	53.13
Salmon Classic	60.24	62.60	32.53	33.80	47.29
Yelloween	78.62	75.50	43.42	46.31	60.96
Cilesta	60.63	59.63	45.44	46.58	53.07
Montego Bay	87.67	86.57	58.83	60.83	73.48
Viviana	84.47	82.83	58.53	58.50	71.08
Sapporo	82.47	81.57	56.40	56.95	69.35
Mean	71.96	69.82	44.50	45.87	-
$CD_{0.05}$	**1.09**	**0.78**	**1.86**	**1.60**	-

$CD_{0.05}$ for pooled mean : Environments = 0.32
Genotypes = 0.68
Environments × Genotypes = 1.35

Pooled analysis of environments revealed that genotypes grown at Katrain conditions during 2016-17 (E_3) took minimum days (44.50 days) for flower bud formation while maximum days (71.96 days) recorded in genotypes under Nauni conditions during 2016-17 (E_1).

Pooling of genotypes over environments indicated that 'Best Seller' (41.60 days) was earliest to flower bud formation while in contrast genotype 'Montego Bay' (73.48 days) took maximum days for flower bud formation.

Interaction effects between environments and genotypes revealed during 2017-18 'Best Seller' (28.53 days) at Katrain conditions (E_4) resulted in early flower bud formation and found to be at par with same genotype ('Best Seller'; 29.83 days) during 2017-18 at same location whereas, 'Montego Bay' (87.67 days) took maximum days for bud formation during 2016-17 at Nauni conditions (E_1) and found to be at par with same genotype ('Montego Bay'; 86.57 days) during 2017-18 under same location (E_2).

Character days to flower bud formation found to be highly associated with genetic make up of *Lilium* genotypes. Under all the environments 'Best Seller' (LA group) recorded early bud formation while Oriental and OT group were late in flower bud formation. Overall performance of genotypes over environments indicated the superiority of Katrain location for earliness in bud formation among different genotypes. Genotypes outperformed with respect to various vegetative parameters such as plant height, stem length, number of leaves and leaf length which might have lead to the more photosynthates and carbohydrate production and ultimately early bud and subsequent flower production.

Findings in this investigation are in close agreement with Dhiman (2003) who observed significant variation among *Lilium* hybrids with respect to days to bud-formation under Kullu conditions.

4.1.1.9 Bud length (cm)

Bud length was measured at harvesting stage with the help of measuring scale and variation in bud length among different genotypes over four different environments has been presented in Table 4.1.1.9.

In general, 'Yelloween' (12.65 cm) and 'Shiraj' (6.80 cm) recorded maximum and minimum bud length, respectively during 2016-17 at Nauni location (E_1). However at same location during 2017-18 (E_2) same genotype ('Yelloween'; 11.99 cm) recorded maximum bud length was at par with 'Sapporo' (11.63 cm) while minimum in 'Shiraj' (5.46 cm) and found to be at par with 'Elite' (5.80 cm).

Similarly, under Katrain conditions during both the years (E_3 & E_4) maximum bud length recorded in 'Yelloween' (13.54 cm & 12.98 cm, respectively) while minimum in genotype 'Shiraj' (7.50 cm & 7.14 cm), respectively.

Table 4.1.1.9: Mean performance of *Lilium* genotypes for bud length (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	8.59	7.28	8.13	8.87	8.22
Prato	9.70	9.35	11.98	10.98	10.50
Tresor	7.43	6.57	8.25	8.17	7.61
Shiraj	6.80	5.46	7.50	7.14	6.72
Brunello	9.47	9.22	11.20	11.78	10.42
Pollyana	9.39	9.08	10.11	11.46	10.01
Elite	9.23	5.80	7.89	7.79	7.68
Eyeliner	10.18	8.83	10.17	10.54	9.93
Ercolano	10.24	8.24	10.82	10.12	9.86
Ceb Dazzle	7.86	9.52	9.81	9.23	9.11
Best Seller	9.31	9.09	10.20	11.56	10.04
Pavia	8.58	8.26	10.70	11.17	9.68
Salmon Classic	7.81	9.55	10.56	8.95	9.22
Yelloween	12.65	11.99	13.54	12.98	12.79
Cilesta	8.08	9.33	10.36	9.80	9.39
Montego Bay	10.49	10.49	9.21	10.20	10.10
Viviana	9.40	9.70	8.14	8.11	8.84
Sapporo	12.02	11.63	10.15	9.94	10.93
Mean	9.29	8.86	9.91	9.93	-
$CD_{0.05}$	**0.65**	**0.57**	**0.08**	**0.07**	-

$CD_{0.05}$ for pooled mean : Environments = 0.10
Genotypes = 0.22
Environments × Genotypes = 0.43

Pooling of environments indicated that genotypes grown at Katrain location during 2017-18 (E_4) recorded maximum bud length (9.93 cm) was at par with genotypes grown at same location during 2016-17 (E_3) i.e. 9.91 cm. In contrast minimum bud length (8.86 cm) recorded in genotypes grown at Nauni location during 2017-18 (E_2).

Among different genotypes, 'Yelloween' (12.79 cm) recoded maximum bud length whereas minimum in 'Shiraj' (6.72 cm).

Interaction between environments and genotypes revealed that 'Yelloween' (13.54 cm) recorded maximum bud length during 2016-17 at Katrain location (E_3) while minimum in 'Shiraj' (5.46 cm) during 2017-18 at Nauni location (E_2).

Variation in bud length might be attributed due to the genetic make up of the genotypes. Oriental and OT hybrids produced larger blooms as compared to Asiatic and LA hybrids owing to the presence of large sized buds. These results are in close conformity with the findings of Dhiman (2003) and Sloan & Harkness (2006) among different *Lilium* hybrids.

4.1.1.10 Days to first flower

Days to first flowering were recorded from the date of sprouting of planted bulbs to the day when first flower of the plant was fully opened (Plate 3b). Like days taken to bulb sprout emergence and days to flower bud formation, days to first flower also differed significantly among different genotypes over environments as presented in Table 4.1.1.10.

In general, during 2016-17, 'Best Seller' (77.47 days) took minimum days to first flower while 'Montego Bay (118.22 days) took the maximum under Nauni conditions (E_1). During 2017-18 at same location (E_2), same genotypes ('Best Seller'; 87.00 days) took minimum days for first flower while 'Montego Bay' (118.20 days) took maximum days to first flower and found to be at par with genotype 'Viviana' (117.74 days).

During 2016-17 & 2017-18 under Katrain conditions (E_3 & E_4), 'Best Seller' (46.03 days & 44.42 days, respectively) took minimum days for first flower while 'Montego Bay' (83.30 days & 85.57 days, respectively) took maximum days to first flower.

Pooled analysis of environments revealed that genotypes at Katrain conditions during 2016-17 (E_3) took minimum (66.58 days) for first flower while genotypes at Nauni conditions during 2016-17 (E_1) took maximum days (105.33 days) for first flower and found to be at par with genotypes grown at same location during 2017-18 (E_2) i.e. 105.14 days.

Pooled analysis of genotypes over environments indicated that 'Best Seller' (63.73 days) took minimum days while 'Montego Bay' (101.32 days) took maximum days for first flower.

Table 4.1.1.10: Mean performance of *Lilium* genotypes for days to first flower

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	94.13	95.37	65.63	64.50	79.91
Prato	106.91	100.89	56.33	54.56	79.67
Tresor	112.67	111.24	63.99	68.43	89.08
Shiraj	109.06	108.10	68.03	65.22	87.60
Brunello	106.08	108.03	63.44	66.23	85.95
Pollyana	110.20	110.73	63.27	65.52	87.43
Elite	107.59	105.18	71.01	72.10	88.97
Eyeliner	108.66	106.58	64.62	65.03	86.22
Ercolano	110.77	104.73	64.82	65.93	86.56
Ceb Dazzle	100.23	102.27	70.77	72.22	86.37
Best Seller	77.47	87.00	46.03	44.42	63.73
Pavia	100.97	101.63	71.50	72.27	86.59
Salmon Classic	96.91	96.46	49.57	50.93	73.47
Yelloween	113.35	112.58	65.33	66.33	89.40
Cilesta	89.53	89.83	67.82	69.23	79.11
Montego Bay	118.22	118.20	83.30	85.57	101.32
Viviana	116.55	117.74	81.50	82.73	99.63
Sapporo	116.53	115.97	81.43	83.23	99.29
Mean	105.33	105.14	66.58	67.47	-
$CD_{0.05}$	**0.99**	**1.48**	**1.47**	**1.26**	**-**

$CD_{0.05}$ for pooled mean : Environments = 0.30
Genotypes = 0.64
Environments × Genotypes = 1.29

Interaction effects of environments and genotypes revealed that ‘Best Seller’ (44.42 days) during 2017-18 at Katrain conditions (E_4) resulted in early flowering whereas ‘Montego Bay’ (118.22 days) grown at Nauni conditions during 2016-17 (E_1) took maximum days for first flower and found to be at par with same genotype (‘Montego Bay’; 118.20 days) and genotype ‘Viviana’ (117.74 days) grown during 2017-18 at same location (E_2).

In general it is apparent that Asiatic and LA hybrids are early flowering while Oriental and OT hybrids are late flowering which could be attributed to the genetic make up of different genotypes. In present investigation, similar results were observed and earlier workers, Dhiman (2003), Sloan & Harkness (2006) and Bhandari *et al*. (2017) has also drawn the similar conclusions.

4.1.1.11 Stem diameter (cm)

Basal stem diameter was measured with the help of digital vernier caliper at the time of harvesting and results thus obtained have been presented in Table 4.1.1.11.

As far as stem diameter is concerned, during 2016-17 at Nauni location (E_1), maximum stem diameter recorded in 'Pavia' (0.73 cm) which was at par with 'Best Seller' (0.74 cm) while minimum in 'Shiraj' (0.36 cm) and found to be at par with genotype 'Prato' (0.43 cm).

Table 4.1.1.11: Mean performance of *Lilium* genotypes for stem diameter (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	0.54	0.71	0.73	0.78	0.69
Prato	0.43	0.63	0.90	0.91	0.72
Tresor	0.48	0.42	0.73	0.76	0.60
Shiraj	0.36	0.37	0.51	0.49	0.44
Brunello	0.44	0.54	0.70	0.71	0.60
Pollyana	0.56	0.49	0.57	0.58	0.55
Elite	0.57	0.49	0.74	0.77	0.64
Eyeliner	0.55	0.70	0.82	0.88	0.74
Ercolano	0.64	0.51	0.76	0.76	0.67
Ceb Dazzle	0.49	0.69	0.73	0.76	0.67
Best Seller	0.74	0.63	0.83	0.81	0.75
Pavia	0.73	0.71	0.88	0.85	0.79
Salmon Classic	0.64	0.73	0.84	0.88	0.77
Yelloween	0.57	0.48	0.73	0.77	0.64
Cilesta	0.53	0.74	0.86	0.87	0.75
Montego Bay	0.51	0.45	0.76	0.77	0.62
Viviana	0.45	0.41	0.55	0.55	0.49
Sapporo	0.65	0.66	0.63	0.65	0.65
Mean	0.55	0.58	0.74	0.75	-
$CD_{0.05}$	**0.07**	**0.08**	**0.02**	**0.04**	-

$CD_{0.05}$ for pooled mean : Environments = 0.01
Genotypes = 0.03
Environments × Genotypes = 0.06

In case of performance of genotypes with regards to stem diameter during 2017-18 at same location (E_2) revealed maximum stem diameter in genotype 'Cilesta' (0.74 cm) and was found to be at par with genotypes 'Navona' (0.71 cm), 'Eyeliner' (0.70 cm), 'Ceb Dazzle' (0.69 cm), 'Pavia' (0.71 cm), 'Salmon Classic' (0.73 cm) and 'Sapporo' (0.66 cm) while minimum stem diameter recorded in 'Shiraj' (0.37 cm) and was found to be at par with genotypes 'Tresor' (0.42 cm), 'Montego Bay' (0.45 cm) and 'Viviana' (0.41 cm).

Similarly in case of performance of genotypes at Katrain conditions during 2016-17 (E_3) revealed that 'Prato' (0.90 cm) recorded maximum stem diameter and was at par with genotype 'Pavia' (0.88 cm) whereas 'Shiraj' (0.51 cm) recorded minimum stem diameter. Under same location during 2017-18 (E_4), maximum stem diameter recorded in genotype

‘Prato’ (0.91cm) and was at par with genotypes ‘Eyeliner’ (0.88 cm), ‘Salmon Classic’ (0.88 cm) and ‘Cilesta’ (0.87 cm) while minimum stem diameter recorded in ‘Shiraj’ (0.49 cm)

Pooled analysis over environments indicated that genotypes grown at Katrain location during 2017-18 (E_4) recorded maximum stem diameter (0.75 cm) and was at par with genotypes grown during 2016-17 at same location (E_3) i.e. 0.74 cm while minimum (0.55 cm) was observed during 2016-17 at Nauni location (E_1).

Pooled analysis of performance of different genotypes revealed that genotype ‘Pavia’ (0.79 cm) recorded maximum stem diameter followed by ‘Salmon Classic’ (0.77 cm) while minimum in genotype ‘Shiraj’ (0.44 cm).

Interaction between environments and genotypes revealed that maximum stem diameter recorded in genotype ‘Prato’ (0.91 cm) during 2017-18 at Katrain location (E_4) which was found to be at par with genotypes ‘Eyeliner’ (0.88 cm), ‘Pavia’ (0.85 cm), ‘Salmon Classic’ (0.88 cm), ‘Cilesta’ (0.87 cm) under same location (E_4) and with genotypes ‘Prato’ (0.90 cm), ‘Pavia’ (0.88 cm) and ‘Cilesta’ (0.86 cm) during 2016-17 at same location (E_3). In contrast minimum stem diameter recorded in ‘Shiraj’ (0.36 cm) during 2016-17 at Nauni location (E_1) and was found to be at par with same genotype (‘Shiraj’; 0.37 cm), ‘Tresor’ (0.42 cm) and ‘Viviana’ (0.41 cm) during 2017-18 at same location (E_2).

Stem diameter or thickness is an important physical-quality parameter in *Lilium* because strength of a flowering stem is determined by its thickness. Studies revealed that more stem thickness/diameter observed in genotypes grown under Katrain conditions which might be due to the interaction between the genotypes and favourable climatic conditions which led to rapid growth and development and accumulation of more carbohydrates in plants. Bhandari *et al*. (2017) observed the similar results among different *Lilium* genotypes under hilly region of Uttrakhand.

4.1.1.12 Size of the flower (cm)

Size of flower was recorded as an average of distance between apices of petals in East to West direction and the distance between apices of petals in North to South direction.

An appraisal of data in Table 4.1.1.12 indicates the variation in the size of the flowers among different genotypes under the influence of environments.

Performance of genotypes with respect to flower size during 2016-17 at Nauni location (E_1) revealed that 'Sapporo' (20.58 cm) recorded maximum flower size and found to be at par with 'Yelloween' (20.47 cm) whereas minimum recorded in genotype 'Shiraj' (13.33 cm). However during 2017-18 at same location (E_2), 'Yelloween' produced largest flowers (20.11 cm) and was at par with genotype 'Sapporo' (20.06 cm) while minimum flower size was recorded in genotype 'Shiraj' (12.52 cm).

Table 4.1.1.12: Mean performance of *Lilium* genotypes for size of the flower (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	15.01	14.20	15.50	15.57	15.07
Prato	17.16	17.86	19.68	19.33	18.51
Tresor	15.18	14.45	15.29	15.20	15.03
Shiraj	13.33	12.52	13.55	13.53	13.23
Brunello	17.23	16.86	17.44	17.45	17.24
Pollyana	15.49	15.81	17.10	17.40	16.45
Elite	14.98	13.25	15.47	15.62	14.83
Eyeliner	15.07	15.66	16.43	16.60	15.94
Ercolano	16.02	15.92	17.40	17.21	16.64
Ceb Dazzle	15.18	15.10	15.73	15.60	15.41
Best Seller	16.03	15.88	15.83	16.13	15.97
Pavia	15.86	15.73	17.28	18.19	16.77
Salmon Classic	15.25	15.27	17.58	15.47	15.89
Yelloween	20.47	20.11	20.81	20.15	20.39
Cilesta	16.86	16.48	15.92	14.37	15.91
Montego Bay	16.55	16.64	16.40	17.60	16.80
Viviana	17.54	16.58	14.98	14.54	15.91
Sapporo	20.58	20.06	20.10	20.04	20.20
Mean	16.32	16.02	16.81	16.67	-
$CD_{0.05}$	**0.89**	**0.94**	**0.31**	**0.41**	-

$CD_{0.05}$ for pooled mean : Environments = 0.16
Genotypes = 0.34
Environments × Genotypes = 0.69

Similarly during 2016-17 at Katrain location (E_3) genotypes 'Yelloween' (20.81 cm) and 'Shiraj' (13.55 cm) recorded maximum and minimum flower size, respectively while during 2017-18 at same location (E_4), genotype 'Yelloween' (20.15 cm) recorded maximum size of the flower and was found to be at par with 'Sapporo' (20.04 cm) while minimum size of the flower was recorded in genotype 'Shiraj' (13.53 cm).

Pooled analysis of environments revealed that maximum size of the flowers observed during 2016-17 at Katrain location (16.81 cm) (E_3) and was at par flower size recorded during 2017-18 at same location (E_4) (16.67 cm) whereas minimum (16.02 cm) recorded during 2017-18 at Nauni location (E_2).

A lot of variation in the flower size again explains the variability among different genotypes. Pooled analysis of genotypes over environments indicated 'Yelloween' (20.39 cm) produced maximum flower size followed by 'Sapporo' (20.20 cm) while minimum in 'Shiraj' (13.23 cm).

Interaction between environments and genotypes revealed that maximum flower size recorded in 'Yelloween' (20.81 cm) during 2016-17 at Katrain location (E_3) and was at par with same genotype (20.15 cm) during 2017-18 at same location (E_4) and with genotypes 'Yelloween' (20.47 cm) and 'Sapporo' (20.58 cm) during 2016-17 at Nauni location (E_1) whereas minimum flower size was recorded in genotype 'Shiraj' (12.52 cm) during 2017-18 at Nauni location (E_2).

Variation in flower size could be attributed to the both genetic make up of the genotypes as well as size of the propagating material used and similar variations also observed by Dhiman (2003), Sloan & Harkness (2006) and Negi *et al*. (2016) in *Lilium*.

4.1.1.13 Number of flowers per plant

The total number of flowers per plant were recorded at the time of peak flowering.

Variations with respect to number of flowers per plant observed among different *Lilium* genotypes over different environments have been presented in Table 4.1.1.13.

In general, during 2016-17 at Nauni location (E_1), genotype 'Eyeliner' (6.20) recorded maximum number of flowers per plant whereas minimum in 'Montego Bay' (2.10) and was found to be at par with genotypes 'Viviana' (2.33) and 'Sapporo' (2.37). Similarly during 2017-18 at same location (E_2), genotype 'Prato' (5.70) recorded maximum number of flowers per plant whereas minimum observed in genotype 'Sapporo' (1.53) and was found to be at par with genotypes 'Viviana' (1.73), 'Montego Bay' (1.80), 'Cilesta' (2.00), 'Pollyana' (1.60) and 'Tresor' (2.17). However, under Katrain conditions, during 2016-17 (E_3), maximum number of flowers per plant recorded in 'Eyeliner' (10.69) whereas minimum in genotype 'Ercolano' (2.62) and was found to be at par with genotype 'Viviana' (2.87). During 2017-18 at same location (E_4), same genotype ('Eyeliner'; 10.50) recorded maximum number of flowers per plant whereas minimum in genotype 'Viviana' (2.37).

Table 4.1.1.13: Mean performance of *Lilium* genotypes for number of flowers per plant

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	3.97	3.77	3.80	4.33	3.97
Prato	5.10	5.70	9.67	9.27	7.43
Tresor	4.20	2.17	5.40	5.13	4.23
Shiraj	3.67	2.43	5.20	4.30	3.90
Brunello	4.57	2.40	8.63	9.53	6.28
Pollyana	3.43	1.60	7.60	6.34	4.74
Elite	2.90	2.70	7.74	7.70	5.26
Eyeliner	6.20	4.50	10.69	10.50	7.97
Ercolano	3.07	2.63	2.62	3.10	2.86
Ceb Dazzle	3.13	2.50	3.08	3.52	3.06
Best Seller	5.80	3.67	3.43	3.17	4.02
Pavia	4.50	4.33	4.67	4.57	4.52
Salmon Classic	3.63	3.45	7.53	6.50	5.28
Yelloween	2.93	2.53	5.63	6.37	4.37
Cilesta	4.30	2.00	8.70	8.57	5.89
Montego Bay	2.10	1.80	5.67	5.30	3.72
Viviana	2.33	1.73	2.87	2.37	2.33
Sapporo	2.37	1.53	3.50	3.27	2.67
Mean	3.79	2.86	5.91	5.77	-
$CD_{0.05}$	**0.82**	**0.81**	**0.33**	**0.20**	-

$CD_{0.05}$ for pooled mean : Environments = 0.14
Genotypes = 0.29
Environments × Genotypes = 0.59

Pooled analysis of environments revealed that maximum number of flowers per plant (5.91) recorded during 2016-17 at Katrain location (E_3) and found to be at par with same location during 2017-18 (E_4) i.e. 5.77 while minimum was recorded during 2017-18 at Nauni location (E_2) i.e. 2.86.

Pooling of genotypes revealed that 'Eyeliner' (7.97) and 'Viviana' (2.33) produced maximum and minimum number of flowers per plant, respectively.

Interaction between environments and genotypes revealed that 'Eyeliner' (10.69) produced maximum number of flowers per plant during 2016-17 at Katrain location (E_3) and found to be at par with same genotype ('Eyeliner'; 10.50) at same location during 2017-18 (E_4) while minimum number of flowers per plant recorded in 'Sapporo' (1.53) during 2017-18 at Nauni location (E_2) and was at par with 'Pollyana' (1.60), 'Cilesta' (2.00), 'Montego

Bay' (1.80), 'Viviana' (1.73) at same location (E_2) and with 'Montego Bay' (2.10) at same location during 2016-17 (E_1).

In present investigation, LA and Asiatic genotypes produced maximum number of blooms per plant whereas Oriental and OT group limited only upto 2-3 blooms per plant. This could be attributed to the genetic make up among different genotypes. For any bulbous crop, size of propagating material plays a major role. Larger sized bulbs will produce more number of flowers per plant as compared to smaller bulb. Moreover, number of flowers per plant varied significantly under the influence of environments again indicating the suitability of Katrain location in *Lilium* cut flower production. Similar variation with respect to variation number of flowers has also been reported by Sloan and Harkness (2006) among different Asiatic, LA and Oriental hybrids.

4.1.1.14 Tepal length (cm)

The length of outermost tepal from base to the tip was measured with the help of measuring scale and expressed in centimeters.

Data presented in Table 4.1.1.14 illustrated that during 2016-17 at Nauni location (E_1), ('Yelloween'; 12.50 cm) recorded maximum tepal length while minimum in genotype 'Shiraj' (7.50 cm). However during 2017-18 at same location (E_2) same genotype ('Yelloween'; 12.49 cm) recorded maximum tepal length while minimum recorded in 'Salmon Classic' (6.33 cm). Similarly during 2016-17 & 2017-18 at Katrain location (E_3 & E_4), genotype 'Yelloween' (12.46 cm & 12.25 cm, respectively) recorded maximum tepal length and was found to be at par with genotype 'Sapporo' (11.81 cm & 11.75 cm, respectively) whereas genotype 'Shiraj' (6.56 cm & 6.54 cm, respectively) recorded minimum tepal length, respectively.

Pooled analysis over environments revealed maximum tepal length (10.10 cm) recorded during 2016-17 at Katrain location (E_3) whereas minimum (8.94 cm) was observed during 2017-18 at Nauni condition (E_2) and was found to be at par during 2016-17 at same location (E_1).

Pooled analysis of genotypes revealed that 'Yelloween' (12.43 cm) and 'Shiraj' (6.95 cm) recorded maximum and minimum tepal length, respectively.

Interaction between environments and genotypes revealed that maximum tepal length recorded in 'Yelloween' (12.50 cm) during 2016-17 at Nauni conditions (E_1) which was found to be at par with same genotype ('Yelloween'; 12.49 cm, 12.46 cm and 12.25 cm, respectively) during 2016-17 & 2017-18 at both the locations (E_2, E_3 and E_4, respectively) and with 'Sapporo' (12.06 cm & 11.98 cm, respectively) during 2016-17 & 2017-18 at Nauni location. In contrast minimum tepal length observed in genotype 'Shiraj' (6.54 cm) during 2017-18 at Katrain location (E_4) and found to be at par with same genotype ('Shiraj'; 6.56 cm) during 2016-17 at same location (E_3) and with 'Salmon Classic' (6.33 cm) during 2017-18 at Nauni location (E_2).

Variation in tepal length among different genotypes could be attributed due to the interaction between genetic and environmental factors which lead to the variation in phenotypic expressions among different genotypes. Such variation in flowering parameters has also been reported by Kumar *et al*. (2011) among different Asiatic *Lilium* under sub-tropical mid hills of Meghalaya.

Table 4.1.1.14: Mean performance of *Lilium* genotypes for tepal length (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	8.30	8.52	10.50	8.43	8.94
Prato	11.44	11.21	10.16	10.87	10.92
Tresor	8.25	8.21	8.48	8.77	8.43
Shiraj	7.50	7.20	6.56	6.54	6.95
Brunello	8.60	8.55	10.10	10.80	9.51
Pollyana	8.27	8.32	10.07	10.18	9.21
Elite	8.17	8.42	7.44	7.51	7.88
Eyeliner	8.50	8.53	10.86	10.55	9.61
Ercolano	8.63	8.23	11.45	8.89	9.30
Ceb Dazzle	8.00	7.90	10.67	10.90	9.37
Best Seller	8.80	8.93	10.02	9.72	9.37
Pavia	8.86	8.84	11.79	9.27	9.69
Salmon Classic	7.73	6.33	8.49	9.61	8.04
Yelloween	12.50	12.49	12.46	12.25	12.43
Cilesta	8.22	8.34	9.82	9.99	9.09
Montego Bay	8.50	8.48	11.21	11.19	9.85
Viviana	8.67	9.52	9.88	10.54	9.65
Sapporo	12.06	11.98	11.81	11.75	11.90
Mean	8.94	8.89	10.10	9.88	-
$CD_{0.05}$	**0.12**	**0.17**	**0.87**	**0.71**	**-**

$CD_{0.05}$ for pooled mean : Environments = 0.13
Genotypes = 0.28
Environments × Genotypes = 0.55

4.1.1.15 Tepal width (cm)

The widest part of the tepal was measured to determine the tepal width with the help of measuring scale.

Variation in data with respect to tepal width has been presented in Table 4.1.1.15.

Genotype 'Best Seller' (3.79 cm) recorded maximum tepal width during 2016-17 at Nauni location (E_1) and was found to be at par with 'Brunello' (3.55 cm), 'Pavia' (3.49 cm), 'Yelloween' (3.56 cm) and 'Sapporo' (3.52 cm) while minimum was recorded in 'Pollyana' (2.34 cm) and was at par with genotype 'Navona' (2.38 cm) and 'Elite' (2.35 cm).

Table 4.1.1.15: Mean performance of *Lilium* genotypes for tepal width (cm)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	2.38	2.87	2.50	2.27	2.50
Prato	3.31	3.51	3.33	3.27	3.36
Tresor	3.18	2.54	2.53	2.63	2.72
Shiraj	2.86	2.27	2.20	2.21	2.38
Brunello	3.55	3.49	3.07	3.37	3.37
Pollyana	2.34	2.48	2.17	2.15	2.28
Elite	2.35	2.34	2.57	2.57	2.46
Eyeliner	2.86	3.20	2.80	2.87	2.93
Ercolano	3.42	3.29	2.73	2.56	3.00
Ceb Dazzle	3.14	3.76	2.77	2.85	3.13
Best Seller	3.79	3.75	2.53	2.65	3.18
Pavia	3.49	3.54	2.80	2.75	3.15
Salmon Classic	3.05	3.94	2.47	2.51	2.99
Yelloween	3.56	3.35	2.30	2.20	2.85
Cilesta	3.07	3.28	2.50	2.40	2.81
Montego Bay	3.42	3.50	2.97	2.93	3.21
Viviana	3.13	3.39	3.02	3.31	3.22
Sapporo	3.52	3.41	3.79	3.74	3.62
Mean	3.13	3.22	2.73	2.74	-
$CD_{0.05}$	**0.33**	**0.28**	**0.19**	**0.13**	-

$CD_{0.05}$ for pooled mean : Environments = 0.06
Genotypes = 0.12
Environments × Genotypes = 0.24

Performance of genotypes during 2017-18 at same location (E_2) revealed that 'Salmon Classic' (3.94 cm) recorded maximum tepal width and was found to be at par with 'Ceb Dazzle (3.76 cm) and 'Best Seller' (3.75 cm) while minimum tepal width recorded in 'Shiraj' (2.27 cm) and was at par with genotypes 'Tresor' (2.54 cm), 'Pollyana' (2.48 cm) and 'Elite' (2.34 cm). Similarly during 2016-17 at Katrain location (E_3), 'Sapporo' (3.79 cm) noted maximum tepal width while minimum in 'Pollyana' (2.17 cm) and was found to be at par with ‘Shiraj’ (2.20 cm) and ‘Yelloween’ (2.30 cm). During 2017-18 at same location (E_4), maximum tepal width observed in ‘Sapporo’ (3.74 cm) while minimum in genotype ‘Pollyana’ (2.15 cm) and found to be at par with ‘Navona’ (2.27 cm), ‘Shiraj’ (2.21 cm) and ‘Yelloween’ (2.20 cm).

Pooled analysis over four different environments revealed maximum tepal width recorded during 2017-18 at Nauni location (E_2) i.e. 3.22 cm while minimum (2.73 cm) during 2016-17 at Katrain location (E_3) and was found to be at par with genotypes grown during 2017-18 at same location (E_4) i.e. 2.74 cm.

As far as pooled analysis of genotypes is concerned, ‘Sapporo’ (3.62 cm) recorded maximum tepal width while ‘Pollyana’ (2.28 cm) recorded minimum and found to be at par with ‘Shiraj’ (2.38 cm).

Interaction between environments and genotypes further revealed that ‘Salmon Classic’ (3.94 cm) during 2017-18 at Nauni location (E_2) observed maximum tepal width and was found to be at par with genotypes ‘Best Seller’ (3.75 cm), ‘Ceb Dazzle’ (3.76 cm) at same location (E_2), ‘Best Seller’ (3.79 cm) during 2016-17 at Nauni location (E_1) and ‘Sapporo’ (3.79 cm & 3.74 cm, respectively) during 2016-17 & 2017-18 at Katrain location (E_3 & E_4). In contrast minimum tepal width was recorded during 2017-18 at Katrain location (E4) in genotype ‘Pollyana’ (2.15 cm) and found to be at par with ‘Navona’ (2.27 cm) and ‘Yelloween’ (2.20 cm) at same location (E_4), ‘Pollyana’ (2.17 cm) and ‘Yelloween’ (2.30 cm) during 2016-17 at same location (E_3), ‘Shiraj’ (2.27 cm) and ‘Elite’ (2.34 cm) during 2017-18 at Nauni location (E_2) and with genotypes ‘Navona’ (2.38 cm), ‘Pollyana’ (2.34 cm) and ‘Elite’ (2.35 cm) during 2016-17 at same location (E_1).

Differences in flowering parameters may be due to their genetic make up. Wide variation in floral parameters has also been reported by Dhiman (2003) under Kullu conditions and Sindhu and Singh (2012) in Asiatic *Lilium* under Northern plains.

4.1.1.16: Duration of flowering (days)

Duration of flowering was recorded by counting the number of days from the first opening of the flower till the fading of last flower.

An appraisal of data presented in Table 4.1.1.16 indicates that in general, during 2016-17 at Nauni location (E_1), genotype 'Prato' (20.87 days) recorded maximum duration of flowering and found to be at par with genotypes 'Eyeliner' (20.22 days) and 'Pavia' (19.95 days) whereas minimum in 'Pollyana' (13.33 days) and was at par with 'Shiraj' (15.00 days), 'Elite' (14.45 days), 'Yelloween' (14.22 days) and 'Cilesta' (13.44 days).

During 2017-18 at same location (E_2), 'Pavia' (22.07 days) recorded maximum duration of flowering and found to be at par with 'Prato' (21.64 days) while minimum observed in 'Montego Bay' (8.13 days) and found to be at par with 'Viviana' (9.13 days), 'Ercolano' (9.60 days), 'Elite' (9.57 days) and 'Shiraj' (9.63 days).

Table 4.1.1.16: Mean performance of *Lilium* genotypes for duration of flowering (days)

Genotypes	**E_1 (FLA, Nauni 2016-17)**	**E_2 (FLA, Nauni 2017-18)**	**E_3 (IARI, RS – Katrain 2016-17)**	**E_4 (IARI, RS – Katrain 2017-18)**	**Pooled Mean**
Navona	16.89	13.80	18.87	18.52	17.02
Prato	20.87	21.64	23.53	25.25	22.82
Tresor	16.45	14.53	23.31	23.29	19.40
Shiraj	15.00	9.63	19.24	17.70	15.39
Brunello	17.33	15.17	25.45	25.79	20.93
Pollyana	13.33	12.60	18.48	19.39	15.95
Elite	14.45	9.57	20.63	22.60	16.81
Eyeliner	20.22	19.62	27.93	27.45	23.81
Ercolano	16.78	9.60	11.63	10.95	12.24
Ceb Dazzle	16.21	10.63	14.29	13.63	13.69
Best Seller	16.33	15.27	10.67	9.74	13.00
Pavia	19.95	22.07	16.57	14.91	18.38
Salmon Classic	17.81	12.77	22.11	21.42	18.53
Yelloween	14.22	15.27	23.56	21.60	18.66
Cilesta	13.44	10.47	23.72	22.66	17.57
Montego Bay	17.00	8.13	25.51	23.61	18.56
Viviana	17.44	9.13	15.52	16.68	14.70
Sapporo	15.33	12.33	15.89	17.56	15.28
Mean	16.62	13.46	19.83	19.60	-
$CD_{0.05}$	**1.86**	**1.88**	**0.79**	**1.01**	-

$CD_{0.05}$ for pooled mean : Environments = 0.33
Genotypes = 0.70
Environments × Genotypes = 1.40

Similarly during 2016-17 & 2017-18 at Katrain location (E_3 & E_4), maximum duration of flowering recorded in 'Eyeliner' (27.93 days & 27.45 days, respectively) while minimum in 'Best Seller' (10.67 days & 9.74 days, respectively) (Plate 4b).

Pooled analysis over different environments showed maximum duration of flowering (19.83 days) during 2016-17 at Katrain location (E_3) and found to be at par during 2017-18 at same location (E_4) i.e. 19.60 days while minimum (13.46 days) during 2017-18 at Nauni location.

In case of pooled analysis of different genotypes, 'Eyeliner' (23.81 days) recorded maximum duration of flowering while minimum in 'Ercolano' (12.24 days).

Interaction between environments and genotypes revealed during 2016-17 at Katrain location (E_3) 'Eyeliner' (27.93 days) recorded maximum duration of flowering and found to be at par with same genotype ('Eyeliner'; 27.45 days) during 2017-18 at same location (E_4) while minimum was recorded in 'Montego Bay' (8.13 days) during 2017-18 at Nauni location (E_2) and found to be at par with 'Viviana' (9.13 days) at same location (E_2).

Duration of flowering is important parameters as it indicates the availability of flowers for any particular period and is directly related to the number of flowers produced among different genotypes. Genotypes with more number of flowers per stem exhibited longer duration of flowering which is dependent upon both genetic as well as prevailing environmental conditions. Similar variation with respect to duration of flowering has also been reported by Negi *et al*. (2016) in *Lilium* under low hill conditions of Himachal Pradesh.

4.1.1.17 Bulb diameter (cm)

In general during 2016-17 at Nauni location (E_1), genotype 'Eyeliner' (5.68 cm) recorded maximum bulb diameter and found to be at par with 'Navona' (5.27 cm), 'Prato' (5.32 cm), 'Brunello' (5.09 cm), 'Pollyana' (5.60 cm), 'Ercolano' (4.96 cm), 'Salmon Classic' (5.29 cm) and 'Montego Bay' (5.41 cm) whereas minimum bulb diameter recorded in ' Viviana' (3.52 cm) found to be at par with 'Sapporo' (3.73 cm) and 'Shiraj' (3.63 cm) (Table 4.1.1.17).

During 2017-18 at same location (E_2) same genotype ('Eyeliner'; 4.76 cm) recorded maximum bulb diameter while minimum in 'Shiraj' (2.48 cm) and found to be at par with Tresor' (2.94 cm).

Similarly during 2016-17 at Katrain location (E_3), 'Prato' (7.13 cm) recorded maximum bulb diameter and found to be at par with 'Pavia' (6.33 cm) while minimum recorded in 'Sapporo' (3.23 cm) and found to be at par with 'Viviana' (3.27 cm), 'Cilesta'

(4.03 cm) and ‘Pollyana’ (4.00 cm). It was also observed that at same location during 2017-18 (E_4), ‘Prato’ (6.50 cm) recorded maximum bulb diameter while minimum in ‘Viviana’ (3.20 cm) and found to be at par with ‘Sapporo’ (3.24 cm).

Pooled analysis over different environment further revealed that genotypes grown at Katrain location during 2016-17 (E_3) recorded maximum (5.26 cm) bulb diameter and found to be at par with same location during 2017-18 (E_4) i.e. 5.12 cm. In contrast minimum (3.59 cm) bulb diameter recorded under Nauni conditions during 2017-18 (E_2).

Table 4.1.1.17: Mean performance of *Lilium* genotypes for bulb diameter (cm)

Genotypes	**E_1 (FLA, Nauni 2016-17)**	**E_2 (FLA, Nauni 2017-18)**	**E_3 (IARI, RS – Katrain 2016-17)**	**E_4 (IARI, RS – Katrain 2017-18)**	**Pooled Mean**
Navona	5.27	3.72	5.63	5.43	5.01
Prato	5.32	4.04	7.13	6.50	5.75
Tresor	4.42	2.94	5.53	4.80	4.42
Shiraj	3.63	2.48	5.43	5.33	4.22
Brunello	5.09	3.94	6.23	5.33	5.15
Pollyana	5.60	3.43	4.00	4.60	4.41
Elite	4.48	3.77	5.50	5.27	4.76
Eyeliner	5.68	4.76	5.90	5.83	5.54
Ercolano	4.96	3.59	4.90	4.75	4.55
Ceb Dazzle	4.54	3.97	5.17	5.39	4.77
Best Seller	4.59	3.43	5.67	5.90	4.90
Pavia	4.77	3.79	6.33	5.81	5.17
Salmon Classic	5.29	3.33	5.43	5.20	4.81
Yelloween	4.67	3.10	5.64	5.20	4.65
Cilesta	4.75	4.16	4.03	4.48	4.36
Montego Bay	5.41	3.39	5.67	5.93	5.10
Viviana	3.52	3.32	3.27	3.20	3.33
Sapporo	3.73	3.45	3.23	3.24	3.41
Mean	4.76	3.59	5.26	5.12	-
$CD_{0.05}$	**0.77**	**0.58**	**0.80**	**0.54**	-

$CD_{0.05}$ for pooled mean : Environments = 0.16
Genotypes = 0.34
Environments × Genotypes = 0.67

Pooled analysis of genotypes revealed that ‘Prato’ (5.75 cm) recorded maximum bulb diameter followed by ‘Eyeliner’ (5.54 cm) whereas minimum in ‘Viviana’ (3.33 cm) and found to be at par with ‘Sapporo’ (3.41 cm).

Interaction between environments and genotypes revealed that maximum bulb diameter recorded in ‘Prato’ (7.13 cm) during 2016-17 at Katrain location (E_3) and found to be at par with same genotype (‘Prato’; 6.50 cm) at same location during 2017-18 (E_4). In contrast minimum bulb diameter observed in ‘Shiraj’ (2.48 cm) during 2017-18 at Nauni location (E_2) and found to be at par with ‘Navona’ (3.72 cm), ‘Tresor’ (2.94 cm), ‘Pollyana’ (3.43 cm), ‘Elite’ (3.77 cm), ‘Ercolano’ (3.59 cm), ‘Best Seller’ (3.43 cm), ‘Pavia’ (3.79 cm), ‘Salmon Classic’ (3.33 cm) and ‘Yelloween’ (3.10 cm) at same location (E_2), Shiraj (3.63 cm) at same location during 2016-17 (E_1) and with ‘Viviana’ and ‘Sapporo’ (3.52 cm & 3.73 cm, 3.32cm & 3.45 cm, 3.27 cm & 3.23 cm and 3.20 cm & 3.24 cm, respectively) at E_1, E_2, E_3 and E_4, respectively.

Wide variation in bulb diameter could be attributed to the genetic make up of the genotypes. Furthermore, genotypes grown at Katrain location outperformed with respect to bulb parameters indicating the congenial environment and edaphic factors for bulb production.

Significant differences for various bulb characters of Asiatic *Lilium* cultivars were also reported by Sindhu and Singh (2012), Deka *et al.* (2010), Gupta (2002) and Gupta (2003).

4.1.1.18 Weight of bulb (g)

Average weight of ten bulbs was calculated with the help of electronic weighing machine and results thus obtained have been presented in Table 4.1.1.18.

In general during 2016-17 at Nauni location (E_1), ‘Brunello’ (45.72 g) recorded maximum bulb weight and found to be at par with ‘Eyeliner’ (45.66 g) whereas minimum in ‘Pavia’ (20.59 g) and found to be at par with ‘Sapporo’ (22.07 g).

During 2017-18 at same location (E_2), ‘Eyeliner’ (43.37 g) recorded maximum bulb weight while minimum in ‘Sapporo’ (18.12 g) and found to be at par with ‘Yelloween’ (19.58 g).

Similarly during 2016-17 at Katrain location (E_3), ‘Prato’ (94.67 g) recorded maximum weight of bulb while minimum in ‘Sapporo’ (28.70 g) and was found to be at par with ‘Viviana’ (29.34 g). At same location during 2017-18 (E_4), same genotype (‘Prato’; 95.84 g) recorded maximum bulb weight while minimum in ‘Sapporo’ (19.71 g) followed by ‘Viviana’ (20.44 g)

Pooled analysis over different environments further revealed that genotypes grown at Katrain location during 2016-17 (E_3) recorded maximum bulb weight (64.34 g) whereas minimum (27.69 g) at Nauni location during 2017-18 (E_2).

Pooled analysis of genotypes revealed that 'Eyeliner' (64.05 g) recorded maximum bulb weight whereas minimum in 'Sapporo' (22.15 g) followed by 'Viviana' (24.18 g).

Interaction between environments and genotypes revealed that maximum weight of bulb recorded in 'Prato' (95.84 g) during 2017-18 at Katrain location (E_4) and found to be at par with same genotype ('Prato'; 94.67 g) at same location during 2016-17 (E_3). In contrast minimum bulb weight observed in 'Sapporo' (18.12 g) during 2017-18 at Nauni (E_2) and was at par with 'Yelloween' (19.58 g) at same location (E_2) and with 'Sapporo' (19.71 g) during 2017-18 at Katrain location (E_4).

Table 4.1.1.18: Mean performance of *Lilium* genotypes for weight of bulb (g)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	42.24	28.53	72.67	58.17	50.40
Prato	23.59	29.09	94.67	95.84	60.80
Tresor	28.11	24.95	51.59	56.37	40.26
Shiraj	27.31	21.69	58.03	55.41	40.61
Brunello	45.72	29.92	63.97	53.56	48.29
Pollyana	35.67	28.46	51.17	55.96	42.81
Elite	31.98	24.77	71.67	68.36	49.19
Eyeliner	45.66	43.37	84.77	82.38	64.05
Ercolano	31.38	31.73	56.23	58.60	44.48
Ceb Dazzle	28.22	28.28	86.41	90.14	58.26
Best Seller	36.06	22.64	58.92	64.71	45.58
Pavia	20.59	32.27	66.76	65.45	46.27
Salmon Classic	24.27	29.30	90.40	88.46	58.11
Yelloween	38.90	19.58	58.27	64.16	45.23
Cilesta	38.82	37.68	49.64	57.49	45.91
Montego Bay	43.37	24.57	84.88	92.53	61.34
Viviana	23.55	23.39	29.34	20.44	24.18
Sapporo	22.07	18.12	28.70	19.71	22.15
Mean	32.64	27.69	64.34	63.76	-
$CD_{0.05}$	**1.99**	**2.85**	**1.60**	**0.98**	-

$CD_{0.05}$ for pooled mean : Environments = 0.46
Genotypes = 0.97
Environments × Genotypes = 1.93

Present investigation is in close conformity with findings of Sindhu and Singh (2012), Deka *et al.* (2010) in Asiatic lily, Gupta (2002) and Gupta (2003) in Oriental lily.

4.1.1.19 Number of bulblets/plant

The total number of bulblets produced per plant just above the mother bulb on the stem was counted after harvesting of each plant and results with this regard have been presented in Table 4.1.1.19.

In general during 2016-17 at Nauni location (E_1) maximum numbers of bulblets per plant recorded in genotype 'Eyeliner' (3.63) while minimum in 'Sapporo' (1.30) and found to be at par with 'Navona' (1.47), 'Prato' (1.53), 'Shiraj' (1.30), 'Brunello' (1.60), 'Pollyana' (1.27), 'Elite' (1.53), 'Ceb Dazzle' (1.40), 'Best Seller' (1.17), 'Pavia' (1.57), 'Salmon Classic' (1.13), 'Yelloween' (1.53), 'Cilesta' (1.40), 'Montego Bay' (1.57) and 'Viviana' (1.37). Similarly during 2017-18 at same location (E_2), 'Eyeliner' (3.83) recorded maximum number of bulblet per plant followed by 'Tresor' (3.50) while minimum in 'Salmon Classic' (1.10) and found to be at par with 'Navona' (1.67), 'Shiraj' (1.57), 'Brunello' (1.30), 'Pollyana' (1.53), 'Elite' (1.57), 'Ercolano' (1.50), 'Best Seller' (1.43), 'Pavia' (1.27), ', 'Yelloween' (1.33), 'Cilesta' (1.53), 'Montego Bay' (1.40), 'Viviana' (1.57) and 'Sapporo' (1.40).

Table 4.1.1.19: Mean performance of *Lilium* genotypes for number of bulblet per plant

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	1.47	1.67	1.87	2.30	1.83
Prato	1.53	2.17	6.67	4.43	3.70
Tresor	2.63	3.50	2.47	2.67	2.82
Shiraj	1.30	1.57	2.53	2.47	1.97
Brunello	1.60	1.30	7.31	4.60	3.70
Pollyana	1.27	1.53	1.33	1.97	1.53
Elite	1.53	1.57	2.41	2.44	1.99
Eyeliner	3.63	3.83	10.87	10.48	7.20
Ercolano	1.83	1.50	3.27	3.82	2.60
Ceb Dazzle	1.40	1.83	9.17	8.69	5.27
Best Seller	1.17	1.43	4.42	4.33	2.84
Pavia	1.57	1.27	8.27	7.84	4.73
Salmon Classic	1.13	1.10	5.29	4.68	3.05
Yelloween	1.53	1.33	1.73	2.70	1.83
Cilesta	1.40	1.53	5.31	4.30	3.14
Montego Bay	1.57	1.40	2.63	3.07	2.17
Viviana	1.37	1.57	2.53	1.45	1.73
Sapporo	1.30	1.40	1.50	1.40	1.40
Mean	1.62	1.75	4.42	4.09	-
$CD_{0.05}$	**0.45**	**0.73**	**0.33**	**0.50**	-

$CD_{0.05}$ for pooled mean : Environments = 0.12
Genotypes = 0.26
Environments × Genotypes = 0.51

During 2016-17 at Katrain location (E_3), ‘Eyeliner’ (10.87) produced maximum number of bulblet per plant while minimum in ‘Pollyana’ (1.33) and found to be at par with ‘Sapporo’ (1.50). At same location during 2017-18 (E_4), same genotype (‘Eyeliner’; 10.48) recorded maximum number of bulblet while minimum in ‘Sapporo’ (1.40) and found to be at par with ‘Viviana’ (1.45).

Pooled analysis of environments revealed that maximum (4.42) bulblets per plant were produced during 2016-17 at Katrain location (E_3) whereas minimum (1.62) recorded during 2016-17 at Nauni location (E_1).

Pooled analysis of genotypes over environments revealed that ‘Eyeliner’ (7.20) recorded maximum number of bulblet per plant while minimum in ‘Sapporo’ (1.40) and found to be at par with ‘Pollyana’ (1.53).

Interaction between environments and genotypes revealed that ‘Eyeliner’ (10.87) produced maximum number of bulblets per plant during 2016-17 at Katrain location (E_3) and found to be at par with same genotype (10.48) during 2017-18 at same location (E_4). In contrast minimum number of bulblets/plant recorded in ‘Salmon Classic’ (1.10) during 2017-18 at Nauni location (E2) and found to be at par with genotypes ‘Shiraj’ (1.57), ‘Brunello’ (1.30), ‘Pollyana’ (1.53), ‘Elite’ (1.57), Ercolano (1.50), ‘Best Seller’ (1.43), ‘Pavia’ (1.27), ‘, ‘Yelloween’ (1.33), ‘Cilesta’ (1.53), ‘Montego Bay’ (1.40), ‘Viviana’ (1.57) and ‘Sapporo (1.40) at same location (E2), ‘Navona’ (1.47), ‘Prato’ (1.53), ‘Shiraj’ (1.30), ‘Brunello’ (1.60), ‘Pollyana’ (1.27), ‘Elite’ (1.53), ‘Ceb Dazzle’ (1.40), ‘Best Seller’ (1.17), ‘Pavia’ (1.57), ‘Salmon Classic’ (1.13), ‘Yelloween’ (1.53), ‘Cilesta’ (1.40), ‘Montego Bay’ (1.57) and ‘Viviana’ (1.37) during 2016-17 at Nauni location (E_1), ‘Pollyana’ & ‘Sapporo’ (1.33 & 1.50, respectively) during 2016-17 at Katrain location (E_3).

Similar results pertaining to various bulblet parameters has also been reported by Kumar *et al*. (2011) and Bhandari *et al*. (2017) under different environments.

4.1.1.20 Weight of bulblet (g)

Total weight of bulblets was recorded first, then total weight of bulblets was divided by the number of bulblets produced per stem, and then the weight of individual bulblet was recorded.

Results pertaining to variation with respect to weight of bulblet have been presented in Table 4.1.1.20.

In general during, 2016-17 at Nauni location (E_1), genotype 'Eyeliner' (2.67 g) recorded maximum weight of bulblet whereas minimum in 'Viviana' (0.67 g) and found to be at par with 'Navona' (1.05 g), 'Prato' (1.02 g), 'Tresor' (1.11 g), 'Pollyana' (0.85 g) and 'Elite' (0.96 g). Similarly at same location during 2017-18 (E_2), 'Salmon Classic' (4.57 g) recorded maximum weight of bulblet while minimum in 'Viviana' (0.73 g) followed by 'Best Seller' (1.10 g) and 'Montego Bay' (1.30 g).

At Katrain location during both the years (E_3 & E_4), 'Eyeliner' (3.66 g & 3.52 g, respectively) recorded maximum bulblet weight whereas minimum in 'Viviana' (0.67 g & 0.61 g, respectively).

Table 4.1.1.20: Mean performance of *Lilium* genotypes for weight of bulblet (g)

Genotypes	**E_1 (FLA, Nauni 2016-17)**	**E_2 (FLA, Nauni 2017-18)**	**E_3 (IARI, RS – Katrain 2016-17)**	**E_4 (IARI, RS – Katrain 2017-18)**	**Pooled Mean**
Navona	1.05	2.55	2.28	1.76	1.91
Prato	1.02	2.34	2.45	1.41	1.81
Tresor	1.11	2.42	1.24	1.09	1.47
Shiraj	1.36	2.23	1.52	1.28	1.60
Brunello	2.14	2.14	2.46	1.52	2.07
Pollyana	0.85	2.69	2.61	1.30	1.86
Elite	0.96	2.43	1.39	1.51	1.57
Eyeliner	2.67	3.20	3.66	3.52	3.26
Ercolano	1.60	1.58	1.73	1.91	1.70
Ceb Dazzle	1.61	1.61	1.63	2.24	1.78
Best Seller	1.20	1.10	2.15	2.68	1.78
Pavia	1.71	2.39	2.47	1.52	2.02
Salmon Classic	1.63	4.57	2.60	1.67	2.62
Yelloween	1.36	1.99	1.47	1.23	1.51
Cilesta	1.27	2.13	2.53	2.67	2.15
Montego Bay	1.80	1.30	2.18	5.76	2.76
Viviana	0.67	0.73	0.67	0.61	0.67
Sapporo	1.17	1.72	1.84	2.46	1.80
Mean	1.40	2.17	2.05	2.01	-
$CD_{0.05}$	**0.49**	**0.78**	**0.39**	**0.32**	-

$CD_{0.05}$ for pooled mean : Environments = 0.12
Genotypes = 0.26
Environments × Genotypes = 0.53

Pooled analysis over environments revealed that during 2017-18 at Nauni location (E_2) maximum (2.17 g) weight of bulblet was recorded followed by Katrain location during 2016-17 (E_3) (2.05 g) whereas minimum during 2016-17 at Nauni location (E_1) i.e. 1.40 g.

Pooled analysis of genotype revealed that 'Eyeliner' (3.26 g) had maximum bulblet weight whereas minimum in 'Viviana' (0.67 g).

Interaction between environments and genotypes revealed that during 2017-18 at Nauni location (E_2) 'Salmon Classic' (4.57 g) recorded maximum bulblet weight while minimum in 'Viviana' (0.61 g) during 2017-18 at Katrain location (E_4) and found to be at par with same genotype ('Viviana'; 0.67 g) at same location during 2016-17 (E_3), 'Best Seller' (1.10 g) and 'Viviana' (0.73 g) at Nauni location during 2017-18 (E_2), 'Navona' (1.05 g), 'Prato' (1.02 g), 'Tresor' (1.11 g) and 'Viviana' (0.67 g) during 2016-17 at Nauni location (E_1).

Similar results with regards to various bulblet parameters have also been reported by Kumar *et al*. (2011) and Bhandari *et al*. (2017) under different environments.

4.1.1.21 Vase life (days)

Vase life of flowers was determined as the number of days taken from placing of cut stem in distilled water till wilting and falling of petals. Variation among different genotypes over four different environments with respect to vase life (days) has been presented in Table 4.1.1.21.

During 2016-17 at Nauni location (E_1), genotype 'Eyeliner' (9.56 days) recorded maximum vase life whereas minimum in 'Ceb Dazzle' (4.67 days) and found to be at par with 'Navona' (5.14 days), 'Prato' (5.26 days), 'Shiraj' (5.30 days), 'Brunello' (5.17 days), 'Pollyana' (5.60 days), 'Ercolano' (4.83 days), 'Best Seller' (5.11 days), 'Salmon Classic (4.78 days) and 'Montego Bay'(5.24 days). During 2017-18 at same location (E_2), 'Eyeliner' (9.67 days) recorded maximum vase life while minimum in 'Ercolano' (6.50 days) and found to be at par with 'Navona' (7.17 days), 'Prato' (6.61 days), 'Shiraj' (7.67 days), 'Brunello' (7.17 days), 'Pollyana' (7.67 days), 'Elite' (7.83 days), Ceb Dazzle (7.33 days), 'Best Seller' (6.71 days), 'Pavia' (6.51 days), Yelloween (6.67 days), Montego Bay' (7.61 days) and 'Viviana' (7.60 days).

Similarly during 2016-17 at Katrain location (E_3), 'Eyeliner' (10.37 days) recorded maximum vase life while minimum in 'Best Seller' (6.40 days) followed by 'Ceb Dazzle' (6.60 days) and 'Viviana' (6.46 days). During 2017-18 at same location (E_4), same genotype

(‘Eyeliner’; 11.54 days) recorded maximum vase life whereas minimum in ‘Tresor’ (6.40 days) and found to be at par with ‘Navona’ (6.50 days), ‘Ercolano’ (6.50 days) and ‘Ceb Dazzle’ (6.47 days).

On pooling of data over environments showed that maximum vase life (7.79 days) of flowers recorded during 2017-18 at Katrain location (E_4) and found to be at par with genotypes during 2016-17 (7.69 days) at same location (E_3) whereas minimum (5.90 days) observed during 2016-17 at Nauni location (E_1).

Pooled analysis of genotypes indicated that ‘Eyeliner’ (10.28 days) recorded maximum vase life whereas minimum in ‘Ercolano’ (6.22 days) and found to be at par with ‘Navona’ (6.59 days), ‘Ceb Dazzle’ (6.27 days) and ‘Best Seller’ (6.36 days).

Table 4.1.1.21: Mean performance of *Lilium* genotypes for vase life (days)

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	5.14	7.17	7.53	6.50	6.59
Prato	5.26	6.61	8.47	8.67	7.25
Tresor	6.22	8.43	7.70	6.40	7.19
Shiraj	5.30	7.67	6.97	7.40	6.83
Brunello	5.17	7.17	8.60	8.87	7.45
Pollyana	5.60	7.67	7.63	7.50	7.10
Elite	6.22	7.83	7.53	7.37	7.24
Eyeliner	9.56	9.67	10.37	11.54	10.28
Ercolano	4.83	6.50	7.03	6.50	6.22
Ceb Dazzle	4.67	7.33	6.60	6.47	6.27
Best Seller	5.11	6.71	6.40	7.24	6.36
Pavia	5.89	6.51	7.27	7.60	6.81
Salmon Classic	4.78	8.17	8.57	10.20	7.93
Yelloween	6.33	6.67	7.17	7.60	6.94
Cilesta	8.44	8.21	9.27	7.75	8.42
Montego Bay	5.24	7.61	7.60	8.16	7.15
Viviana	6.23	7.60	6.46	6.62	6.73
Sapporo	6.11	8.83	7.34	7.88	7.54
Mean	5.90	7.57	7.69	7.79	-
$CD_{0.05}$	**0.94**	**1.51**	**0.34**	**0.19**	-

$CD_{0.05}$ for pooled mean : Environments = 0.21
Genotypes = 0.44
Environments × Genotypes = 0.88

Interaction between environments and genotypes revealed that ‘Eyeliner’ (11.54 days) observed maximum vase life during 2017-18 at Katrain location (E_4) whereas minimum in ‘Ceb Dazzle’ (4.67 days) during 2016-17 at Nauni location (E_1) and found to be at par with

‘Navona’ (5.14 days), ‘Prato’ (5.26 days), ‘Shiraj’ (5.30 days), ‘Brunello’ (5.17 days), ‘Ercolano’ (4.83 days), ‘Best Seller’ (5.11 days), ‘Salmon Classic (4.78 days) and ‘Montego Bay’(5.24 days) at same location (E_1).

Variation in vase life could also be attributed to the increased accumulation of carbohydrates since, these genotypes could produce more number of leaves and higher chlorophyll content, which might have led to increased photosynthesis and increased carbohydrates. Moreover, vase life of flowers is directly related to the number of flowers in a cut stem. Similar variations for vase life were also observed by Mahesh (1996), Krishnappa *et al*. (2017) and Chandrashekar *et al*. (2018).

4.1.1.22 Stem strength (%)

Stem strength is an important parameter which gives the idea about the sturdiness of cut stem which is essential in cut flower production. Based on the level of sturdiness, cut stems were characterized as ‘A’ grade, ‘B’ grade and ‘C’ grade.

(i) ‘A’ grade (%) flowers based on stem strength

Data presented in Table 4.1.1.22(a) depicts during 2016-17 at Nauni location (E_1), ‘Prato’ (93.43 %) recorded maximum ‘A’ grade cut stems whereas minimum in ‘Viviana’ (2.45 %).

During 2017-18 at same location (E_2), ‘Eyeliner’; 94.72 % produced maximum ‘A’ grade cut flowers while minimum in ‘Pavia’ 47.50 %).

At Katrain location during 2016-17 (E_3), ‘Eyeliner’ (100.00 %) produced hundred per cent cut flowers whereas minimum were recorded in ‘Shiraj’ (42.17 %). At same location during 2017-18 (E_4), genotype ‘Eyeliner’ (97.50 %) produced ‘A’ grade cut flowers and found to be statistically at par with ‘Navona’ (94.37 %), ‘Prato’ (97.48 %), and ‘Best Seller’ (96.67 %) whereas minimum percentage of ‘A’ grade cut stems were produced in ‘Montego Bay’ (53.33 %).

Pooled analysis of environment indicated that maximum percentage of ‘A’ grade cut stems were produced during 2017-18 at Katrain location (E_4) i.e. (78.68 %) while minimum during 2016-17 at Nauni location (E_1) i.e. (59.75 %).

Table 4.1.1.22(a): Variation in percentage of 'A' grade cut flower stems on the basis of stem strength in *Lilium* genotypes

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	34.93 (36.22)*	84.82 (67.06)	81.67 (64.67)	94.37 (76.33)	73.95 (61.07)
Prato	93.43 (75.12)	89.86 (71.41)	96.50 (79.26)	97.48 (80.96)	94.32 (76.68)
Tresor	62.92 (52.47)	83.34 (65.88)	63.50 (52.81)	88.63 (70.28)	74.60 (60.36)
Shiraj	60.33 (50.94)	60.00 (50.75)	42.17 (40.48)	60.00 (50.75)	55.63 (48.23)
Brunello	83.34 (65.88)	80.74 (63.95)	85.17 (67.32)	82.15 (65.00)	82.85 (65.54)
Pollyana	84.57 (66.85)	63.33 (52.71)	89.67 (71.23)	63.82 (53.00)	75.35 (60.95)
Elite	79.63 (63.15)	78.50 (62.36)	61.00 (51.34)	80.00 (64.61)	74.78 (60.36)
Eyeliner	90.33 (71.86)	94.72 (76.73)	100.00 (82.86)	97.50 (80.89)	95.64 (76.39)
Ercolano	91.50 (73.02)	93.33 (75.01)	48.33 (44.03)	78.67 (62.47)	77.96 (63.63)
Ceb Dazzle	45.40 (42.34)	50.00 (44.98)	44.80 (42.00)	66.67 (54.71)	51.72 (46.01)
Best Seller	62.67 (52.32)	66.67 (54.71)	45.33 (42.31)	96.67 (79.45)	67.83 (57.20)
Pavia	45.17 (42.21)	47.50 (43.55)	89.67 (71.23)	92.47 (74.04)	68.70 (57.76)
Salmon Classic	44.50 (41.83)	54.00 (47.28)	67.93 (55.49)	72.17 (58.14)	59.65 (50.68)
Yelloween	54.33 (47.47)	66.67 (54.71)	66.22 (54.45)	66.67 (54.71)	63.47 (52.84)
Cilesta	46.17 (42.78)	85.43 (67.55)	82.47 (65.26)	90.10 (71.63)	76.04 (61.81)
Montego Bay	58.33 (49.78)	63.34 (52.71)	76.20 (60.78)	53.33 (46.89)	62.80 (52.54)
Viviana	2.45 (9.00)	76.67 (61.09)	65.59 (54.06)	60.33 (50.94)	51.26 (43.78)
Sapporo	35.56 (36.59)	76.67 (61.09)	50.45 (45.24)	75.17 (60.09)	59.46 (50.75)
Mean	59.75 (51.10)	73.09 (59.64)	69.82 (57.67)	78.68 (64.16)	-
$CD_{0.05}$	**0.78**	**1.15**	**1.53**	**4.93**	-

*Figures in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = 0.61
Genotypes = 1.29
Environments × Genotypes = 2.58

Pooled analysis of genotypes revealed that 'Eyeliner' and 'Viviana' (95.64 % & 51.26 %, respectively) recorded maximum and minimum percentage of 'A' grade cut flowers.

Interaction between environments and genotypes revealed that 'Eyeliner' produced 100.00 %) 'A' grade cut stems during 2016-17 at Katrain location (E_3) found to be at par with 'Prato' (97.48 %) during 2017-18 at Katrain location (E_4). In contrast minimum 'A' grade cut stems were produced in 'Viviana' (2.45 %) under Nauni location during 2016-17.

Studies further indicated the superiority of Katrain location in maximum production of 'A' grade cut stem indicating the role of congenial environment. Furthermore same location also reported more stems thickness which might have added to the sturdier cut stems.

Bhandari *et al*. (2017) observed the similar results among different *Lilium* genotypes under hilly region of Uttrakhand.

(ii) 'B' grade (%) flowers based on stem strength

An appraisal of data in Table 4.1.1.22(b) indicates the variation in percentage of 'B' grade cut stems produced by different genotypes over different environments.

During 2016-17 at Nauni location (E_1), 'Salmon Classic' (47.67 %) recorded maximum percentage of 'B' grade cut stems whereas minimum in 'Ercolano' (5.64 %). However, at same location during 2017-18 (E_2), 'Ceb Dazzle' (50.00 %) recorded maximum percentage of 'B' grade cut stem while minimum in 'Eyeliner' (3.78 %).

Similarly during 2016-17 at Katrain location (E_3), 'Best Seller' (45.60 %) recorded maximum percentage of 'B' grade cut stem while minimum in 'Prato' (1.67 %). Under same location, 'Eyeliner' (0.00 %) didn't produce 'B' grade cut stems. However at same location during 2017-18 (E_4), 'Montego Bay' (43.33 %) produced maximum percentage of 'B' grade cut stem while minimum in 'Eyeliner' (1.43 %) followed by 'Prato' (2.52 %).

Table 4.1.1.22(b): Variation in percentage of 'B' grade cut flower stems on the basis of stem strength in *Lilium* genotypes

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	42.17 (40.48)*	10.00 (18.43)	10.67 (19.05)	2.90 (9.78)	16.43 (21.93)
Prato	6.57 (14.85)	7.40 (15.74)	1.67 (7.40)	2.52 (9.12)	4.54 (11.78)
Tresor	16.91 (24.27)	13.33 (21.41)	20.50 (26.91)	10.07 (18.49)	15.20 (22.77)
Shiraj	31.83 (34.33)	33.33 (35.25)	33.33 (35.25)	33.33 (35.25)	32.96 (35.02)
Brunello	16.66 (24.08)	14.67 (22.51)	12.50 (20.70)	15.41 (23.10)	14.81 (22.60)
Pollyana	15.43 (23.12)	36.67 (37.25)	8.67 (17.11)	32.89 (34.98)	23.42 (28.11)
Elite	15.33 (23.04)	19.00 (25.83)	30.33 (33.41)	9.33 (17.76)	18.50 (25.01)
Eyeliner	6.67 (14.11)	3.78 (11.12)	0.00 (0.00)	1.43 (6.86)	3.72 (9.02)
Ercolano	5.64 (13.73)	6.67 (14.96)	21.33 (27.49)	18.33 (25.34)	12.99 (20.38)
Ceb Dazzle	44.00 (41.54)	50.00 (44.98)	28.43 (32.21)	33.33 (35.25)	38.94 (38.50)
Best Seller	15.50 (23.18)	26.67 (31.08)	45.60 (42.46)	3.33 (10.52)	22.78 (26.81)
Pavia	40.17 (39.31)	45.23 (42.25)	10.33 (18.74)	3.74 (11.15)	24.87 (27.86)
Salmon Classic	47.67 (43.65)	41.67 (40.19)	20.17 (26.67)	11.83 (20.11)	30.92 (32.99)
Yelloween	25.26 (30.16)	23.33 (28.87)	18.17 (25.22)	23.33 (28.87)	22.52 (28.29)
Cilesta	36.50 (37.15)	9.87 (18.30)	15.70 (23.33)	5.50 (13.52)	16.89 (23.08)
Montego Bay	25.50 (30.32)	33.33 (35.25)	16.78 (24.17)	43.33 (41.15)	29.74 (32.72)
Viviana	40.78 (39.67)	16.67 (24.09)	16.35 (23.84)	16.67 (24.09)	22.62 (27.92)
Sapporo	44.02 (41.55)	16.67 (24.09)	42.45 (40.64)	12.53 (20.73)	28.92 (31.75)
Mean	26.78 (30.22)	22.68 (27.31)	19.61 (24.70)	15.55 (21.45)	-
$CD_{0.05}$	**0.65**	**0.89**	**0.71**	**1.12**	-

*Figures in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = 0.19
Genotypes = 0.42
Environments × Genotypes = 0.84

Pooled analysis over environments revealed maximum 'B' grade cut stems (26.78 %) during 2016-17 at Nauni location (E_1) while minimum during 2017-18 at Katrain location (E_4) i.e. (15.55 %).

Pooled analysis of genotype revealed 'Ceb Dazzle' (38.94 %) produced maximum 'B' grade cut stems while minimum were noticed in 'Eyeliner' (3.72 %).

Interaction between environments and genotypes revealed that 'Ceb Dazzle' (50.00 %) produced maximum 'B' grade cut stems during 2017-18 at Nauni location (E_2) whereas minimum in 'Eyeliner' (1.43 %) during 2017-18 at Katrain location (E_4) and found to be at par with 'Prato' (1.67 %) at same location during 2016-17 (E_3).

(iii) 'C' grade (%) flowers based on stem strength

During 2016-17 at Nauni location (E_1), genotypes 'Prato' (0.00 %), 'Brunello (0.00 %) and 'Pollyana' (0.00 %) did not produce any 'C' grade cut stem whereas 'Eyeliner' (2.50 %) recorded minimum percentage of 'C' grade cut stem followed by 'Ercolano' (2.86 %) while maximum were recorded in genotype 'Viviana' (56.77 %). At same location during 2017-18 (E_2), 'Pollyana' (0.00 %), 'Ercolano' (0.00 %) and 'Ceb Dazzle' (0.00 %) did not produce 'C' grade cut stems however, maximum were recorded in genotype 'Yelloween' (10.00 %).

At Katrain location during 2016-17, 'Eyeliner' (0.00 %) and 'Pavia' (0.00 %) didn't produce any 'C' grade cut stem while maximum were noticed in 'Ercolano' (30.33 %). Similarly during 2017-18 at same location (E_4), 'Prato' (0.00 %), 'Ceb Dazzle' (0.00 %) and 'Best Seller' (0.00 %) did not produce 'C' grade cut flower stems while maximum recorded in 'Viviana' (23.00 %).

An appraisal of pooled data with regards to environments as presented in Table 4.1.1.22(c) indicates maximum percentage of 'C' grade cut stems produced during 2016-17 at Nauni location (E_1) i.e.13.47 % whereas minimum at same location during 2017-18 (E_2) i.e. 4.23 %.

On pooling of genotypes over environments revealed 'Viviana' (26.12 %) with maximum percentage of 'C' grade flowers while minimum were noticed in genotype 'Prato' (1.14 %) followed by 'Brunello' (2.34 %), 'Pollyana' (1.24 %) and 'Eyeliner' (1.27 %).

Table 4.1.1.22(c): Variation in percentage of 'C' grade cut flower stems on the basis of stem strength in *Lilium* genotypes

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	22.90 (28.53)*	5.18 (13.14)	7.67 (16.06)	2.73 (9.46)	9.62 (16.80)
Prato	0.00 (0.00)	2.74 (9.50)	1.83 (7.75)	0.00 (0.00)	1.14 (4.31)
Tresor	20.17 (26.67)	3.33 (6.14)	16.00 (23.56)	1.30 (6.53)	10.20 (15.73)
Shiraj	7.83 (16.24)	6.67 (14.96)	24.50 (29.65)	6.67 (14.96)	11.42 (18.95)
Brunello	0.00 (0.00)	4.59 (12.35)	2.33 (8.74)	2.43 (8.97)	2.34 (7.51)
Pollyana	0.00 (0.00)	0.00 (0.00)	1.67 (7.33)	3.29 (10.41)	1.24 (4.44)
Elite	5.03 (12.92)	2.50 (8.97)	8.67 (17.11)	10.67 (19.04)	6.72 (14.51)
Eyeliner	2.50 (4.61)	1.50 (6.97)	0.00 (0.00)	1.07 (5.92)	1.27 (4.46)
Ercolano	2.86 (9.66)	0.00 (0.00)	30.33 (33.41)	3.00 (9.97)	9.05 (13.26)
Ceb Dazzle	10.60 (18.99)	0.00 (0.00)	26.77 (31.14)	0.00 (0.00)	9.34 (12.53)
Best Seller	21.83 (27.84)	6.67 (12.29)	9.07 (17.490	0.00 (0.00)	9.39 (14.40)
Pavia	14.67 (22.49)	7.27 (15.59)	0.00 (0.00)	3.79 (11.21)	6.43 (12.32)
Salmon Classic	5.50 (13.56)	4.33 (11.99)	11.90 (20.17)	16.00 (23.57)	9.43 (17.32)
Yelloween	20.41 (26.84)	10.00 (14.99)	15.61 (23.25)	10.00 (18.43)	14.00 (20.88)
Cilesta	17.33 (24.59)	4.70 (12.51)	1.83 (7.72)	4.40 (12.10)	7.07 (14.23)
Montego Bay	16.17 (23.70)	3.33 (10.51)	7.02 (15.35)	3.33 (10.52)	7.46 (15.02)
Viviana	56.77 (48.87)	6.67 (14.96)	18.06 (25.14)	23.00 (28.64)	26.12 (29.40)
Sapporo	20.42 (26.85)	6.67 (14.96)	7.10 (15.39)	12.30 (20.52)	11.62 (19.43)
Mean	13.47 (18.21)	4.23 (9.99)	10.58 (16.63)	5.78 (11.68)	-
$CD_{0.05}$	**1.45**	**8.26**	**1.44**	**0.95**	-

*Figures in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = 0.96
Genotypes = 2.04
Environments × Genotypes = 4.08

As far as interaction between environments and genotypes is concerned, 'Viviana' (56.77 %) recorded maximum percentage of 'C' grade cut stem during 2016-17 at Nauni location (E_1) while minimum in 'Eyeliner' (1.07 %) during 2017-18 at Katrain location (E_4) and found to be at par with 'Tresor' (1.30 %) and 'Brunello' (2.43 %) at same location (E_4), 'Prato' (2.74 %), 'Eyeliner' (1.50 %), 'Salmon Classic' (4.33 %) and 'Montego Bay' (3.33 %) during 2017-18 at Nauni location (E_2), 'Prato' (1.83 %), 'Brunello' (2.33 %), 'Pollyana' (1.67 %) and 'Cilesta' (1.83 %) during 2016-17 at Katrain location (E_3), 'Eyeliner' (2.50 %) and 'Ercolano' (2.86 %) during 2016-17 at Nauni location (E_1).

4.1.1.23 Grading of cut flowers (%)

Cut flower stems of *Lilium* were divided to five *viz*., grades '1', grades '2', grades '3', grades '4' and grades '5' based on the stem length and number of flowers/plant with grade '1' being the most desirable grade while grade '5' as least desirable grade.

(i) Grade '1'

It is clear from the data presented in Table 4.1.1.23(a) which revealed during 2016-17 at Nauni location (E_1), genotype 'Best Seller' (93.33 %) produced maximum percentage of grade '1' cut flowers while minimum in 'Viviana' (4.76 %). During 2017-18 at same location (E_2), 'Eyeliner' (98.34 %) recorded maximum grade '1' cut flowers while minimum in 'Navona' (3.33 %).

At Katrain location during 2016-17 (E_3), 'Yelloween' produced 100 % of grade '1' cut flowers while minimum in 'Shiraj' (5.75 %), Ercolano (5.75 %) and 'Best Seller' (5.75 %). At same location during 2017-18 (E_4), 'Eyeliner' (98.33 %) recorded maximum production of grade '1' cut flowers while minimum in 'Navona' (3.00 %).

Table 4.1.1.23(a): Variation in percentage of grade '1' cut flower stems on the basis of stem length and number of flowers/plant in *Lilium* genotypes

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	50.00 (44.98)*	3.33 (10.52)	46.67 (43.07)	3.00 (9.94)	25.75 (27.13)
Prato	60.00 (50.75)	86.67 (39.22)	40.00 (68.56)	80.38 (63.69)	66.76 (55.55)
Tresor	50.00 (44.98)	16.66 (29.99)	25.00 (24.08)	16.67 (24.09)	27.08 (30.78)
Shiraj	10.00 (13.87)	10.00 (13.87)	5.75 (18.43)	20.69 (63.44)	11.61 (27.40)
Brunello	21.67 (27.70)	56.67 (41.15)	43.33 (48.81)	80.04 (69.64)	50.43 (45.28)
Pollyana	50.00 (44.98)	86.66 (52.71)	63.33 (68.55)	87.91 (38.81)	71.98 (58.97)
Elite	63.33 (53.13)	36.66 (50.75)	60.00 (37.25)	39.31 (38.81)	49.83 (44.99)
Eyeliner	73.33 (59.19)	98.34 (58.89)	73.33 (82.56)	98.33 (82.63)	85.83 (70.82)
Ercolano	20.00 (26.55)	26.66 (13.87)	5.75 (18.43)	19.07 (25.88)	16.43 (24.35)
Ceb Dazzle	33.33 (35.25)	13.33 (24.09)	16.67 (21.41)	19.42 (26.14)	20.69 (26.72)
Best Seller	93.33 (75.01)	10.00 (13.87)	5.75 (18.43)	15.48 (23.16)	29.70 (32.62)
Pavia	40.00 (39.22)	36.67 (37.25)	36.67 (37.25)	42.56 (40.71)	38.97 (38.61)
Salmon Classic	16.67 (24.09)	29.67 (29.99)	25.00 (32.99)	24.70 (29.79)	24.01 (29.21)
Yelloween	36.50 (37.15)	73.34 (76.10)	100.00 (83.85)	65.59 (54.06)	68.86 (56.55)
Cilesta	40.00 (39.22)	46.48 (56.77)	70.00(42.96)	69.35 (56.36)	56.46 (48.83)
Montego Bay	40.00 (39.22)	43.21 (18.43)	10.20 (41.08)	49.51 (44.70)	35.68 (35.86)
Viviana	4.76 (12.60)	4.59 (24.09)	16.67 (41.08)	10.63 (19.02)	9.16 (17.01)
Sapporo	16.67 (24.09)	16.78 (18.43)	10.00 (12.32)	15.00 (22.78)	14.61 (22.37)
Mean	39.42 (38.44)	38.65 (35.70)	35.37 (37.74)	42.09 (40.10)	-
$CD_{0.05}$	**5.80**	**0.01**	**0.60**	**0.86**	-

*Figures in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = 0.67
Genotypes = 1.42
Environments × Genotypes = 2.83

Pooled analysis over environment clearly demonstrated that maximum percentage of grade '1' cut stem (42.09 %) recorded during 2017-18 at Katrain location (E_4) whereas minimum (35.37 %) during 2016-17 at same location (E_3).

Pooling of genotypes over environments revealed maximum percentage of grade '1' cut stem production in 'Eyeliner' (85.83 %) while minimum in 'Viviana' (9.16 %).

Interaction between genotype and environment depicted 'Yelloween' (100.00 %) produced maximum grade '1' cut flowers during 2016-17 at Katrain location (E_3) and found to be at par with 'Eyeliner' (98.33 % & 98.34 %, respectively) during 2017-18 at same location (E_4) and at Nauni location (E_3); respectively. In contrast minimum in 'Navona' (3.00 %) during 2017-18 at Katrain location (E_4) and found to be statistically at par with same genotype ('Navona'; 3.33 %) and 'Viviana' (4.59 %) during 2017-18 at same location (E_2) and 'Shiraj' (5.75 %), 'Ercolano' (5.75 %) and 'Best Seller' (5.75 %) during 2016-17 at Katrain location (E_3).

(ii) Grade '2'

It is evident from data presented in Table 4.1.1.23(b) that during 2016-17 at Nauni location (E_1), genotype 'Sapporo' (73.22 %) produced maximum percentage of grade '2' cut flowers while minimum in 'Navona' (3.22 %) and 'Prato' (3.22 %).

During 2017-18 at same location (E_2), 'Tresor' (70.00 %) recorded maximum grade '2' cut flowers production while minimum in 'Eyeliner' (1.66 %).

At Katrain location during 2016-17 (E_3), 'Prato' produced maximum (36.67 %) of grade '2' cut flowers while minimum in 'Sapporo' (5.00 %).However, at same location and under similar conditions (E_3), genotypes such as 'Shiraj' (0.00 %), 'Ercolano' (0.00 %), 'Best Seller' (0.00 %), 'Yelloween' (0.00 %) and 'Viviana' (0.00 %) did not produce grade '2' cut flower stems. At same location during 2017-18 (E_4), 'Tresor' (68.83 %) recorded maximum production of grade '2' cut flowers while minimum in 'Eyeliner' (1.67 %) and under similar conditions 'Viviana' (0.00 %) didn't produce grade '2' cut flowers.

Pooled analysis over environment revealed that maximum percentage of grade '2' cut stems (17.68 %) recorded during 2017-18 at Katrain location (E4) and found to be at par with Nauni location during 2016-17 & 2017-18 (E_1 & E_2) i.e. 17.24 % and 16.15 %, respectively whereas minimum (13.80 %) during 2016-17 at same location (E_3).

Pooling of genotypes over environments revealed the maximum percentage of grade '2' cut flower production in 'Tresor' (48.04 %) while minimum in 'Viviana' (2.88 %) and found to be statistically at par with 'Viviana' (2.88 %), 'Shiraj' (3.21 %), 'Eyeliner' (5.83 %), 'Ercolano' (6.42 %) and 'Best Seller' (6.54 %).

Table 4.1.1.23(b): Variation in percentage of grade '2' cut flower stems on the basis of stem length and number of flowers/plant in *Lilium* genotypes

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	3.22 (10.34)*	6.67 (14.96)	23.33 (28.27)	26.70 (31.10)	14.98 (19.92)
Prato	10.00 (18.43)	6.61 (14.90)	36.67 (37.13)	9.52 (17.95)	15.70 (21.68)
Tresor	30.00 (33.20)	70.00 (56.77)	23.33 (28.07)	68.83 (56.04)	48.04 (39.86)
Shiraj	3.22 (10.33)	3.34 (10.53)	0.00 (0.00)	6.29 (14.03)	3.21 (8.72)
Brunello	16.67 (24.04)	16.66 (24.083)	26.67 (31.08)	6.84 (15.16)	16.71 (23.06)
Pollyana	16.67 (23.85)	6.67 (14.96)	16.67 (24.09)	5.66 (13.76)	11.42 (19.16)
Elite	23.33 (28.07)	41.67 (40.19)	20.00 (26.55)	39.50 (38.92)	31.13 (31.58)
Eyeliner	10.00 (18.43)	1.66 (7.41)	10.00 (18.43)	1.67 (7.37)	5.83 (11.43)
Ercolano	10.00 (18.43)	6.67 (14.96)	0.00 (0.00)	9.00 (17.45)	6.42 (13.47)
Ceb Dazzle	10.00 (18.43)	6.66 (14.95)	10.00 (18.43)	17.29 (24.56)	10.99 (22.24)
Best Seller	10.00 (18.43)	13.34 (21.41)	0.00 (0.00)	12.81 (20.96)	6.54 (9.69)
Pavia	50.00 (44.98)	30.00 (33.20)	25.00 (29.99)	31.38 (34.05)	34.10 (35.00)
Salmon Classic	3.33 (10.49)	20.67 (27.03)	18.33 (25.34)	23.50 (28.99)	16.46 (22.96)
Yelloween	10.00 (18.43)	10.00 (18.43)	0.00 (0.00)	12.63 (20.81)	8.16 (14.42)
Cilesta	18.33 (24.99)	17.49 (24.70)	20.00 (26.55)	16.93 (24.29)	18.19 (24.94)
Montego Bay	16.67 (23.85)	23.33 (28.87)	13.33 (21.41)	19.66 (26.31)	18.25 (24.49)
Viviana	5.71 (13.81)	5.82 (13.95)	0.00 (0.00)	0.00 (0.00)	2.88 (8.56)
Sapporo	73.22 (58.81)	3.36 (10.56)	5.00 (12.92)	10.00 (18.43)	22.90 (25.55)
Mean	17.24 (21.97)	16.15 (18.29)	13.80 (18.24)	17.68 (22.79)	-
$CD_{0.05}$	**7.68**	**0.38**	**5.80**	**1.99**	-

*Figures in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = 2.13
Genotypes = 4.52
Environments × Genotypes = 9.03

Interaction between genotype and environment indicated that 'Sapporo' (73.22 %) produced maximum grade '2' cut flowers during 2016-17 at Nauni location (E_1) and found to be at par with 'Tresor' (70.00 % & 68.83 %, respectively) during 2017-18 at same location (E_2) and Katrain location (E_4), respectively. In contrast minimum grade '2' cut flowers were produced in 'Eyeliner' (1.66 %) during 2017-18 at Nauni location (E_2).

(iii) Grade '3'

Perusal of data presented in Table 4.1.1.23(c) revealed that during 2016-17 at Nauni location (E_1), genotype 'Viviana' (31.75 %) produced maximum percentage of grade '3' cut flowers while minimum in 'Navona' (3.33 %) under same condition, 'Best Seller' (0.00 %) and Yelloween (0.00 %) did not produce grade '3' cut flowers. During 2017-18 at same location (E_2), 'Ceb Dazzle' (63.34 %) recorded maximum grade '3' cut flowers while minimum in 'Prato' (2.77 %). Under same environment Navona (0.00 %) and 'Eyeliner' (0.00 %) did not produce grade '3' cut flowers.

At Katrain location during 2016-17 (E_3), 'Salmon Classic' (46.67 %) recorded maximum grade '3' cut flowers while minimum in 'Navona' (3.33 %), 'Shiraj' (3.33 %) and 'Eyeliner' (3.33 %). Genotype 'Best Seller' (0.00 %) and 'Yelloween' (0.00 %) did not produce grade '3' cut flowers under same environment. At same location during 2017-18 (E_4), 'Ceb Dazzle' (45.50 %) recorded maximum production of grade '3' cut flowers while minimum in 'Pollyana' (1.34 %).

Table 4.1.1.23(c): Variation in percentage of grade '3' cut flower stems on the basis of stem length and number of flowers/plant in *Lilium* genotypes

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	3.33 (10.52)*	0.00 (0.00)	3.33 (10.52)	10.42 (18.82)	4.27 (9.96)
Prato	16.67 (23.85)	2.77 (9.57)	16.67 (24.09)	7.00 (15.32)	10.78 (18.21)
Tresor	10.00 (18.43)	5.00 (12.92)	6.67 (14.96)	5.06 (12.99)	6.68 (14.82)
Shiraj	5.00 (12.92)	3.34 (10.52)	3.33 (10.52)	4.69 (12.44)	4.09 (11.60)
Brunello	15.00 (22.59)	9.34 (17.79)	16.67 (24.09)	4.34 (12.02)	11.34 (19.12)
Pollyana	23.33 (28.77)	6.67 (14.96)	10.00 (18.43)	1.34 (6.64)	10.33 (17.20)
Elite	6.67 (8.85)	9.83 (18.27)	10.00 (18.43)	9.47 (17.91)	8.99 (15.86)
Eyeliner	6.67 (12.29)	0.00 (0.00)	3.33 (6.14)	0.00 (0.00)	2.50 (4.61)
Ercolano	20.00 (26.55)	16.67 (24.09)	23.33 (28.87)	20.50 (26.91)	20.13 (26.61)
Ceb Dazzle	20.00 (26.55)	63.34 (52.71)	20.00 (26.55)	40.50 (39.51)	35.96 (36.33)
Best Seller	0.00 (0.00)	3.34 (10.53)	0.00 (0.00)	10.70 (19.08)	3.51 (7.40)
Pavia	10.00 (18.43)	20.00 (26.55)	10.00 (18.43)	15.62 (23.27)	13.91 (21.67)
Salmon Classic	26.67 (31.08)	19.67 (26.31)	46.67 (43.07)	10.97 (19.33)	25.99 (29.95)
Yelloween	0.00 (0.00)	10.00 (18.43)	0.00 (0.00)	15.78 (23.39)	6.45 (10.45)
Cilesta	21.67 (27.70)	16.00 (23.57)	10.00 (18.43)	5.52 (13.58)	13.30 (20.82)
Montego Bay	20.00 (26.55)	13.34 (21.41)	40.00 (39.22)	11.53 (19.84)	21.22 (26.76)
Viviana	31.75 (34.28)	31.40 (34.07)	16.66 (24.08)	17.14 (24.44)	24.24 (29.22)
Sapporo	6.67 (14.96)	6.82 (15.13)	10.00 (18.43)	10.00 (18.43)	8.37 (16.74)
Mean	13.52 (19.13)	13.20 (18.71)	13.70 (19.12)	13.14 (18.00)	-
$CD_{0.05}$	**7.76**	**0.42**	**4.18**	**0.89**	-

*Figures in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = NS
Genotypes = 2.16
Environments × Genotypes = 4.31

Pooled analysis over environments was found to be non significant (Appendices-VI). Pooling of genotypes over environment revealed the maximum percentage of grade '3' cut flower stem production in 'Salmon Classic' (25.99 %) and found to be at par with 'Viviana' (24.24 %) while minimum in 'Eyeliner' (2.50 %) and found to be statistically at par with 'Navona' (4.27 %), 'Shiraj' (4.09 %) and 'Best Seller' (3.51 %).

Interaction between genotype and environment indicated that 'Ceb Dazzle' (63.34 %) produced maximum grade '3' cut flowers during 2017-18 at Nauni location (E_2) whereas minimum in 'Pollyana' (1.34 %) during 2017-18 at Katrain location (E_4).

(iv) Grade '4'

Data presented in Table 4.1.1.23(d) revealed that during 2016-17 at Nauni location (E_1), genotype 'Shiraj' (63.33 %) produced maximum percentage of grade '4' cut flowers while minimum in 'Sapporo' (3.33 %). However, under same location 'Pavia' (0.00 %) did not produce any grade '4' cut flowers. During 2017-18 at same location (E_2), 'Viviana' (47.67 %) recorded maximum percentage of grade '4' cut flowers while minimum in 'Prato' (2.34 %). On the other hand 'Pollyana' (0.00 %) and 'Eyeliner' (0.00 %) did not produce grade '4' cut flower under same environment.

Table 4.1.1.23(d): Variation in percentage of grade '4' cut flower stems on the basis of stem length and number of flowers/plant in *Lilium* genotypes

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	40.00 (39.22)*	30.00 (33.20)	13.33 (17.21)	19.78 (26.40)	25.78 (29.00)
Prato	13.33 (21.14)	2.34 (8.80)	6.67 (12.29)	1.77 (7.53)	6.03 (12.44)
Tresor	10.00 (18.43)	5.15 (13.12)	25.00 (29.91)	6.11 (14.31)	11.57 (18.94)
Shiraj	63.33 (52.71)	41.33 (39.99)	13.33 (21.14)	26.34 (30.86)	36.08 (36.18)
Brunello	30.00 (33.20)	4.00 (11.51)	3.33 (10.52)	6.63 (14.92)	10.99 (17.53)
Pollyana	10.00 (18.43)	0.00 (0.00)	10.00 (18.43)	3.56 (10.87)	5.89 (11.93)
Elite	6.67 (8.85)	6.67 (14.96)	6.67 (14.96)	7.00 (15.33)	6.75 (13.53)
Eyeliner	6.67 (12.29)	0.00 (0.00)	3.33 (10.52)	0.00 (0.00)	2.50 (5.70)
Ercolano	20.00 (26.55)	33.34 (35.25)	60.00 (50.75)	34.78 (36.12)	37.03 (37.17)
Ceb Dazzle	10.00 (18.43)	10.00 (18.43)	46.67 (43.07)	11.20 (19.54)	19.47 (24.87)
Best Seller	6.67 (14.96)	9.98 (8.41)	16.67 (24.09)	9.40 (17.84)	10.68 (18.82)
Pavia	0.00 (0.00)	13.33 (21.41)	11.67 (19.96)	10.43 (18.84)	8.86 (15.05)
Salmon Classic	43.33 (41.15)	19.33 (26.07)	6.67 (14.96)	19.00 (25.83)	22.08 (27.00)
Yelloween	42.86 (40.88)	6.66 (14.95)	0.00 (0.00)	6.00 (14.17)	13.88 (17.50)
Cilesta	10.00 (18.43)	10.03 (18.46)	0.00 (0.00)	5.67 (13.77)	6.42 (12.66)
Montego Bay	20.00 (26.55)	10.12 (18.54)	26.67 (31.08)	10.30 (18.71)	16.77 (23.72)
Viviana	47.61 (43.61)	47.67 (43.65)	66.67 (54.72)	66.60 (54.68)	57.15 (49.17)
Sapporo	3.33 (10.52)	36.67 (37.25)	25.00 (29.99)	20.00 (26.55)	21.25 (26.08)
Mean	21.32 (24.74)	15.92 (20.78)	18.98 (22.42)	14.70 (20.35)	-
$CD_{0.05}$	**7.76**	**0.52**	**8.08**	**0.81**	-

*Figures in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = 1.27
Genotypes = 2.70
Environments × Genotypes = 5.39

At Katrain location during 2016-17 (E_3), 'Viviana' produced 66.67 % of grade '4' cut flowers while minimum in 'Brunello' (3.33 %) and 'Eyeliner' (3.33 %). Data further revealed that under same environment 'Yelloween' (0.00 %) and 'Cilesta' (0.00 %) did not produce any grade '4' cut flower. At same location during 2017-18 (E_4), 'Viviana' (66.60 %) recorded maximum production of grade '4' cut flowers while minimum in 'Prato' (1.77 %) and under similar conditions 'Eyeliner' (0.00 %) didn't produce grade '4' cut flowers.

Pooled analysis over environments revealed that maximum percentage of grade '4' cut stems (21.32 %) recorded during 2016-17 at Nauni location (E_1) whereas minimum (14.70 %) produced during 2017-18 at Katrain location (E_4) and found to be at par with Nauni location during 2017-18 (E_2) i.e. 15.92 %.

Pooling of genotypes over environment revealed the maximum percentage of grade '4' cut stem production in 'Viviana' (57.15 %) while minimum were recorded in 'Eyeliner' (2.50 %). Interaction between genotype and environment further revealed that 'Viviana' (66.67 %) produced maximum grade '4' cut flowers during 2016-17 at Katrain location (E_3) and found to be at par with same genotype ('Viviana'; 66.60 %) during 2017-18 at same location (E_4) and with 'Shiraj' (63.33 %) during 2016-17 at Nauni location (E_1). In contrast minimum grade '4' cut flowers recorded in 'Prato' (1.77 %) during 2017-18 at Katrain location (E_4).

(v) Grade '5'

An appraisal of data in Table 4.1.1.23(e) clearly demonstrated that during 2016-17 at Nauni location (E_1), genotype 'Ercolano' (30.00 %) produced maximum percentage of grade '5' cut flowers and found to be at par with 'Shiraj' (28.33 %) and 'Ceb Dazzle' (26.67 %) whereas minimum in 'Navona' (3.33 %), 'Eyeliner' (3.33 %) and 'Montego Bay' (3.33 %).. However, under same location 'Prato' (0.00 %), 'Tresor' (0.00 %) 'Pollyana' (0.00 %) 'Elite' (0.00 %), 'Best Seller' (0.00 %), 'Pavia' (0.00 %) and 'Sapporo' (0.00 %) did not produce grade '5' cut flowers. During 2017-18 at same location (E_2), 'Best Seller' (63.34 %) recorded maximum percentage of grade '5' cut flowers while minimum in 'Prato' (1.61 %). Genotypes such as 'Eyeliner' (0.00 %), 'Pavia' (0.00 %) and 'Yelloween' (0.00 %) did not produce grade '5' cut flower under same environment.

At Katrain location during 2016-17 (E_3), 'Shiraj' produced 63.33 % of grade '5' cut flowers and found to be at par with 'Tresor' (43.33 %), 'Best Seller' (61.11 %) and 'Sapporo' (53.33 %) while minimum in 'Pollyana' (1.11 %). Data in Table 4.1.1.23(e) further revealed that under same environment 'Yelloween' (0.00 %) did not produce any grade '5' cut flowers. At same location during 2017-18 (E_4), 'Best Seller' (33.73 %) recorded maximum production of grade '5' cut flowers while minimum in 'Yelloween' (1.83 %).

Pooled analysis over environment revealed that maximum percentage of grade '5' cut stems (19.26 %) recorded during 2016-17 at Katrain location (E_3) and found to be at par with Nauni location during 2017-18 (16.10 %) whereas minimum (8.48 %) produced during 2016-17 at Nauni location (E_1).

Table 4.1.1.23(e): Variation in percentage of grade '5' cut flower stems on the basis of stem length and number of flowers/plant in *Lilium* genotypes

Genotypes	E_1 (FLA, Nauni 2016-17)	E_2 (FLA, Nauni 2017-18)	E_3 (IARI, RS – Katrain 2016-17)	E_4 (IARI, RS – Katrain 2017-18)	Pooled Mean
Navona	3.33 (10.52)*	60.00 (50.75)	13.33 (21.14)	27.10 (28.12)	25.94 (27.63)
Prato	0.00 (0.00)	1.61 (7.25)	1.34 (6.64)	2.11 (8.13)	1.69 (7.34)
Tresor	0.00 (0.00)	3.18 (10.27)	43.33 (40.06)	16.11 (20.41)	15.66 (17.68)
Shiraj	28.33 (32.15)	41.99 (40.38)	63.33 (53.83)	28.89 (29.91)	40.64 (39.07)
Brunello	16.67 (23.85)	13.34 (21.41)	6.67 (12.29)	1.93 (7.97)	9.65 (16.38)
Pollyana	0.00 (0.00)	1.77 (7.53)	1.11 (3.50)	2.64 (8.94)	1.38 (6.65)
Elite	0.00 (0.00)	5.17 (13.13)	5.56 (13.16)	3.05 (8.23)	3.44 (8.63)
Eyeliner	3.33 (6.14)	0.00 (0.00)	12.22 (20.31)	5.55 (8.03)	5.28 (8.62)
Ercolano	30.00 (33.20)	16.66 (24.08)	13.33 (21.04)	14.59 (22.34)	18.65 (25.17)
Ceb Dazzle	26.67 (31.08)	6.67 (14.96)	32.22 (31.93)	25.98 (29.28)	22.88 (26.81)
Best Seller	0.00 (0.00)	63.34 (52.72)	61.11 (51.95)	33.73 (30.22)	39.55 (33.72)
Pavia	0.00 (0.00)	0.00 (0.00)	12.22 (19.56)	7.17 (9.21)	4.85 (7.19)
Salmon Classic	10.00 (18.43)	10.67 (19.05)	2.22 (7.01)	14.67 (18.64)	9.39 (15.78)
Yelloween	10.64 (19.03)	0.00 (0.00)	0.00 (0.00)	1.83 (7.89)	2.75 (5.52)
Cilesta	10.00 (18.43)	10.00 (18.43)	3.33 (6.14)	4.57 (11.81)	6.98 (13.70)
Montego Bay	3.33 (6.14)	10.00 (18.43)	6.67 (12.29)	7.99 (16.31)	7.00 (14.39)
Viviana	10.32 (18.73)	10.67 (19.05)	16.67 (14.99)	18.70 (23.12)	14.09 (18.98)
Sapporo	0.00 (0.00)	36.54 (37.18)	53.33 (46.90)	30.00 (28.08)	28.30 (27.08)
Mean	8.48 (12.34)	16.10 (19.28)	19.26 (20.90)	13.65 (17.32)	-
$CD_{0.05}$	**4.52**	**0.55**	**27.45**	**0.89**	-

*Figures in parentheses are arc sine transformed values

$CD_{0.05}$ for pooled mean : Environments = 3.98
Genotypes = 8.44
Environments × Genotypes = NS

Pooling of genotypes over environment revealed the maximum percentage of grade '5' cut stem produced in 'Shiraj' (40.64 %) and found to be at par with 'Best Seller' (39.55 %).

Interaction between environments and genotypes was found to be non-significant (Appendices-VI).

Present studies revealed that maximum grade '1' cut flowers produced under Katrain location owing to favourable climatic conditions which led to the full expression of phenotypic characters among different *Lilium* genotypes.

4.1.1.24 Axillary bulbils/stem

In present investigation, none of the genotypes showed bulbils formation.

4.1.1.25 Incidence of insect-pest and disease (%)

Bulb rot and scale rot were noticed in some of the genotypes (particularly Oriental and OT hybrids) which were cured by drenching with Dithane M-45 (0.2 %) and Bavistin (0.1 %) solution. Leaf blight was also noticed in few plants of some of the genotypes which were checked by spraying with calcium nitrate at weekly intervals.

4.1.2 Parameters of variability

The extent of variation with respect to 21 characters of 18 genotypes of *Lilium* studied at two locations along with pooled analysis of environments measured in terms of mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), along with the amount of heritability (h^2) and the expected genetic advance as per cent of mean have been presented in Table 4.1.2.24(a).

The pooled analysis of variance presented in Table 4.1.2.24(a) revealed that the treatment mean squares were significant for all the characters indicating the genotypic differences among the various characters studied. The widest range of variation was recorded for the number of leaves/plant (18.37 to 80.92) followed by days to first flower (82.23 to 119.29) and days to flower bud formation (54.02 to 87.12). However, narrowest range for variability was observed for stem diameter (0.40 to 0.72) followed by tepal width (2.35 to 3.97) and bulb diameter (3.16 to 4.79).

4.1.2.1 Coefficients of variability

The variability observed in the characters among all the genotypes is due to the interaction effects of genotype and the prevailing environment conditions. Environmental variations are not fixable. The perusal of data present in Table 4.1.2.24(a) clearly demonstrated that the phenotypic coefficients of variability (PCV) was higher than the genotypic coefficients of variability (GCV) for all the characters and thus indicating the role of environment in the expression of characters in genotypes. Pooled analysis of environments over Nauni location revealed the high values for phenotypic coefficient of variability (PCV) was recorded for number of bulblet/plant (61.69 %), number of flowers per plant (44.91 %), number of leaves/plant (37.82 %), weight of bulblet (35.41 %) and leaf width (30.39 %); moderate values were observed in characters such as weight of bulb (24.03 %), stem length (22.15 %), days to sprouting (20.37 %), leaf length (20.14 %), stem diameter (18.12 %), bud length (16.28 %), vase life (15.30 %) and plant height (15.25 %) while low PCV values were observed for parameters like; per cent bulb sprouting (2.68 %), days to flower bud formation (11.63 %), days to first flower (9.26 %), size of the flower (11.26 %), tepal length (13.47 %), tepal width (14.99 %), duration of flowering (11.63 %) and bulb diameter (13.03 %).

Table 4.1.2.24(a): Pooled estimates of mean, genotypic and phenotypic coefficient of variability, heritability, genetic advance and genetic gain among 18 *Lilium* genotypes under Nauni conditions

Characters	Mean ± Standard error	Range	Coefficients of variability (%)		Heritability (%)	Genetic advance (%)	Genetic gain (%)
			PCV	GCV			
Days taken for bulb sprout emergence	48.26 ± 0.86	33.50 – 66.89	20.37	20.25	98.86	20.02	41.49
Per cent bulb sprouting (%)	98.70 ±1.59	93.33 - 100.00	2.68	1.80	45.31	2.47	2.50
Plant height (cm)	71.07 ± 3.18	53.55 - 87.46	15.25	14.23	87.06	19.44	27.36
Number of leaves/plant	48.35 ±1.26	18.37 - 80.92	37.82	37.68	99.29	37.40	77.35
Leaf length (cm)	10.27 ± 0.26	6.55 - 13.81	20.14	19.90	97.62	4.16	40.51
Leaf width (cm)	2.11 ± 0.11	1.43 - 3.92	30.39	29.66	95.22	1.26	59.61
Stem length (cm)	50.99 ± 0.92	32.03 - 69.24	22.15	22.04	99.00	23.04	45.18
Days to flower bud formation	70.89 ± 0.35	54.02 – 87.12	11.63	11.62	99.73	16.94	23.90
Bud length (cm)	9.04 ± 0.25	6.13 - 12.32	16.28	15.93	95.79	2.90	32.12
Days to first flower	105.23 ± 0.38	82.23 – 119.29	9.26	9.25	99.77	20.03	19.04
Stem diameter (cm)	0.56 ± 0.03	0.40 - 0.72	18.12	16.83	86.21	0.18	32.18
Size of the flower (cm)	16.11 ± 0.46	13.29 - 20.43	11.26	10.70	90.27	3.37	20.93
Number of flowers per plant	4.06 ± 0.38	1.78 - 8.05	44.91	43.43	93.52	3.51	86.51
Tepal length (cm)	10.0 ± 0.29	7.48 - 12.45	13.47	13.00	93.18	2.61	25.86
Tepal width (cm)	3.21 ± 0.11	2.35 - 3.97	14.99	14.40	92.26	0.92	28.49
Duration of flowering (days)	13.95 ± 0.68	11.96 - 16.28	11.63	10.00	73.94	2.47	17.71
Bulb diameter (cm)	4.11 ± 0.28	3.16- 4.79	13.03	9.91	57.83	0.64	15.52
Weight of bulb (g)	25.56 ± 1.03	13.86 - 36.03	24.03	23.52	95.80	12.12	47.43
Number of bulblets/plant	0.96 ± 0.22	0.42 - 2.23	61.69	54.77	78.82	0.96	100.16
Weight of bulblet (g)	2.01 ± 0.33	0.62 - 3.10	35.41	29.22	68.07	1.00	49.66
Vase life (days)	6.74 ± 0.44	6.67 - 9.20	15.30	13.00	72.18	1.53	22.76

The genotypic coefficient of variability (GCV) revealed that high value of GCV were obtained for number of bulblet per plant (54.77 %) followed by number of flowers per plant (43.43 %) number of leaves/plant (37.68 %); moderate values of GCV were observed for characters such as weight of bulblet (29.22 %), weight of bulb (23.52 %), stem length (22.04 %), days to sprouting (20.25 %), leaf length (19.90 %), stem diameter (16.83 %), bud length (15.93 %) and low GCV values were observed for parameters like; per cent bulb sprouting (1.80 %), plant height (14.23 %), days to flower bud formation (11.62 %), days to first flower (9.25 %), size of the flower (10.70 %), tepal length (13.00 %), tepal width (14.40 %), duration of flowering (10.00 %), vase life (13.00 %) and bulb diameter (9.91 %).

In present study over Nauni location; for all the characters studied, phenotypic coefficients of variability (PCV) were higher in magnitude than genotypic coefficients of variability (GCV), though difference was less in majority of the cases. Thus, it showed that some of these traits were less influenced by environmental factors. Kumar (2013) in *Lilium*, Pratap and Rao (2006), Kumar *et al*. (2015) in gladiolus and Jhon (2006) in tulip also reported higher PCV than GCV for most of the characters. Coefficients of variability varied in magnitude from character to character (either low or moderate or high) indicating that there was a great diversity in the experimental material used. High GCV was recorded for number of bulblet per plant, number of flowers per plant and number of leaves/plant indicating these traits were little influenced by environment on the expression of characters and selection for improvement will be effective. Similar results have also been reported by Choudhary *et al*. (2012) and Kumar *et al.* (2010) in gladiolus.

4.1.2.2 Heritability

The estimates of heritability in broad sense give a measure of transmission of characters from one generation to another thus, giving an idea of heritable portion of variability and enabling the plant breeder in isolating the elite selection in the crop. Perusal of data in Table 4.1.2.24(a) indicates that high to moderate heritability with low heritability only for character per cent bulb sprouting (45.31 %) was recorded. High heritability estimates were recorded for parameters like; days taken for bulb sprout emergence (98.86 %), plant height (87.06 %), number of leaves/plant (99.29 %), leaf length (97.62 %), leaf width (95.22 %), stem length (99.00 %), days to flower bud formation (99.73 %), bud length (95.79 %), days to first flower (99.77 %), stem diameter (86.21 %), size of the flower (90.27 %), number of flowers per plant (93.52 %), tepal length (93.18 %), tepal width (92.26 %) and weight of bulb (95.80 %) and moderate heritability estimates were observed for duration of flowering (73.94 %), vase life (72.18 %), Bulb diameter (57.83 %), number of bulblet/plant (78.82 %) and weight of bulblet (68.07 %).

High value of heritability indicates that there is a very good scope for the improvement for these traits. Low heritability values suggest the involvement of environmental component in the expression of character thereby direct selection of a particular character would be futile exercise; hence indirect selection needs to be adopted.

In present study, high estimates of heritability were obtained for all the characters except per cent bulb sprouting. These results are in agreement with the earlier findings of Negi *et al*. (1982), Singh and Singh (1983) & Lal *et al*. (1985) in gladiolus; Jhon *et al*. (2006) in tulip and Dhiman *et al*. (2015b) in *Lilium*.

4.1.2.3 Genetic advance and genetic gain

High heritability estimates along with high genetic advance as per cent of mean will be more useful than heritability alone to know the ultimate effect of selection. Perusal of data in Table 4.1.2.24(a) revealed that high heritability coupled with moderate genetic advance was observed for number of leaves/plant (37.40 %) suggesting the involvement dominant and epistatic gene action and these traits can be improved through hybridization.

Kumar (2013) also reported high heritability with moderate genetic advance as per cent of mean for number of leaves/ plant, flower diameter, bud diameter, petal breadth and bulb height among different Asiatic *Lilium* hybrids.

In the present study low genetic advance was recorded for most of the parameters. High heritability along with low genetic advance observed in traits *viz*., days taken for bulb sprout emergence (2.47 %), leaf length (4.16 %), leaf width (1.26 %), stem length (23.04 %), days to flower bud formation (16.94 %), bud length (2.90 %), days to first flower (20.03 %), stem diameter (0.18 %), size of the flower (3.37 %), number of flowers/plant (3.51 %), tepal length (2.61 %), tepal width (0.92 %) and weight of bulb (12.12 %) indicating that high heritability of these characters is purely governed by favourable environmental conditions and selection of such traits may not be rewarding.

High heritability along with low genetic advance for days to first flower has also been reported by Dhiman *et al*. (2015b) in Asiatic hybrid lily and Bhatia *et al*. (2017) in tulip.

Moderate heritability with highest genetic gain (100.16 %) was recorded for the character number of bulblet/plant. High heritability along with high genetic gain was observed for the traits like; number of leaves per plant (77.35 %), leaf width (59.61 %) and number of flowers per plant (86.51 %) indicating the involvement of both additive and non-additive gene action signifying that simple selection will serve the purpose of selecting better genotypes. High heritability along with low genetic gain was recorded for traits like; days to flower bud formation (23.90 %), days to first flower (19.04 %) and size of the flower (20.93 %) indicating that the selection for these characters would not be effective for improvement.

4.2.1 Correlation Studies

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. In the present study, the correlation coefficients among the different characters were worked out at phenotypic and genotypic levels. The phenotypic and genotypic correlation coefficients among all the combinations of different pairs of characters studied were computed for pooled data of two years of two locations separately and further the pooled analysis of data of environments (E_1, E_2, E_3 and E_4) carried out. The results pertaining to different characters with respect to phenotypic and genotypic correlation coefficients for different plant characters as studied over Nauni location, Katrain location and their pooled analysis has been presented in Table 4.2.24(b), Table 4.2.25(b) and Table 4.2.26(b), respectively.

4.2.1.1 Phenotypic correlations

i) Days taken for bulb sprout emergence

Analysis of pooled data presented in Table 4.2.24(b) showed significant positive correlation of days taken for bulb sprout emergence with leaf width (0.72), days to flower bud formation (0.65), bud length (0.51), days to first flower (0.63), size of the flower (0.40), tepal length (0.36), tepal width (0.34) and vase life (0.32) whereas non-significant positive correlation with plant height (0.23), stem length (0.23) and weight of bulblet (0.22) was also recorded. Characters such as number of leaves/plant (-0.30), leaf length (-0.55), number of flower/plant (-0.28), bulb diameter (-0.61) and weight of bulb (-0.47) observed significantly negative correlation with days taken for bulb sprout emergence.

ii) Per cent bulb sprouting

In case of per cent bulb sprouting, only leaf length parameter (0.27) exhibited significant positive correlation while rest of other parameters like; days taken for bulb sprout emergence (0.16), plant height (0.16), number of leaves/plant (0.16), leaf width (0.08), stem length (0.19), bud length (0.07), number of flowers/plant (0.17), duration of flowering (0.16), bulb diameter (0.13), weight of bulb (0.001), number of bulblets/plant (0.002), weight of bulblet (0.09) and vase life (0.05) recorded positive non significant correlation with per cent bulb sprouting while characters such as days taken for bulb sprout emergence (-0.03), days to flower bud formation (-0.05), days to first flower (-0.09), stem diameter (-0.03), size of the flower (-0.01), tepal length (-0.06) and tepal width (-0.15) observed negative non significant correlation with per cent bulb sprouting.

iii) Plant height

Highly significant positive correlation of plant height was recorded with number of leaves/plant (0.60), leaf length (0.44), stem length (0.95), bud length (0.29) and number of flowers/plant (0.68) while negative significant correlation was observed with duration of flowering (-0.34). Other parameters like; days taken for bulb sprout emergence (0.23), per cent bulb sprouting (0.16), days to flower bud formation (0.06), days to first flower (0.16), size of the flower (0.11), tepal length (0.14), bulb diameter (0.02), weight of bulb (0.21), weight of bulblet (0.19) and vase life (0.10) recorded positive non significant while leaf width (-0.12), stem diameter (-0.05), tepal width (-0.18) and number of bulblets/plant (-0.03) observed negative non-significant correlation with plant height.

iv) Number of leaves/plant

Number of leaves per plant recorded significant positive correlation with plant height (0.60), leaf length (0.44), stem length (0.59), number of flowers per plant (0.87), bulb diameter (0.32), weight of bulb (0.60), number of bulblet per plant (0.30) and significant negative correlation with days taken for bulb sprout emergence (-0.30), leaf width (-0.61), days to flower bud formation (-0.51), days to first flower (-0.37), size of the flower (-0.33), tepal length (-0.29) and tepal width (-0.48). Characters such as stem diameter (0.13), weight of bulblet (0.24) and vase life (0.02) exhibited non significant positive correlation while bud length (-0.23) and duration of flowering (-0.03) observed negative non significant correlation with number of leaves per plant.

v) Leaf length

Significant positive correlation of leaf length was observed with per cent bulb sprouting (0.27), plant height (0.44), number of leaves/plant (0.73), stem length (0.48), number of flowers per plant (0.70), bulb diameter (0.60), weight of bulb (0.57) along with significant negative correlation with days taken for bulb sprout emergence (-0.55), leaf width (-0.64), days to flower bud formation (-0.63), days to first flower (-0.48), vase life (-0.33). On the other hand characters such as stem diameter (0.21), number of bulblets/plant (0.25) and weight of bulblet (0.02) observed non significant positive correlation and bud length (-0.07), size of the flower (-0.20), tepal length (-0.16), tepal width (-0.23) and duration of flowering (-0.05) recorded non significant negative correlation with leaf length.

vi) Leaf width

This trait showed significant positive correlation with characters such as days taken for bulb sprout emergence (0.72), days to flower bud formation (0.58), bud length (0.47), days to first flower (0.48), size of the flower (0.58), tepal length (0.46), tepal width (0.54) and vase life (0.42) along with significant negative correlation with number of leaves/plant (-0.61), leaf length (-0.64) number of flowers/plant (-0.42), bulb diameter (-0.49) and weight of bulb (-0.45) (Table 4.2.24b).

vii) Stem length

Significant positive correlation of this trait was recorded with plant height (0.95), number of leaves/plant (0.59), leaf length (0.48), bud length (0.31) and number of flowers/plant (0.70) while this trait showed significant negative correlation with character duration of flowering (-0.35) only.

viii) Days to flower bud formation

It is evident from Table 4.2.24(b) that character days to flower bud formation showed significant positive correlation with days taken for bulb sprout emergence (0.65), leaf width (0.58), bud length (0.39), days to first flower (0.94), size of the flower (0.41) and tepal length (0.40) while significant negative correlation was recorded with number of leaves/plant (-0.51), leaf length (-0.63), stem diameter (-0.54), number of flowers/plant (-0.32), bulb diameter (-0.53) and weight of bulb (-0.61).

ix) Bud length

Character bud length exhibited significant positive correlation with days taken for bulb sprout emergence (0.51), plant height (0.29), leaf width (0.47), stem length (0.31), days to flower bud formation (0.39), days to first flower (0.31), size of the flower (0.84), tepal length (0.88) and tepal width (0.64) whereas this trait observed negative significant correlation with number of bulblets/plant (-0.27)

x) Days to first flower

It is clearly evident from the table that days to first flower was significantly positively correlated with days taken for bulb sprout emergence (0.63), leaf width (0.48), days to flower bud formation (0.94), bud length (0.31), size of the flower (0.29) and tepal length (0.27) while traits such as number of leaves/plant (-0.37), leaf length (-0.48), stem diameter (-0.59), bulb diameter (-0.46) and weight of the bulb (-0.45) recorded significant negative correlation with this trait.

xi) Stem diameter

Stem diameter showed significant positive correlation with characters such as tepal width (0.36), bulb diameter (0.33) and weight of bulb (0.35) while traits such as days to flower bud formation (-0.54) and days to first flower (-0.59) recorded negative significant correlation with stem diameter.

xii) Size of the flower

This character recorded significantly high positive correlation with days taken for bulb sprout emergence (0.40), leaf width (0.58), days to flower bud formation (0.41), bud length (0.84), days to first flower (0.29), tepal length (0.82), tepal width (0.65), duration of flowering (0.32) and vase life (0.29) whereas characters number of leaves/plant (-0.33) and weight of bulb (-0.29) observed significant negative correlation with this trait.

xiii) Number of flowers/plant

This trait recorded significant positive phenotypic correlation with plant height (0.68), number of leaves/plant (0.87), leaf length (0.70), stem length (0.70), bulb diameter (0.27), weight of bulb (0.44) and number of bulblets/plant (0.30) while characters such as days taken for bulb sprout emergence (-0.28), leaf width (-0.42), days to flower bud formation (-0.32) and tepal width (-0.34) observed significant negative correlation with number of flowers/plant.

xiv) Tepal length

This character recorded significantly high positive correlation with days taken for bulb sprout emergence (0.36), leaf width (0.46), days to flower bud formation (0.40), bud length (0.88), days to first flower (0.27), size of the flower (0.82), tepal width (0.71) and duration of flowering (0.29) while number of leaves/plant (-0.29) recorded negative significant correlation with tepal length.

xv) Tepal width

Tepal width recorded significant positive correlation with days taken for bulb sprout emergence (0.34), leaf width (0.54), bud length (0.64), stem diameter (0.36) and size of the flower (0.65). Significant negative correlation was observed with number of leaves/plant (-0.48) and number of flowers/plant (-0.34).

xvi) Duration of flowering

Flowering duration observed significant positive correlation with size of the flower (0.32) and tepal length (0.29) while significant negative correlation of duration of flowering was observed with plant height (-0.34) and stem length (-0.35) as presented in Table 4.2.24(b).

xvii) Bulb diameter

This trait recorded significant positive correlation with number of leaves/plant (0.32), leaf length (0.60), stem diameter (0.33), number of flowers/plant (0.27) and weight of bulb (0.47) while characters such as days taken for bulb sprout emergence (-0.61), leaf width (-0.49), days to flower bud formation (-0.53), days to first flower (-0.46) and vase life (-0.44) observed significant negative correlation with this trait.

xviii) Weight of bulb

Characters such as number of leaves/plant (0.30), leaf length (0.57), stem diameter (0.35), number of flowers/plant (0.44) and bulb diameter (0.47) recorded significantly positive correlation while traits such as days taken for bulb sprout emergence (-0.47), leaf width (-0.45), days to flower bud formation (-0.61), days to first flower (-0.45) and size of the flower (-0.29) recorded significantly negative correlation with weight of the bulb.

xix) Number of bulblet/plant

Number of bulblet/plant observed significantly positive correlation with number of leaves/plant (0.30) and number of flowers/plant (0.30) while bud length (-0.27) observed significant negative correlation with this trait.

xx) Weight of bulblet

Weight of bulblet observed non-significant correlation with all the other characters.

xxi) Vase life

Days taken for bulb sprout emergence (0.32), leaf width (0.42) and size of the flower (0.29) observed significantly positive correlation with vase life of the flowers while leaf length (-0.33) and bulb diameter (-0.44) exhibited significantly negative correlation with vase life.

4.2.1.2 Genotypic correlations

i) Days taken for bulb sprout emergence

Highly significant positive correlation (Table 4.2.24b) of character days taken for bulb sprout emergence was recorded with leaf width (0.74), days to flower bud formation (0.65), bud length (0.52), days to first flower (0.63), size of the flower (0.42), tepal length (0.38), tepal width (0.36), weight of bulblet (0.28) and vase life (0.37) while significant negative correlation was recorded with number of leaves per plant (-0.38), leaf length (-0.56), number of flowers/plant (-0.29), bulb diameter (-0.81) and weight of bulb (-0.48).

ii) Per cent bulb sprouting

Per cent bulb sprouting observed significantly positively correlated with plant height (0.31), leaf length (0.32), stem length (0.32) and bulb diameter (0.33) whereas rest of all the traits recorded non significant correlation with per cent bulb sprouting.

Table 4.2.24(b): Pooled analysis of coefficients of correlation of phenotypic (above diagonal) and genotypic (below diagonal) among different characters in *Lilium* genotypes under Nauni conditions

*C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	-	-0.02	0.23	-0.30**	-0.55**	0.72**	0.23	0.65**	0.51**	0.63**	-0.06	0.40**	-0.28*	0.36**	0.34*	-0.09	-0.61**	-0.47**	-0.20	0.22	0.32*
2	-0.03	-	0.16	0.16	0.27*	0.08	0.19	-0.05	0.07	-0.09	-0.03	-0.01	0.17	-0.06	-0.15	0.16	0.13	0.001	0.002	0.09	0.05
3	0.24	0.31*	-	0.60**	0.44**	-0.12	0.95**	0.06	0.29*	0.16	-0.05	0.11	0.68**	0.14	-0.18	-0.34*	0.02	0.21	-0.03	0.19	0.10
4	-0.38**	0.20	0.65**	-	0.73**	-0.61**	0.59**	-0.51**	-0.23	-0.37**	0.13	-0.33*	0.87**	-0.29*	-0.48**	-0.03	0.32*	0.60**	0.30*	0.24	0.02
5	-0.56**	0.32*	0.48**	0.74**	-	-0.64**	0.48**	-0.63**	-0.07	-0.48**	0.21	-0.20	0.70**	-0.16	-0.23	-0.05	0.60**	0.57**	0.25	0.02	-0.33*
6	0.74**	0.10	-0.12	-0.62**	-0.67**	-	-0.08	0.58**	0.47**	0.48**	0.04	0.58**	-0.42**	0.46**	0.54**	0.14	-0.49**	-0.45**	-0.26	0.19	0.42**
7	0.23	0.32*	1.01**	0.60**	0.49**	-0.09	-	0.05	0.31*	0.15	0.001	0.13	0.70**	0.17	-0.14	-0.35**	0.01	0.24	0.02	0.18	0.14
8	0.65**	-0.07	0.06	-0.51**	-0.64**	0.60**	0.05	-	0.39**	0.94**	-0.54**	0.41**	-0.32*	0.40**	0.14	-0.04	-0.53**	-0.61**	-0.02	0.16	0.22
9	0.52**	0.14	0.33*	-0.24	-0.06	0.49**	0.32*	0.40**	-	0.31*	0.20	0.84**	-0.06	0.88**	0.64**	0.23	-0.15	-0.19	-0.27*	0.04	0.09
10	0.63**	-0.14	0.17	-0.37**	-0.48**	0.50**	0.15	0.94**	0.32*	-	-0.59**	0.29*	-0.21	0.27*	0.02	-0.10	-0.46**	-0.45**	0.09	0.24	0.20
11	-0.05	0.04	-0.03	0.15	0.24	0.03	0.00	-0.58**	0.21	-0.63**	-	0.14	0.14	0.25	0.36**	0.20	0.33*	0.35**	-0.18	0.16	-0.01
12	0.42**	0.07	0.15	-0.35**	-0.21	0.63**	0.14	0.43**	0.89**	0.31*	0.14	-	-0.13	0.82**	0.65**	0.32*	-0.21	-0.29*	-0.26	0.08	0.29*
13	-0.29*	0.26	0.74**	0.90**	0.75**	-0.44**	0.72**	-0.33*	-0.07	-0.22	0.17	-0.15	-	-0.11	-0.34*	-0.13	0.27*	0.44**	0.30*	0.22	0.04
14	0.38**	-0.02	0.16	-0.30*	-0.16	0.49**	0.18	0.42**	0.93**	0.29*	0.28*	0.89**	-0.13	-	0.71**	0.29*	-0.12	-0.15	-0.19	0.14	0.10
15	0.36**	-0.17	-0.24	-0.50**	-0.24	0.56**	-0.15	0.15	0.67**	0.02	0.401**	0.74**	-0.39**	0.73**	-	0.27	-0.11	-0.14	-0.26	0.05	0.04
16	-0.11	0.16	-0.37**	-0.05	-0.07	0.13	-0.41**	-0.04	0.31*	-0.11	0.20	0.39**	-0.15	0.30*	0.32*	-	0.08	0.17	0.13	0.26	0.13
17	-0.81**	0.33*	-0.05	0.41**	0.80**	-0.65**	0.00	-0.70**	-0.26	-0.62**	0.37**	-0.31*	0.36**	-0.16	-0.24	0.17	-	0.47**	0.06	0.02	-0.44**
18	-0.48**	-0.09	0.23	0.62**	0.58**	-0.48**	0.24	-0.62**	-0.20	-0.46**	0.38**	-0.32*	0.47**	-0.15	-0.14	0.17	0.58**	-	0.17	0.24	-0.13
19	-0.22	0.03	-0.05	0.34*	0.29*	-0.29*	0.02	-0.01	-0.30*	0.10	-0.21	-0.35**	0.33*	-0.21	-0.27	0.21	0.13	0.19	-	0.26	0.12
20	0.28*	0.11	0.20	0.29*	0.00	0.24	0.24	0.19	0.07	0.29*	0.20	0.15	0.30*	0.16	0.08	0.42**	0.10	0.30*	0.34*	-	0.17
21	0.37**	0.00	0.20	0.03	-0.38**	0.51**	0.17	0.26	0.11	0.24	0.01	0.35*	0.05	0.13	0.02	0.11	-0.68**	-0.16	0.14	0.31*	-

*Significant at 5% level of significance
**Significant at 1% level of significance

*C : Characters=1: Days taken for bulb sprout emergence; 2: Per cent bulb sprouting (%); 3: Plant height (cm); 4: Number of leaves/plant; 5: Leaf length (cm); 6: Leaf width (cm); 7: Stem length (cm); 8: Days to flower bud formation ; 9: Bud length (cm); 10: Days to first flower; 11: Stem diameter (cm); 12: Size of the flower (cm); 13: Number of flowers/plant; 14: Tepal length (cm); 15: Tepal width (cm); 16: Duration of flowering (days); 17: Bulb diameter (cm); 18: Weight of bulb (g); 19: Number of bulblets/plant; 20: Weight of bulblet (g); 21: Vase life (days)

iii) Plant height

Plant height recorded significant positive correlation with per cent bulb sprouting (0.31), number of leaves per plant (0.65), leaf length (0.48), stem length (1.01), bud length (0.33) and number of flowers/plant (0.74) whereas duration of flowering (-0.37) recorded significant negative correlation with plant height.

iv) Number of leaves/plant

Number of leaves per plant recorded significant positive correlation with plant height (0.65), leaf length (0.74), stem length (0.60), number of flowers/plant (0.90), bulb diameter (0.41), weight of bulb (0.62), number of bulblets/plant (0.34) and weight of bulblet (0.29) while negative significant correlation was recorded with days taken for bulb sprout emergence (-0.38), leaf width (-0.62), days to flower bud formation (-0.51), days to first flower (-0.37), size of the flower (-0.35), tepal length (-0.30) and tepal width (-0.50).

v) Leaf length

Significant positive correlation of leaf length was observed with per cent bulb sprouting (0.32), plant height (0.48), number of leaves/plant (0.74), stem length (0.49), number of flowers/plant (0.75), bulb diameter (0.80), weight of bulb (0.58) and number of bulblets/plant (0.29) whereas traits such as days taken for bulb sprout emergence (-0.56), leaf width (-0.67), days to flower bud formation (-0.64), days to first flower (-0.48) and vase life (-0.38) observed negative significant correlation with leaf length.

vi) Leaf width

This trait showed significant positive correlation with characters such days taken for bulb sprout emergence (0.74) days to flower bud formation (0.60), bud length (0.49), days to first flower (0.50), size of the flower (0.63), tepal length (0.49), tepal width (0.56) and vase life (0.51) whereas significant negative correlation was recorded with traits such as number of leaves/plant (-0.62), leaf length (-0.67), number of flowers per plant (-0.44), bulb diameter (-0.65), weight of bulb (-0.48) and number of bulblets/plant (-0.29) as shown in Table 4.2.24(b).

vii) Stem length

Significant positive correlation of this trait was recorded with per cent bulb sprouting (0.32), plant height (1.01), number of leaves/plant (0.60), leaf length (0.49), bud length

(0.32), number of flowers/plant (0.72) while character duration of flowering (-0.41) exhibited negative significant correlation with stem length.

viii) Days to flower bud formation

It is evident from data presented in Table 4.2.24(b) that character days to flower bud formation showed significant positive correlation with days taken for bulb sprout emergence (0.65),leaf width (0.60), bud length (0.40), days to first flower (0.94), size of the flower (0.43) and tepal length (0.42) while significant negative correlation was recorded with number of leaves/plant (-0.51), leaf length (-0.64), stem diameter (-0.58), number of flowers/plant (-0.33), bulb diameter (-0.70) and weight of bulb (-0.62).

ix) Bud length

Character bud length exhibited significant positive correlation with days taken for bulb sprout emergence (0.52), plant height (0.33), leaf width (0.49), stem length (0.32), days to flower bud formation (0.40), days to first flower (0.32), size of the flower (0.89), tepal length (0.93), tepal width (0.67) and duration of flowering (0.31) whereas this trait observed negative significant correlation with number of bulblets/plant (-0.30).

x) Days to first flower

It is clearly evident from the Table 4.2.24(b) that days to first flower was significantly positively correlated with days taken for bulb sprout emergence (0.63), leaf width (0.50), days to flower bud formation (0.94), bud length (0.32), size of the flower (0.31) tepal length (0.29) and weight of bulblet (0.29) while traits such as number of leaves per plant (-0.37), leaf length (-0.48), stem diameter (-0.63), bulb diameter (-0.62) and weight of the bulb (-0.46) recorded significant negative correlation with this trait.

xi) Stem diameter

Stem diameter showed significant positive correlation with characters such as tepal length (0.28), tepal width (0.40) bulb diameter (0.37) and weight of bulb (0.38) while traits such as days to flower bud formation (-0.58) and days to first flower (-0.63) recorded negative significant correlation with stem diameter.

xii) Size of the flower

Significantly high positive correlation of size of the flower was recorded with days taken for bulb sprout emergence (0.42), leaf width (0.63), tepal length (0.89), tepal width

(0.74), duration of flowering (0.39) and vase life (0.35) whereas characters such as number of leaves/plant (-0.35), bulb diameter (-0.31), weight of bulb (-0.32) and number of bulblets/plant (-0.35) observed significant negative correlation with this trait

xiii) Number of flowers/plant

Number of flowers per plant recorded significant positive correlation with plant height (0.74), number of leaves per plant (0.90), leaf length (0.75), stem length (0.72), days to flower bud formation (0.43), bud length (0.89), days to first flower (0.31), bulb diameter (0.36), weight of bulb (0.47), number of bulblets/plant (0.33) and weight of bulblet (0.30) while characters such as days taken for bulb sprout emergence (-0.29), days to flower bud formation (-0.33), leaf width (-0.44) and tepal width (-0.39) observed significant negative correlation with number of flowers/plant

xiv) Tepal length

Tepal length recorded significantly high positive correlation with days taken for bulb sprout emergence (0.38), leaf width (0.49), days to flower bud formation (0.42), bud length (0.93), days to first flower (0.29), stem diameter (0.28), size of the flower (0.89), tepal width (0.73), duration of flowering (0.30) while characters number of leaves/plant (-0.30) recorded negative significant correlation.

xv) Tepal width

Significant positive correlation was associated with characters such as days taken for bulb sprout emergence (0.36), leaf width (0.56), bud length (0.67), stem diameter (0.40), size of the flower (0.74), tepal length (0.73) and duration of flowering (0.32) while traits such as number of leaves/plant (-0.50) and number of flowers/plant (-0.39) showed significant negative correlation with tepal width while rest of all the characters exhibited non significant correlation with tepal width.

xvi) Duration of flowering

Characters such as bud length (0.31), size of the flower (0.39), tepal length (0.30), tepal width (0.32) and weight of bulblet (0.42) recorded significant positive correlation while plant height (-0.37) and stem length (-0.41) recorded significant negative correlation with duration of flowering while rest of all the characters exhibited non significant correlation with duration of flowering.

xvii) Bulb diameter

This trait recorded significant positive correlation with per cent bulb sprouting (0.33), number of leaves per plant (0.41), leaf length (0.80), stem diameter (0.37), number of flowers per plant (0.36) and weight of bulb (0.58) while characters such as days taken for bulb sprout emergence (-0.81), leaf width (-0.65), days to flower bud formation (-0.70), days to first flower (-0.62), size of the flower (-0.31) and vase life (-0.68) observed negative significant correlation with this trait.

xviii) Weight of bulb

Significant positive correlation of weight of bulb was recorded with number of leaves/plant (0.62), leaf length (0.58), stem diameter (0.38), number of flowers/plant (0.47), bulb diameter (0.58) and weight of bulblet (0.30) while characters such as days taken for bulb sprout emergence (-0.48), leaf width (-0.48), days to flower bud formation (-0.62), days to first flower (-0.46) and size of the flower (-0.32) recorded negative significant correlation with this trait (Table 4.2.24b).

xix) Number of bulblet/plant

Number of bulblet/plant recorded significant positive correlation with characters such as number of leaves per plant (0.34), leaf length (0.29), number of flowers/plant (0.33) and weight of bulblet (0.34) while negative significant correlation was recorded with leaf width (-0.29), bud length (-0.30) and size of the flower (-0.35).

xx) Weight of bulblet

This trait recorded significant positive correlation with plant height (0.28), number of leaves/plant (0.29), days to first flower (0.29), number of flowers/plant (0.30), duration of flowering (0.42), weight of bulb (0.30) and number of bulblets/plant (0.34) while all the other characters recorded non significant correlation with weight of bulblet.

xxi) Vase life

Vase life recorded significant positive correlation with days taken for bulb sprout emergence (0.37), leaf width (0.51), size of the flower (0.35) and weight of bulblet (0.31) while significant negative correlation with leaf length (-0.38) and bulb diameter (-0.68).

Positive correlations ensure simultaneous improvement in one or more variables and negative correlations bring out the need to obtain a compromise between the desirable traits.

Estimates of coefficient of correlation worked out at genotypic level over Nauni location revealed the strong positive and significant correlation of number of flowers per plant with plant height, number of leaves per plant, leaf length, stem length, days to flower bud formation, bud length, days to first flower, bulb diameter, weight of bulb, number of bulblets/plant and weight of bulblet. Balaram and Janakiram (2009) also reported positive correlation between number of leaves/plant and florets/spike in gladiolus. More photosynthates are made available through more number of leaves which in turn improved the number of flowers/plant.

Plant height which is an important trait for use as cut flower had significant and positive correlation with per cent bulb sprouting, number of leaves per plant, leaf length, stem length, bud length and number of flowers/plant which could be improved with the improvement in any of these characters. These results are in close agreement with Dhiman *et al*. (2015b) in *Lilium* and Bhatia *et al*. (2017) in tulip.

Bulb diameter recorded significant positive correlation with per cent bulb sprouting, number of leaves per plant, leaf length, stem diameter, number of flowers per plant and weight of bulb. Likewise weight of bulb recorded positively correlated with number of leaves/plant, leaf length, stem diameter, number of flowers/plant, bulb diameter and weight of bulblet indicating improvement in size and weight of bulb could be achieved through selection of any of these traits. Similar results were also reported by Kumar (2013) in *Lilium*.

4.3 PATH COEFFICIENT ANALYSIS

The correlation studies could only indicate the overall relationship of independent traits with dependent trait but does not provide cause and effect of relationship. Using path analysis, it is possible to resolve the correlations, which provides clue about such relationship. Path coefficient analysis depicts the effects of different independent characters individually and in combination with other characters on the expression of different characters on flower yield i.e., number of flowers per plant. The data on path coefficient analysis at genotypic level showing the direct and indirect effects of significant characters over number of flower stems per plant studied under Nauni location, Katrain location and pooled analysis over four environments (E_1, E_2, E_3 and E_4) have been presented in Table 4.3.24(c), Table 4.3.25(c) and Table 4.3.26(c), respectively. In the given table, the diagonal values show the direct effect of different characters on the number of flower per plant.

Table 4.3.24(c): Estimates of direct and indirect effects of different characters on number of flowers per plant among *Lilium* genotypes under Nauni conditions

*C	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
1	**2.94**	-0.01	0.11	-0.11	-2.71	-0.33	-0.85	3.77	-1.08	-2.72	0.02	0.57	0.38	-0.32	0.13	0.31	-0.92	0.12	0.05	0.35
2	-0.10	**0.15**	0.14	0.06	1.57	-0.04	-1.17	-0.40	-0.28	0.62	-0.02	0.09	-0.02	0.15	-0.20	-0.13	-0.17	-0.02	0.02	0.001
3	0.70	0.05	**0.45**	0.18	2.35	0.05	-3.70	0.33	-0.68	-0.72	0.01	0.20	0.16	0.21	0.46	0.02	0.44	0.03	0.04	0.18
4	-1.11	0.03	0.29	**0.28**	3.59	0.28	-2.20	-2.94	0.49	1.61	-0.06	-0.48	-0.30	0.44	0.06	-0.16	1.18	-0.19	0.06	0.02
5	-1.64	0.05	0.22	0.21	**4.86**	0.30	-1.81	-3.70	0.13	2.09	-0.10	-0.29	-0.16	0.21	0.08	-0.30	1.11	-0.16	0.001	-0.35
6	2.18	0.01	-0.05	-0.18	-3.25	**-0.45**	0.32	3.43	-1.01	-2.14	-0.01	0.86	0.49	-0.49	-0.16	0.25	-0.92	0.16	0.05	0.47
7	0.68	0.05	0.45	0.17	2.39	0.04	**-3.68**	0.27	-0.66	-0.65	0.001	0.19	0.18	0.13	0.51	0.001	0.46	-0.01	0.05	0.16
8	1.92	-0.01	0.03	-0.15	-3.11	-0.27	-0.17	**5.78**	-0.83	-4.06	0.24	0.59	0.42	-0.13	0.05	0.27	-1.19	0.01	0.04	0.24
9	1.54	0.02	0.15	-0.07	-0.31	-0.22	-1.17	2.33	**-2.06**	-1.37	-0.09	1.21	0.94	-0.59	-0.38	0.10	-0.38	0.16	0.01	0.10
10	1.85	-0.02	0.07	-0.11	-2.35	-0.22	-0.56	5.42	-0.65	**-4.32**	0.26	0.42	0.29	-0.02	0.14	0.24	-0.89	-0.06	0.06	0.22
11	-0.16	0.01	-0.01	0.04	1.16	-0.02	0.01	-3.36	-0.44	2.73	**-0.41**	0.19	0.28	-0.35	-0.24	-0.14	0.73	0.11	0.04	0.00
12	1.23	0.01	0.07	-0.10	-1.03	-0.28	-0.52	2.50	-1.82	-1.33	-0.06	**1.37**	0.90	-0.65	-0.48	0.12	-0.62	0.19	0.03	0.32
14	1.12	0.001	0.07	-0.09	-0.76	-0.22	-0.65	2.43	-1.92	-1.24	-0.11	1.22	**1.01**	-0.65	-0.37	0.06	-0.29	0.12	0.03	0.12
15	1.06	-0.03	-0.11	-0.14	-1.17	-0.25	0.54	0.85	-1.38	-0.08	-0.17	1.01	0.74	**-0.88**	-0.39	0.09	-0.27	0.15	0.02	0.02
16	-0.32	0.02	-0.17	-0.02	-0.33	-0.06	1.52	-0.24	-0.63	0.49	-0.08	0.53	0.31	-0.28	**-1.23**	-0.07	0.33	-0.11	0.08	0.10
17	-2.37	0.05	-0.02	0.12	3.88	0.29	-0.01	-4.06	0.54	2.66	-0.15	-0.43	-0.16	0.21	-0.21	**-0.38**	1.10	-0.07	0.02	-0.64
18	-1.41	-0.01	0.10	0.18	2.81	0.21	-0.89	-3.58	0.41	2.01	-0.16	-0.44	-0.15	0.13	-0.21	-0.22	**1.91**	-0.10	0.06	-0.15
19	-0.65	0.001	-0.02	0.10	1.42	0.13	-0.08	-0.07	0.62	-0.44	0.09	-0.48	-0.21	0.23	-0.26	-0.05	0.36	**-0.55**	0.07	0.13
20	0.82	0.02	0.09	0.08	0.02	-0.11	-0.87	1.12	-0.14	-1.24	-0.08	0.20	0.16	-0.07	-0.51	-0.04	0.58	-0.18	**0.20**	0.29
21	1.09	0.001	0.09	0.01	-1.82	-0.23	-0.64	1.49	-0.23	-1.03	0.001	0.47	0.13	-0.02	-0.14	0.26	-0.31	-0.08	0.06	**0.93**

(Residual effect: 0.058)

4.3.1 Path coefficient analysis over Nauni location

The pooled data over Nauni location as presented in Table 4.3.24 (c) revealed days to flower bud formation (5.78) had very high positive direct effect on the number of flowers per plant followed by leaf length (4.86), days taken for bulb sprout emergence (2.94) weight of bulb (1.91), size of the flower (1.37), tepal length (1.01), vase life (0.93), plant height (0.45), number of leaves per plant (0.28), weight of bulblet (0.20) and per cent bulb sprouting (0.15). In contrast, negative direct effect on number of flowers per plant was observed from parameters such as bulb diameter (-0.38), stem diameter (-0.41), leaf width (-0.45), number of bulblets per plant (-0.55), tepal width (-0.88), duration of flowering (-1.23), bud length (-2.06), stem length (-3.68) and days to first flower (-4.32).

The perusal of data presented in Table 4.3.24(c) also revealed that days taken for bulb sprout emergence (2.94) had very high positive direct effect on number of flowers per plant along with indirect positive effect through characters such as days to flower bud formation (3.77) followed by size of the flower (0.57), tepal length (0.38), vase life (0.35), bulb diameter (0.31), duration of flowering (0.13), number of bulblets per plant (0.12), plant height (0.11), weight of bulblet (0.05) and stem diameter (0.02) which have masked the negative indirect effect on number of flowers/plant caused by the traits like; per cent bulb sprouting (-0.01), number of leaves per plant (-0.11), tepal width (-0.32), leaf width (-0.33), stem length (-0.85), weight of bulb (-0.92), bud length (-1.08), leaf length (-2.71) and days to first flower (-2.72) which have enabled the trait to establish positive and significant association.

Per cent bulb sprouting had low positive direct effect (0.15) on number of flowers/plant associated with strong positive indirect effect through leaf length (1.57), days to first flower (0.62), tepal width (0.15), plant height (0.14), size of the flower (0.09), number of leaves per plant (0.06), weight of bulblet (0.02) and vase life (0.001) which have masked the negative indirect effect on number of flowers/plant caused through number of bulblets per plant (-0.02), tepal length (-0.02), stem diameter (-0.02), leaf width (-0.04), days taken for bulb sprout emergence (-0.10), bulb diameter (-0.13), weight of bulb (-0.17), duration of flowering (-0.20), bud length (-0.28), days to flower bud formation (-0.40) and stem length (-1.17) which have enabled the trait to establish positive and significant association.

Trait plant height (0.45) exhibited high positive direct effect on number of flowers/plant coupled with strong positive indirect effect through leaf length (2.35), days to first flower (0.62), weight of bulb (0.44), days to flower bud formation (0.33), tepal width (0.21), size of the flower (0.20), vase life (0.18), number of leaves per plant (0.18), tepal length (0.16), leaf width (0.05), per cent bulb sprouting (0.05), weight of bulblet (0.04), number of bulblets per plant (0.03), bulb diameter (0.02) and stem diameter (0.01) which have masked the negative indirect effect on number of flowers/plant caused through traits such as bud length (-0.68), days to first flower (-0.72) and stem length (3.70) which have enabled the trait to establish positive and significant association.

As far as direct and indirect effect of number of leaves/plant is concerned, this trait exhibited moderate positive direct effect (0.28) on number of flowers/plant along with maximum positive indirect effect through leaf length (3.59) followed by days to first flower (1.61), weight of bulb (1.18), bud length (0.49), tepal width (0.44), plant height (0.29), leaf width (0.28), weight of bulblet (0.06), duration of flowering (0.06), per cent bulb sprouting (0.03) and vase life (0.02) which have masked the negative indirect effect on number of flowers/plant caused through traits such as days to flower bud formation (-2.94), stem length (-2.20), days taken for bulb sprout emergence (-1.11), size of the flower (-0.48), tepal length (-0.30), number of bulblets per plant (-0.19), bulb diameter (-0.16) and stem diameter (-0.06) which have enabled the trait to establish positive and significant association

Leaf length observed very high positive direct effect (4.86) on number of flowers/plant along with maximum positive indirect effect through days to first flower (2.09) followed by weight of bulb (1.11), leaf width (0.30), plant height (0.22), tepal width (0.21), number of leaves per plant (0.21), bud length (0.13), duration of flowering (0.08), per cent bulb sprouting (0.05) and weight of bulblet (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as stem diameter (-0.10), number of bulblets per plant (-0.16), tepal length (-0.16), size of the flower (-0.29), bulb diameter (-0.30), vase life (-0.35), days taken for bulb sprout emergence (-1.64), stem length (-1.81) and days to flower bud formation (-3.70) which have enabled the trait to establish positive and significant association.

Leaf width (-0.45) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through leaf length (-3.25) followed by days to first flower (-

2.14), bud length (-1.01), weight of bulb (-0.92), tepal width (-0.49), number of leaves per plant (-0.18), duration of flowering (-0.16), plant height (-0.05) and stem diameter (-0.01). However, higher magnitude of positive indirect effect of the trait through days to flower bud formation (3.43), days taken for bulb sprout emergence (2.18), size of the flower (0.86), tepal length (0.49), vase life (0.47), stem length (0.32), bulb diameter (0.25), number of bulblets per plant (0.16), weight of bulblet (0.05) and per cent bulb sprouting (0.01) nullified the negative direct and indirect effects of the trait.

Similarly character stem length (-3.68) also exhibited negligible negative direct effect on number of flowers/plant along with maximum negative indirect effect through bud length (-0.66) followed by days to first flower (-0.65) and number of bulblets per plant (-0.01). However, higher magnitude of positive indirect effect of the trait through leaf length (2.39), days taken for bulb sprout emergence (0.68), duration of flowering (0.51), weight of bulb (0.46), plant height (0.45), days to flower bud formation (0.27), size of the flower (0.19), tepal length (0.18), number of leaves per plant (0.17), vase life (0.16), tepal width (0.13), weight of bulblet (0.05), per cent bulb sprouting (0.05), leaf width (0.04), bulb diameter (0.001) and stem diameter (0.001) nullified the negative direct and indirect effects of the trait.

Days to flower bud formation exhibited very high positive direct effect (5.78) on number of flowers/plant along with positive indirect effect through days taken for bulb sprout emergence (1.92) followed by size of the flower (0.59), tepal length (0.42), bulb diameter (0.27), vase life (0.24), stem diameter (0.24), duration of flowering (0.05), weight of bulblet (0.04), plant height (0.03) and number of bulblets per plant (0.01) which have masked the negative indirect effect on number of flowers/plant caused through traits such as per cent bulb sprouting (-0.01), tepal width (-0.13), number of leaves per plant (-0.15), stem length (-0.17), leaf width (-0.27), bud length (-0.83), weight of bulb (-1.19), leaf length (-3.11) and days to first flower (-4.06) which have enabled the trait to establish positive and significant association (Table 4.3.24c).

Bud length (-2.06) had negligible negative direct effect on number of flowers/plant along with negative indirect effect through traits such as days to first flower (-1.37) followed by stem length (-1.17), tepal width (-0.59), duration of flowering (-0.38), weight of bulb (-0.38), leaf length (-0.31), leaf width (-0.22), stem diameter (-0.09) and number of leaves per plant (-0.07). On the other hand, higher magnitude of positive indirect effect of the trait through days to flower bud formation (2.33), days taken for bulb sprout emergence (1.54), size of the flower (1.21), tepal length (0.94), number of bulblets per plant (0.16), plant height (0.15), vase life (0.10), bulb diameter (0.10), per cent bulb sprouting (0.02) and weight of bulblet (0.01) nullified the negative direct and indirect effects of the trait.

Days to first flower (-4.32) had negligible negative direct effect on number of flowers/plant along with negative indirect effect through traits such as leaf length (-2.35) followed by weight of bulb (-0.89), bud length (-0.65), stem length (-0.56), leaf width (-0.22), number of leaves per plant (-0.11), number of bulblets per plant (-0.06), per cent bulb sprouting (-0.02) and tepal width (-0.02). However, higher magnitude of positive indirect effect of the trait through days to flower bud formation (5.42), days taken for bulb sprout emergence (1.85), size of the flower (0.42), tepal length (0.29), stem diameter (0.26), bulb diameter (0.24), vase life (0.22), duration of flowering (0.14), plant height (0.07) and weight of bulblet (0.06) nullified the negative direct and indirect effects of the trait.

Stem diameter (-0.41) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through traits such as days to flower bud formation(-3.36) followed by bud length (-0.44), tepal width (-0.35), duration of flowering (-0.24),days taken for bulb sprout emergence (-0.16), bulb diameter (-0.14), leaf width (-0.02) and plant height (-0.01). However, higher magnitude of positive indirect effect of the trait through days to first flower (2.73), leaf length (1.16), weight of bulb (0.73), tepal length (0.28), size of the flower (0.19), number of bulblets per plant (0.11), weight of bulblet (0.04), number of leaves per plant (0.04), stem length (0.01), per cent bulb sprouting (0.01) and vase life (0.001) nullified the negative direct and indirect effects of the trait.

Size of the flower (1.37) had strong positive direct effect on number of flowers/plant along with maximum positive indirect effect through days to flower bud formation (2.50) followed by days taken for bulb sprout emergence (1.23), tepal length (0.9), vase life (0.32), number of bulblets per plant (0.19), bulb diameter (0.12), plant height (0.07), weight of bulblet (0.03) and per cent bulb sprouting (0.01) which have masked the negative indirect effect on number of flowers/plant caused through traits such as bud length (-1.82), days to first flower (-1.33), leaf length (-0.30), tepal width (-0.65), weight of bulb (-0.62),stem length (-0.52), duration of flowering (-0.48), leaf width (-0.28), number of leaves per plant (-

0.10) and stem diameter (-0.06) which have enabled the trait to establish positive and significant association.

Tepal length (1.01) had strong positive direct effect on number of flowers/plant along with maximum positive indirect effect through days to flower bud formation (2.43) followed by size of the flower (1.22), days taken for bulb sprout emergence (1.12), vase life (0.12), number of bulblets per plant (0.12), plant height (0.07), bulb diameter (0.06), weight of bulblet (0.03) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as number of leaves per plant (-0.09), stem diameter (-0.11), leaf width (-0.22), weight of bulb (-0.29), duration of flowering (-0.37), tepal width (-0.65),stem length (-0.65), leaf length (-0.76), days to first flower (-1.24) and bud length (-1.92) which have enabled the trait to establish positive and significant association.

Tepal width (-0.88) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through traits such as bud length (-1.38) followed by leaf length (-1.17), duration of flowering (-0.39), weight of bulb (-0.27), leaf width (-0.25), stem diameter (-0.17), number of leaves per plant (-0.14), plant height (-0.11), days to first flower (-0.08) and per cent bulb sprouting (-0.03). In contrast higher magnitude of positive indirect effects of the trait through days taken for bulb sprout emergence (1.06), size of the flower (1.01), days to flower bud formation (0.85), tepal length (0.74), stem length (0.54), number of bulblets per plant (0.15), stem length (0.09), vase life (0.02) and weight of bulblet (0.02) nullified the negative direct and indirect effects of the trait.

Duration of flowering (-1.23) recorded strong negative direct effect on number of flowers/plant along with maximum negative indirect effect through traits such as bud length (-0.63) followed by leaf length (-0.33), days taken for bulb sprout emergence (-0.32), tepal width (-0.28), days to flower bud formation (-0.24), plant height (-0.17), number of bulblets per plant (-0.11), stem diameter (-0.08), bulb diameter (-0.07), leaf width (-0.06) and number of leaves per plant (-0.02). In contrast higher magnitude of positive indirect effects of the trait through stem length (1.52), size of the flower (0.53), days to first flower (0.49), weight of bulb (0.33), tepal length (0.31), vase life (0.10), weight of bulblet (0.08) and per cent bulb sprouting(0.02) nullified the negative direct and indirect effects of the trait.

Table 4.3.24(c) also shows that bulb diameter (-0.38) recorded negative direct effect on number of flowers/plant along with negative indirect effect through traits such as days to flower bud formation (-4.06) followed by days taken for bulb sprout emergence (-2.37), vase life (-0.64), size of the flower (-0.43), duration of flowering (-0.21), tepal length (-0.16), stem diameter (-0.15), number of bulblets per plant (-0.07),plant height(-0.02) and stem length (-0.01). In contrast highest magnitude of positive indirect effects of the trait through leaf length (3.88) followed by days to first flower (2.66), weight of bulb (1.10), leaf length (3.88), bud length (0.54), leaf width (0.29), tepal width (0.21), number of leaves per plant (0.12), per cent bulb sprouting (0.05) and weight of bulblet (0.02) nullified the negative direct and indirect effects of the trait.

Weight of bulb (1.91) had strong positive direct effect on number of flowers/plant along with maximum positive indirect effect through leaf length (2.81) followed by days to first flower (2.01), weight of bulb (1.91), bud length (0.41), leaf width (0.21), number of leaves per plant (0.18), tepal width (0.13), plant height (0.10) and weight of bulblet (0.06) which have masked the negative indirect effect on number of flowers/plant caused through traits such as per cent bulb sprouting (-0.01), number of bulblets per plant (-0.10), vase life (-0.15), tepal length (-0.15), stem diameter (-0.16), duration of flowering (-0.21), bulb diameter (-0.22), size of the flower (-0.44), stem length (-0.89), days taken for bulb sprout emergence (-1.41) and days to flower bud formation (-3.58) which have enabled the trait to establish positive and significant association.

Number of bulblets/plant (-0.55) observed strong negative direct effect on number of flowers/plant along with maximum negative indirect effect through traits such as days taken for bulb sprout emergence (-0.65) followed by size of the flower (-0.48), days to first flower (-0.44), duration of flowering (-0.26), tepal length (-0.21), stem length (-0.08), 8 (-0.07), bulb diameter (-0.05) and plant height (-0.02). In contrast highest magnitude of positive indirect effects of the trait was observed through leaf length (1.42) followed by bud length (0.62), weight of bulb (0.36), tepal width (0.23), vase life (0.13), leaf width (0.13), number of leaves per plant (0.10), stem diameter (0.09), weight of bulblet (0.07) and per cent bulb sprouting (0.001) nullified the negative direct and indirect effects of the trait.

Weight of bulblet (0.20) had moderate direct effect on number of flowers/plant along with maximum positive indirect effect through days to flower bud formation (1.12) followed by days taken for bulb sprout emergence (0.82), weight of bulb (0.58), vase life (0.29), size of the flower (0.20), tepal length (0.16), plant height (0.09), number of leaves per plant (0.08), leaf length (0.02) and per cent bulb sprouting(0.02) which have masked the negative indirect effect on number of flowers/plant caused through traits such as bulb diameter (-0.04), tepal width (-0.07), stem diameter (-0.08), leaf width (-0.11),bud length(-0.14), number of bulblets per plant (-0.18), duration of flowering (-0.51),stem length (-0.87) and days to first flower (-1.24) which have enabled the trait to establish positive and significant association.

Vase life (0.93) recoded high positive direct effect on number of flowers/plant along with maximum positive indirect effect through 8 (1.49) followed by days taken for bulb sprout emergence (1.09), size of the flower (0.47), bulb diameter (0.26), tepal length (0.13), plant height (0.09), weight of bulblet (0.06), number of leaves per plant (0.01), stem diameter (0.001) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused via traits such as tepal width (-0.02), number of bulblets per plant (-0.08), duration of flowering (0.14), bud length (-0.23), leaf width (-0.23), weight of bulb (-0.31), stem length (-0.64), days to first flower (-1.03) and leaf length (-1.82) which have enabled the trait to establish positive and significant association.

The residual effect was estimated as 0.058 (5.80 %) indicating that all the characters contributed only 94.20 % to the variability in number of flowers per plant.

Pooled data of path co-efficient analysis over Nauni location demonstrated that days to flower bud formation (5.78) had very high positive direct effect on the number of flowers per plant followed by leaf length (4.86), days taken for bulb sprout emergence (2.94) weight of bulb (1.91), size of the flower (1.37), tepal length (1.01), vase life (0.93), plant height (0.45), number of leaves per plant (0.28), weight of bulblet (0.20) and per cent bulb sprouting (0.15). However, present investigation also demonstrated that genotypic correlation studies between yield parameter (number of flowers/plant) and days to flower bud formation and days taken for bulb sprout emergence exhibited negative correlation indicating direct selection for such trait should be practiced to reduce the undesirable indirect effect. Moreover trait such as plant height, number of leaves/plant, leaf length, weight of bulb and weight of bulblet recorded both direct effect as well as positive correlation with number of flowers per plant thus indicating true relationship among these traits and direct selection for these traits will be useful for yield improvement.

These findings indicate that selection should be made on the basis of plant height, number of leaves/plant, leaf length, weight of bulb and weight of bulblet by taking other traits into consideration, while making improvement in number of flowers per plant.

Similar results were also reported by Hedge (1994) and Patra & Mohanty (2015) in gladiolus.

Table 4.1.2.25(a): Pooled estimates of mean, genotypic and phenotypic coefficient of variability, heritability, genetic advance and genetic gain among 18 *Lilium* genotypes under Katrain conditions

Characters	Mean ± Standard error	Range	Coefficients of variability (%)		Heritability (%)	Genetic advance (%)	Genetic gain (%)
			PCV	GCV			
Days taken for bulb sprout emergence	172.68 ± 0.54	158.24 - 193.67	6.77	6.76	99.68	23.99	13.90
Per cent bulb sprouting (%)	98.52 ± 1.91	93.33 - 100.00	2.90	1.68	33.33	1.96	1.99
Plant height (cm)	70.78 ± 0.66	44.74 - 100.65	22.80	22.77	99.75	33.16	46.85
Number of leaves/plant	53.57 ± 0.77	17.99 - 86.32	36.23	36.19	99.77	39.89	74.47
Leaf length (cm)	10.81 ± 0.12	6.49 - 14.85	24.26	24.22	99.68	5.38	49.81
Leaf width (cm)	2.21 ± 0.03	1.35 - 3.60	26.88	26.81	99.55	1.22	55.11
Stem length (cm)	50.78 ± 0.66	24.74 - 80.65	31.78	31.74	99.75	33.16	65.30
Days to flower bud formation	45.19 ± 0.67	29.80-55.52	17.47	17.37	99.94	16.09	35.60
Bud length (cm)	9.94 ± 0.02	6.82 - 13.26	15.38	15.38	99.97	3.15	31.67
Days to first flower	67.02 ± 0.52	45.23 – 84.43	15.15	15.12	99.61	20.83	31.08
Stem diameter (cm)	0.75 ± 0.01	0.51 - 0.90	15.42	15.29	99.86	0.23	31.21
Size of the flower (cm)	16.45 ± 0.13	13.04 - 20.48	10.56	10.52	98.26	3.55	21.57
Number of flowers per plant	7.26 ± 0.10	2.62 - 9.91	24.82	24.76	99.19	3.69	50.87
Tepal length (cm)	8.91 ± 0.11	7.31 - 12.25	16.15	16.08	99.50	2.94	32.99
Tepal width (cm)	2.73 ± 0.06	2.19 - 3.77	15.69	15.42	99.19	0.85	31.23
Duration of flowering (days)	19.71 ± 0.47	10.21 - 27.69	25.33	25.16	96.65	10.15	51.48
Bulb diameter (cm)	5.18 ± 0.28	3.22 - 6.23	18.12	16.90	98.67	1.68	32.47
Weight of bulb (g)	63.50 ± 0.45	19.21 - 95.26	33.42	33.41	86.98	43.68	68.79
Number of bulblets/plant	4.25 ± 0.15	1.45 - 10.68	63.69	63.55	99.93	5.55	130.63
Weight of bulblet (g)	12.68 ± 0.66	2.57 - 23.56	52.50	52.11	99.57	13.51	106.55
Vase life (days)	7.71 ± 0.07	6.53 – 9.91	12.36	12.31	98.51	13.51	106.54

4.1.3.1 Coefficients of variability

The pooled analysis of data over Katrain location as presented in Table 4.1.2.25(a) revealed treatment mean squares significant for all the characters indicating the genotypic differences among the various characters studied. The widest range of variation was recorded for weight of bulb (19.21 to 95.26) followed by number of leaves/plant (17.99 to 86.32) and plant height (44.74 to 100.65). In contrast, narrowest range for variability observed for stem diameter (0.51 to 0.90) followed by tepal width (2.19 to 3.77) and leaf width (1.35 to 3.60).

The phenotypic coefficient of variability (PCV) was higher than the genotypic coefficients of variability (GCV) for all the characters which clearly demonstrate the role of environment in the expression of characters among different genotypes. Furthermore pooled analysis of environments over Katrain location revealed the high values for phenotypic coefficient of variability (PCV) for the trait such as number of bulblet/plant (63.69 %), weight of bulblet (52.50 %), weight of bulb (33.42 %), stem length (31.78 %) and number of leaves/plant (36.23 %) ; moderate values for characters such as leaf width (26.88 %), leaf length (24.26 %), number of flowers/plant (24.82 %), plant height (22.80 %), days to flower bud formation (17.47 %), bud length (15.38 %), stem diameter (15.42 %), days to first flower (15.15 %) tepal length (16.15 %), tepal width (15.69 %), duration of flowering (25.33 %) and bulb diameter (18.12 %) whereas low values were observed for parameters *viz*., days taken for bulb sprout emergence (6.77 %), per cent bulb sprouting (2.90 %), size of the flower (10.56 %) and vase life (12.36 %).

The genotypic coefficient of variability (GCV) revealed that characters such as number of bulblet per plan (63.55 %) followed by weight of bulblet (52.11 %) number of leaves/plant (36.19 %), weight of bulb (33.41 %) and number of leaves/plant (36.19 %) recorded high value of GCV; moderate values for characters such as plant height (22.77 %), leaf length (24.22 %), leaf width (26.81 %), days to flower bud formation (17.37 %), bud length (15.38 %), days to first flower (15.12 %), stem diameter (15.29 %), number of flowers/plant (24.76 %), tepal length (16.08 %), tepal width (15.42 %), duration of flowering (25.16 %) and bulb diameter (16.90 %) and low GCV values were observed for parameters such as days taken for bulb sprout emergence (6.76 %), per cent bulb sprouting (1.68 %), size of the flower (10.52 %) and vase life (12.31 %).

Similarly under Katrain conditions, all the characters observed phenotypic coefficients of variability higher in magnitude than genotypic coefficients of variability, though difference was less in most of the parameters. Thus, it showed that some of these traits were less influenced by environmental factors. Similarly magnitude of coefficients of variability varied from character to character because of the presence of great diversity in the experimental material used. Moreover, genotypic coefficient of variability for most of the parameters were comparatively higher under Katrain conditions than those observed under Nauni conditions indicating Katrain conditions were congenial for full expression of traits particularly bulb and bulblet parameters.

Similar results were also reported by Nazir *et al*. (2004), Choudhary *et al*. (2012) and Kumar *et al.* (2010) in gladiolus.

4.1.3.2 Heritability

Data presented in Table 4.1.2.25(a) indicates character per cent bulb sprouting (33.33 %) recorded low heritability while rest of all the characters such as days taken for bulb sprout emergence (99.68 %), plant height (99.75 %), number of leaves/plant (99.77 %), leaf length (99.68 %), leaf width (99.55 %), stem length (99.75 %), days to flower bud formation (99.94 %), bud length (99.97 %), days to first flower (99.61 %), stem diameter (99.86 %), size of the flower (98.26 %), number of flowers per plant (99.19 %), tepal length (99.50 %), tepal width (99.19 %), duration of flowering (96.65 %), bulb diameter (98.67 %),weight of bulb (86.98 %), number of bulblet/plant (99.93 %), weight of bulblet (99.57 %) and vase life (98.51 %).

High estimates of heritability were obtained for all the characters except per cent bulb sprouting .These results are in agreement with the findings of Negi *et al*. (1982), Singh and Singh (1983), Lal *et al*. (1985) in gladiolus and Jhon *et al*. (2006) in tulip.

4.1.3.3 Genetic advance and genetic gain

Results obtained under Katrain conditions as presented in Table 4.1.2.25(a) indicates high heritability coupled with moderate genetic advance observed for plant height (33.16 %), number of leaves/plant (39.89 %), stem length (33.16 %) and weight of bulb (43.68 %) suggesting the involvement of dominant and epistatic gene action indicating that these traits can be improved with hybridization programme.

High heritability along with low genetic advance reported in traits *viz*., days taken for bulb sprout emergence (23.99 %), leaf length (5.38 %), leaf width (1.22 %), days to flower bud formation (16.09 %), bud length (3.15 %), days to first flower (20.83 %), stem diameter (0.23 %), size of the flower (3.55 %), number of flowers per plant (3.69 %), tepal length (2.94 %), tepal width (0.85 %), duration of flowering (10.15 %), bulb diameter (1.68 %), number of bulblet/plant (5.55 %), weight of bulblet (13.51 %) and vase life (13.51 %) indicating high heritability of these characters is highly governed by favourable environment conditions and selection of such traits may not be rewarding.

High heritability with highest genetic gain (130.63 %) was recorded for the character number of bulblet/plant followed by traits such as number of leaves per plant (74.47 %), leaf width (55.11 %), stem length (65.30 %), number of flowers per plant (50.87 %), duration of flowering (51.48 %), weight of bulb (68.79 %), weight of bulblet (106.54 %) and vase life (106.54 %) indicating the involvement of additive gene action and selection for such characters will be very effective. High heritability along with moderate genetic gain was recorded for traits such as plant height (46.85 %), days to flower bud formation (35.60 %), bud length (31.67 %), days to first flower (31.08 %), stem diameter (31.21 %), tepal length (32.99 %) and bulb diameter (32.47 %) indicating the involvement of both additive and non-additive genetic control and simple selection will be helpful for improvement of traits.

High heritability along with low genetic gain recorded for parameters such as days taken for bulb sprout emergence (13.90 %), per cent bulb sprouting (1.99 %) and size of the flower (21.57 %) suggesting that the selection for these characters would not be effective for improvement.

These results are in close agreement with the earlier findings of Kadam *et al*. (2014), Kumar *et al*. (2015) and Manoj (2016) in gladiolus.

4.2.1.3 Phenotypic correlations

i) Days taken for bulb sprout emergence

Analysis of pooled data over Katrain location (Table 4.2.25b) showed significant positive correlation of days taken for bulb sprout emergence with leaf width (0.52), days to flower bud formation (0.72), days to first flower (0.76), tepal length (0.31) and tepal width (0.64). Characters such as plant height (-0.36), number of leaves/plant (-0.56), leaf length (-0.39), stem length (-0.36), stem diameter (-0.37), number of flower/plant (-0.58) and weight of bulb (-0.36) observed significantly negative correlation with days taken for bulb sprout emergence.

ii) Per cent bulb sprouting

In case of per cent bulb sprouting, parameters *viz*., plant height (0.02), number of leaves/plant (0.16), stem length (0.02), duration of flowering (0.16), number of flowers/plant (0.03), weight of bulb (0.001) and vase life (0.18) recorded positive non significant correlation with per cent bulb sprouting while characters such as days taken for bulb sprout emergence (-0.06), days to flower bud formation (-0.05), leaf length (-0.02), leaf width (-0.01), bud length (-0.11), days to first flower (-0.09), stem diameter (-0.22), size of the flower (-0.22), tepal length (-0.07), tepal width (-0.03),), bulb diameter (-0.03), number of bulblets/plant (-0.06) and weight of bulblet (-0.14) observed negative non significant correlation with per cent bulb sprouting.

iii) Plant height

Highly significant positive correlation of plant height was recorded with number of leaves/plant (0.59), leaf length (0.57), stem length (1.00), bud length (0.57), stem diameter (0.46), size of the flower (0.60), number of flowers/plant (0.69), duration of flowering (0.60), bulb diameter (0.40), weight of bulb (0.50), number of bulblet/plant (0.29), weight of bulblet (0.42) and vase life (0.52) while negative significant correlation was observed with days taken for bulb sprout emergence (-0.36), leaf width (-0.39) and tepal width (-0.31).

iv) Number of leaves/plant

Number of leaves per plant recorded significant positive correlation with plant height (0.59), leaf length (0.48), stem length (0.59), number of flowers per plant (0.80), duration of flowering (0.39), bulb diameter (0.26), weight of bulb (0.39), number of bulblets/plant (0.20), weight of bulblet (0.46) and vase life (0.60) whereas significant negative correlation with days taken for bulb sprout emergence (-0.56), leaf width (-0.43), days to flower bud formation (-0.45), days to first flower (-0.54) tepal length (-0.36) and tepal width (-0.33).

v) Leaf length

This trait showed significant positive correlation with characters such as plant height (0.57), number of leaves/plant (0.48), stem length (0.57), bud length (0.47), stem diameter (0.68), size of the flower (0.44), number of flowers/plant (0.59), tepal length (0.01), duration of flowering (0.35), bulb diameter (0.41), weight of bulb (0.64), number of bulblets/plant

(0.49) and vase life (0.35) along with significant negative correlation with days taken for bulb sprout emergence (-0.39), days to flower bud formation (-0.43) and days to first flower (-0.59).

vi) Leaf width

Leaf width recorded significantly positive correlation with days taken for bulb sprout emergence (0.42), days to flower bud formation (0.52), days to first flower (0.34), tepal length (0.39) and tepal width (0.72) whereas traits such as plant height (-0.39), number of leaves/plant (-0.43), stem length (-0.39), number of flowers/plant (-0.58), bulb diameter (-0.63), weight of bulb (-0.54) and weight of bulblet (-0.34) recorded significantly negative correlation with leaf width.

vii) Stem length

Significant positive correlation of this trait was recorded with plant height (1.00), number of leaves/plant (0.59), bud length (0.57), stem diameter (0.46), size of flower (0.60), number of flowers per plant (0.69), duration of flowering (0.60), bulb diameter (0.40), weight of bulb (0.50), number of bulblets per plant (0.29), weight of bulblet (0.42) and vase life (0.52) while negative significant correlation was recorded with days taken for bulb sprout emergence (-0.36), leaf width (-0.39) and tepal width (-0.31) (Table 4.2.25b).

viii) Days to flower bud formation

It is evident from Table 4.2.27(b) that character days to flower bud formation showed significant positive correlation with days taken for bulb sprout emergence (0.72), leaf width (0.42), days to first flower (0.85) and tepal width (0.43) while significant negative correlation was recorded with number of leaves/plant (-0.45), leaf length (-0.43), stem diameter (-0.49), number of flowers/plant (-0.48), bulb diameter (-0.45) and weight of bulb (-0.33).

ix) Bud length

Character bud length exhibited significant positive correlation with plant height (0.57), leaf length (0.47), stem length (0.57), stem diameter (0.45) size of the flower (0.89), number of flowers/plant (0.28) and tepal length (0.58) whereas this trait recorded negative significant correlation with days to first flower (-0.28).

x) Days to first flower

It is clearly evident from the table that days to first flower was significantly positively correlated with days taken for bulb sprout emergence (0.76), leaf width (0.34), days to flower bud formation (0.85), and tepal width (0.38) while traits such as stem length (-0.59), stem diameter (-0.42), number of flowers/plant (-0.57), bulb diameter (-0.40), weight of the bulb (-0.41) and vase life (-0.32) recorded significant negative correlation with this trait.

xi) Stem diameter

Stem diameter showed significant positive correlation with characters such as plant height (0.46), leaf length (0.68), stem length (0.46), bud length (0.45), size of the flower (0.46), number of flowers/plant (0.52), bulb diameter (0.42), weight of bulb (0.63), weight of bulblet (0.55), weight of bulblet (0.29) and vase life (0.33) while traits such as days taken for bulb sprout emergence (-0.37), days to flower bud formation (-0.49) and days to first flower (-0.42) recorded significant negative correlation with stem diameter.

xii) Size of the flower

This character recorded significantly high positive correlation with plant height (0.60), leaf length (0.44), stem length (0.60), bud length (0.89) and stem diameter (0.46), number of flowers/plant (0.33), tepal length (0.57), bulb diameter (0.35) and weight of bulb (0.37) whereas rest of all other parameters observed non significant correlation with size of the flower.

xiii) Number of flowers/plant

Significant positive phenotypic correlation of number of flowers/plant with plant height (0.69), number of leaves/plant (0.80), leaf length (0.59), stem length (0.69), bud length (0.28), stem diameter (0.52), size of the flower (0.33), duration of flowering (0.51), bulb diameter (0.59), weight of bulb (0.75), number of bulblets/plant (0.39), weight of bulblet (0.50) and vase life (0.70) while characters such as days taken for bulb sprout emergence (-0.58), leaf width (-0.58), days to flower bud formation (-0.48), days to first flower (-0.57), tepal length (-0.38) and tepal width (-0.45) observed significantly negative correlation with number of flowers/plant.

xiv) Tepal length

Character tepal length recorded significantly high positive correlation with days taken for bulb sprout emergence (0.31), leaf width (0.39), bud length (0.58), size of the flower (0.57) and tepal width (0.46) while number of leaves/plant (-0.36), number of flowers/plant (-0.38) and weight of bulblet (-0.33) recorded negative significant correlation with tepal length.

xv) Tepal width

Tepal width recorded significant positive correlation with days taken for bulb sprout emergence (0.64), leaf width (0.72), days to flower bud formation (0.43), days to first flower (0.38) and tepal length (0.46). Significant negative correlation was observed with plant height (-0.31), number of leaves/plant (-0.33), stem length (-0.31), number of flowers/plant (-0.45) and bulb diameters (-0.36).

xvi) Duration of flowering

Flowering duration observed significant positive correlation with plant height (0.60), number of leaves/plant (0.39), leaf length (0.35), stem length (0.60), number of flower/plant (0.51), weight of bulb (0.34) and vase life (0.64) while rest of all the other characters showed non significant correlation with duration of flowering.

xvii) Bulb diameter

This trait recorded significant positive correlation with plant height (0.40), leaf length (0.41), stem length (0.40), stem diameter (0.42), size of the flower (0.35), number of flowers/plant (0.59), weight of bulb (0.68), number of bulblets per plant (0.39) and weight of bulblet (0.46) while characters such as leaf width (-0.63), days to flower bud formation (-0.45), days to first flower (-0.40) and tepal width (-0.36) observed significant negative correlation with this trait.

xviii) Weight of bulb

Characters such as plant height (0.50), number of leaves/plant (0.39), leaf length (0.64), stem length (0.50), stem diameter (0.63), size of the flower (0.37), number of flowers/plant (0.75), duration of flowering (0.34) and bulb diameter (0.68), number of bulblets/plant (0.55) and weight of bulblet (0.50) and vase life (0.37) recorded significantly positive correlation while traits such as days taken for bulb sprout emergence (-0.36), leaf width (-0.54), days to flower bud formation (-0.33) and days to first flower (-0.41) recorded significantly negative correlation with weight of the bulb.

xix) Number of bulblet/plant

Number of bulblet/plant observed significantly positive correlation with plant height (0.29), leaf length (0.49), stem length (0.29), stem diameter (0.55), number of flowers/plant (0.39), bulb diameter (0.39), weight of bulb (0.55) and weight of bulblet (0.74) while rest of all the other traits recorded non significant correlation with number of bulblets/plant.

xx) Weight of bulblet

Characters such as plant height (0.42), number of leaves/plant (0.46), stem length (0.42), stem diameter (0.29), number of flowers/plant (0.50), bulb diameter (0.46), weight of bulb (0.50) and number of bulblets/plant (0.74) while traits such as leaf width (-0.34) and tepal length (-0.33) recorded significantly negative correlation with weight of bulblet.

xxi) Vase life

Plant height (0.52), number of leaves/plant (0.60), leaf length (0.35), stem length (0.52), stem diameter (0.33), number of flowers/plant (0.70), duration of flowering (0.64) and weight of bulb (0.37) observed significantly positive correlation with vase life of the flowers while days to first flower (-0.32) exhibited significantly negative correlation with vase life.

4.2.1.4 Genotypic correlations

i) Days taken for bulb sprout emergence

An appraisal of data presented in Table 4.2.25 (b) demonstrated significantly positive correlation of character days taken for bulb sprout emergence with leaf width (0.52), days to flower bud formation (0.72), days to first flower (0.76), tepal length (0.31) and tepal width (0.65) whereas significant negative correlation recorded with plant height (-0.36), number of leaves per plant (-0.56), leaf length (-0.39), stem length (-0.36), stem diameter (-0.38), number of flowers/plant (-0.58) and weight of bulb (-0.36).

ii) Per cent bulb sprouting

Per cent bulb sprouting was reported significantly positively correlated with vase life (0.30) whereas negative non significant stem diameter (-0.42), size of the flower (-0.42) and weight of bulblet (-0.28) rest of all the traits recorded non significant correlation with per cent bulb sprouting.

iii) Plant height

Plant height recorded significant positive correlation with number of leaves per plant (0.59), leaf length (0.57), stem length (1.00), bud length (0.57), stem diameter (0.46), size of the flower (0.61), number of flowers per plant (0.70), duration of flowering (0.61), bulb diameter (0.43), weight of bulb (0.50), number of bulblet/plant (0.29) weight of bulblet (0.42) and vase life (0.53) whereas days taken for bulb sprout emergence (-0.36), leaf length (-0.39) and tepal width (-0.32) recorded significant negative correlation with plant height.

iv) Number of leaves/plant

Number of leaves per plant recorded significant positive correlation with plant height (0.59), leaf length (0.48), stem length (0.59), number of flowers/plant (0.80), duration of flowering (0.39), bulb diameter (0.27), weight of bulb (0.39), weight of bulblet (0.46) and vase life (0.60) while negative significant correlation was recorded with days taken for bulb sprout emergence (-0.56), leaf width (-0.43), days to flower bud formation (-0.45), days to first flower (-0.54), tepal length (-0.37) and tepal width (-0.34).

v) Leaf length

Significant positive correlation of leaf length was observed with plant height (0.57), number of leaves/plant (0.48), stem length (0.57), bud length (0.47), stem diameter (0.69), size of the flower (0.44), number of flowers/plant (0.60), duration of flowering (0.35), bulb diameter (0.44), weight of bulb (0.65), number of bulblets/plant (0.49) and vase life (0.35) whereas traits such as days taken for bulb sprout emergence (-0.39), days to flower bud formation (-0.44) and days to first flower (-0.59) observed negative significant correlation with leaf length.

vi) Leaf width

This trait showed significant positive correlation with characters such days taken for bulb sprout emergence (0.52), days to flower bud formation (0.43), days to first flower (0.34), tepal length (0.39) and tepal width (0.43) whereas significant negative correlation was recorded with traits such as plant height (-0.39), number of leaves/plant (-0.43), stem length (-0.39), number of flowers per plant (-0.58), bulb diameter (-0.68), weight of bulb (-0.54) and number of bulblets/plant (-0.35).

vii) Stem length

Significant positive correlation of this trait was recorded with plant height (1.00), number of leaves/plant (0.59), leaf length (0.57), bud length (0.57), stem diameter (0.46), size of the flower (0.61), number of flowers/plant (0.70), duration of flowering (0.61), bulb diameter (0.43), weight of bulb (0.50), number of bulblets/plant (0.29), weight of bulblet (0.42) and vase life (0.53) while character days taken for bulb sprout emergence (-0.36), leaf width (-0.39) and tepal width (-0.32) exhibited negative significant correlation with stem length.

viii) Days to flower bud formation

It is evident from data presented in Table 4.2.25(b) that character days to flower bud formation showed significant positive correlation with days taken for bulb sprout emergence (0.72),leaf width (0.43), days to first flower (0.86) and tepal width (0.44) while significant negative correlation was recorded with number of leaves/plant (-0.45), leaf length (-0.44), stem diameter (-0.49), number of flowers/plant (-0.48), bulb diameter (-0.49) and weight of bulb (-0.33).

ix) Bud length

Character bud length exhibited significant positive correlation with plant height (0.57), leaf length (0.47), stem length (0.57), stem diameter (0.46), size of the flower (0.89), number of flowers/plant (0.28) and tepal length (0.58) whereas this trait observed negative significant correlation with days to first flower (-0.28).

x) Days to first flower

It is clearly evident from the table that days to first flower was significantly positively correlated with days taken for bulb sprout emergence (0.76), leaf width (0.34), days to flower bud formation (0.86) and tepal width (0.39) while traits such as number of leaves per plant (-0.54), leaf length (-0.59), bud length (-0.28), stem diameter (-0.43), number of flowers/plant

(-0.57), bulb diameter (-0.43), weight of the bulb (-0.41) and vase life (-0.33) recorded significant negative correlation with this trait.

xi) Stem diameter

Stem diameter showed significant positive correlation with characters such as plant height (0.46), leaf length (0.69), stem length (0.46), bud length (0.46), size of the flower (0.47), number of flowers/plant (0.52), bulb diameter (0.45), weight of bulb (0.64), number of bulblets/plant (0.56), weight of bulblet (0.29) and vase life (0.33) while traits such as days taken for bulb sprout emergence (-0.38), per cent bulb sprouting (-0.42), days to flower bud formation (-0.49) and days to first flower (-0.43) recorded negative significant correlation with stem diameter.

xii) Size of the flower

Significantly high positive correlation of size of the flower was recorded with plant height (0.61), leaf length (0.44), stem length (0.61), bud length (0.89), stem diameter (0.47), number of flowers/plant (0.33), tepal length (0.58), bulb diameter (0.37) and weight of bulb (0.37). Characters such as per cent bulb sprouting (-0.42) showed significant negative correlation with this trait while rest all of the other parameters reported non significant correlation with size of the flower.

xiii) Number of flowers/plant

Number of flowers per plant recorded significant positive genotypic correlation with plant height (0.70), number of leaves per plant (0.80), leaf length (0.60), stem length (0.70), bud length (0.28), stem diameter (0.52), size of the flower (0.33), duration of flowering (0.51), bulb diameter (0.63), weight of bulb (0.74), number of bulblets/plant (0.38), weight of bulblet (0.50) and vase life (0.70) while characters such as days taken for bulb sprout emergence (-0.58), leaf width (-0.58), days to flower bud formation (-0.48), days to first flower (-0.57), tepal length (-0.38) and tepal width (-0.46) observed significant negative correlation with number of flowers/plant.

xiv) Tepal length

Tepal length recorded significantly high positive correlation with days taken for bulb sprout emergence (0.31), leaf width (0.39), bud length (0.58), size of the flower (0.58) and tepal width (0.47) while characters number of leaves/plant (-0.37), number of flowers/plant (-0.38) and weight of bulblet (-0.33) recorded negative significant correlation.

xv) Tepal width

Significant positive correlation was associated with characters such as days taken for bulb sprout emergence (0.65), leaf width (0.73), days to flower bud formation (0.44), days to first flower (0.39) and tepal length (0.47) while traits such as plant height (-0.32), number of leaves/plant (-0.34), stem length (-0.32) number of flowers/plant (-0.46) and bulb diameter (-0.41) showed significant negative correlation with tepal width while rest of all the characters exhibited non significant correlation with tepal width.

xvi) Duration of flowering

Characters such as plant height (0.61), number of leaves/plant (0.39), leaf length (0.35), stem length (0.61), number of flowers/plant (0.51), weight of bulb (0.34) and vase life (0.64) while rest of all the characters exhibited non significant correlation with duration of flowering.

xvii) Bulb diameter

This trait recorded significant positive correlation with plant height (0.43), number of leaves/plant (0.27), leaf length (0.44), stem length (0.43), stem diameter (0.45), size of the flower (0.37), number of flowers per plant (0.63), weight of bulb (0.73), number of bulblets/plant (0.41) and weight of bulblet (0.48) while characters such as leaf width (-0.68), days to flower bud formation (-0.49), days to first flower (-0.43) and tepal width (-0.41) observed negative significant correlation with this trait.

xviii) Weight of bulb

Significant positive correlation of weight of bulb was recorded with plant height (0.50), number of leaves/plant (0.39), leaf length (0.65), stem length (0.50), stem diameter (0.64), size if the flower (0.37), number of flowers/plant (0.74), duration of flowering (0.34), bulb diameter (0.73), number of bulblets/plant (0.55), weight of bulblet (0.50) and vase life (0.37) while characters such as days taken for bulb sprout emergence (-0.36), leaf width (-0.54), days to flower bud formation (-0.33) and days to first flower (-0.41) recorded negative significant correlation with this trait (Table 4.2.25b).

xix) Number of bulblet/plant

Number of bulblet/plant recorded significant positive correlation with characters such as plant height (0.29), leaf length (0.49), stem length (0.29), stem diameter (0.56), number of flowers/plant (0.38), bulb diameter (0.41), weight of bulb (0.55) and weight of bulblet (0.75) while rest of all the parameters recorded non significant correlation with number of bulblet/plant.

xx) Weight of bulblet

This trait recorded significant positive correlation with plant height (0.42), number of leaves/plant (0.46), stem length (0.42), stem diameter (0.29), number of flowers/plant (0.50), bulb diameter (0.48), weight of bulb (0.50) and number of bulblets/plant (0.75) while per cent bulb sprouting (-0.28), leaf width (-0.35) and tepal length (0.33) recorded significant negative correlation with weight of bulblet.

xxi) Vase life

Vase life recorded significant positive correlation with per cent bulb sprouting (0.30), plant height (0.53), number of leaves/plant (0.60), leaf length (0.35), stem length (0.53) stem diameter (0.33), number of flowers/plant (0.70), duration of flowering (0.64) and weight of bulb (0.37) whereas this trait recorded significant negative correlation with days to first flower (-0.33).

Correlation studies over Katrain location revealed that yield component i.e. number of flowers/plant at genotypic level recorded positive correlation with plant height, number of leaves per plant, leaf length, stem length, bud length, stem diameter, size of the flower, duration of flowering, bulb diameter, weight of bulb, number of bulblets/plant, weight of bulblet and vase life. All these characters showed the positive relationship with number of flowers per plant and together contribute to overall quality in *Lilium*. A positive correlation between desirable characters is favourable as it assists in simultaneous improvement of both of the desired characters.

Days taken for bulb sprout emergence, leaf width, days to flower bud formation, days to first flower, tepal length and tepal width observed significant negative correlation with number of flowers/plant. This leads to the conclusion that early sprout emergence and early flowering leads to less number of flower flowers per plant.

Table 4.2.25(b): Pooled analysis of coefficients of correlation of phenotypic (above diagonal) and genotypic (below diagonal) among different characters in *Lilium* genotypes under Katrain conditions

C*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	-	-0.03	-0.36**	-0.56**	-0.39**	0.52**	-0.36**	0.72**	-0.08	0.76**	-0.37**	-0.04	-0.58**	0.31*	0.64**	0.15	-0.23	-0.36**	-0.13	-0.24	-0.25
2	-0.06	-	0.02	-0.004	-0.02	-0.001	0.02	0.11	-0.11	-0.09	-0.22	-0.22	0.03	-0.07	-0.03	0.09	-0.03	0.001	-0.06	-0.14	0.18
3	-0.36**	0.04	-	0.59**	0.57**	-0.39**	1.00**	-0.15	0.57**	-0.24	0.46**	0.60**	0.69**	0.12	-0.31*	0.60**	0.40**	0.50**	0.29*	0.42**	0.52**
4	-0.56**	0.01	0.59**	-	0.48**	-0.43**	0.59**	-0.45**	0.21	-0.54**	0.24	0.22	0.80**	-0.36**	-0.33*	0.39**	0.26	0.39**	0.20	0.46**	0.60**
5	-0.39**	-0.04	0.57**	0.48**	-	-0.26	0.57**	-0.43**	0.47**	-0.59**	0.68**	0.44**	0.59**	0.01	-0.08	0.35*	0.41**	0.64**	0.49**	0.22	0.35**
6	0.52**	-0.02	-0.39**	-0.43**	-0.26	-	-0.39**	0.42**	0.19	0.34*	-0.16	0.04	-0.58**	0.39**	0.72**	-0.21	-0.63**	-0.54**	-0.01	-0.34*	0.04
7	-0.36**	0.04	1.00**	0.59**	0.57**	-0.39**	-	-0.15	0.57**	-0.24	0.46**	0.60**	0.69**	0.2	-0.31*	0.60**	0.40**	0.50**	0.29*	0.42**	0.52**
8	0.72**	0.19	-0.15	-0.45**	-0.44**	0.43**	-0.15	-	-0.18	0.85**	-0.49**	-0.13	-0.48**	0.26	0.43**	0.19	-0.45**	-0.33*	-0.23	-0.25	-0.12
9	-0.08	-0.19	0.57**	0.21	0.47**	0.19	0.57**	-0.18	-	-0.28*	0.45**	0.89**	0.28*	0.58**	0.13	0.12	0.24	0.19	0.26	0.14	0.26
10	0.76**	-0.12	-0.24	-0.54**	-0.59**	0.34*	-0.24	0.86**	-0.28*	-	-0.42**	-0.23	-0.57**	0.5	0.38**	0.06	-0.40**	-0.41**	-0.22	-0.19	-0.32*
11	-0.38**	-0.42**	0.46**	0.24	0.69**	-0.16	0.46**	-0.49**	0.46**	-0.43**	-	0.46**	0.52**	0.07	0.05	0.23	0.42**	0.63**	0.55**	0.29*	0.33*
12	-0.04	-0.42**	0.61**	0.23	0.44**	0.04	0.61**	-0.13	0.89**	-0.23	0.47**	-	0.33*	0.57**	0.09	0.23	0.35*	0.37**	0.16	0.16	0.23
13	-0.58**	0.05	0.70**	0.80**	0.60**	-0.58**	0.70**	-0.48**	0.28*	-0.57**	0.52**	0.33*	-	-0.38**	-0.45**	0.51**	0.59**	0.75**	0.39**	0.50**	0.70**
14	0.31*	-0.14	0.12	-0.37**	0.01	0.39**	0.12	0.26	0.58**	0.15	0.07	0.58**	-0.38**	-	0.46**	0.07	-0.15	-0.26	-0.21	-0.33*	-0.12
15	0.65**	-0.08	-0.32*	-0.34*	-0.08	0.73**	-0.32*	0.44**	0.13	0.39**	0.05	0.08	-0.46**	0.47**	-	0.05	-0.36**	-0.21	0.15	-0.17	0.02
16	0.15	0.16	0.61**	0.39**	0.35**	-0.21	0.61**	0.21	0.12	0.06	0.24	0.24	0.51**	0.07	0.06	-	0.24	0.34*	0.15	0.16	0.64**
17	-0.25	-0.15	0.43**	0.27*	0.44**	-0.68**	0.43**	-0.49**	0.25	-0.43**	0.45**	0.37**	0.63**	-0.17	-0.41**	0.26	-	0.68**	0.39**	0.46**	0.07
18	-0.36**	0.01	0.50**	0.39**	0.65**	-0.54**	0.50**	-0.33*	0.19	-0.41**	0.64**	0.37**	0.74**	-0.26	-0.21	0.34*	0.73**	-	0.55**	0.50**	0.37**
19	-0.13	-0.12	0.29*	0.20	0.49**	-0.01	0.29*	-0.23	0.26	-0.22	0.56**	0.17	0.38**	-0.21	0.15	0.15	0.41**	0.55**	-	0.74**	0.24
20	-0.24	-0.28*	0.42**	0.46**	0.22	-0.35*	0.42**	-0.26	0.14	-0.19	0.29*	0.16	0.50**	-0.33*	-0.18	0.16	0.48**	0.50**	0.75**	-	0.21
21	-0.25	0.30*	0.53**	0.60**	0.35**	0.04	0.53**	-0.12	0.26	-0.33*	0.33*	0.23	0.70**	-0.12	0.03	0.64**	0.07	0.37**	0.24	0.21	-

*Significant at 5% level of significance
**Significant at 1% level of significance
*C: Characters=1: Days taken for bulb sprout emergence; 2: Per cent bulb sprouting (%); 3: Plant height (cm); 4: Number of leaves/plant; 5: Leaf length (cm); 6: Leaf width (cm); 7: Stem length (cm); 8: Days to flower bud formation ; 9: Bud length (cm); 10: Days to first flower; 11: Stem diameter (cm); 12: Size of the flower (cm); 13: Number of flowers/plant; 14: Tepal length (cm); 15: Tepal width (cm); 16: Duration of flowering (days); 17: Bulb diameter (cm); 18: Weight of bulb (g); 19: Number of bulblets/plant; 20: Weight of bulblet (g); 21: Vase life (days)

Table 4.2.25(c): Estimates of direct and indirect effects of different characters on number of flowers per plant among *Lilium* genotypes under Katrain conditions

*C	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19	20	21
1	**-0.17**	0.001	0.10	-0.38	-0.05	0.18	0.02	0.05	-0.02	0.33	-0.07	0.02	0.09	-0.31	0.001	-0.14	-0.14	0.02	-0.01	-0.11
2	0.01	**-0.02**	-0.01	0.01	0.00	-0.01	0.00	0.01	-0.05	-0.05	-0.07	0.20	-0.04	0.04	0.001	-0.08	0.01	0.02	-0.02	0.13
3	0.06	0.001	**-0.29**	0.40	0.07	-0.13	-0.05	-0.01	0.15	-0.11	0.08	-0.28	0.04	0.15	-0.01	0.24	0.20	-0.05	0.02	0.22
4	0.09	0.001	-0.17	**0.67**	0.06	-0.15	-0.03	-0.03	0.06	-0.23	0.04	-0.11	-0.11	0.16	-0.01	0.15	0.16	-0.04	0.03	0.25
5	0.07	0.001	-0.16	0.33	**0.13**	-0.09	-0.03	-0.03	0.12	-0.26	0.12	-0.21	0.00	0.04	-0.01	0.25	0.26	-0.09	0.01	0.15
6	-0.09	0.001	0.11	-0.29	-0.03	**0.34**	0.02	0.03	0.05	0.15	-0.03	-0.02	0.12	-0.35	0.00	-0.38	-0.22	0.001	-0.02	0.02
7	0.06	0.001	-0.29	0.40	0.07	-0.13	**-0.05**	-0.01	0.15	-0.11	0.08	-0.28	0.04	0.15	-0.01	0.24	0.20	-0.05	0.02	0.22
8	-0.12	0.001	0.04	-0.30	-0.06	0.14	0.01	**0.07**	-0.05	0.37	-0.09	0.06	0.08	-0.21	0.001	-0.28	-0.13	0.04	-0.01	-0.05
9	0.01	0.001	-0.16	0.14	0.06	0.07	-0.03	-0.01	**0.27**	-0.12	0.08	-0.42	0.17	-0.06	0.001	0.14	0.08	-0.05	0.01	0.11
10	-0.13	0.001	0.07	-0.36	-0.07	0.11	0.01	0.06	-0.08	**0.43**	-0.07	0.11	0.05	-0.19	0.001	-0.24	-0.17	0.04	-0.01	-0.14
11	0.06	0.01	-0.13	0.16	0.09	-0.05	-0.02	-0.03	0.12	-0.19	**0.17**	-0.22	0.02	-0.02	0.001	0.25	0.26	-0.10	0.02	0.14
12	0.01	0.01	-0.17	0.15	0.06	0.01	-0.03	-0.01	0.24	-0.10	0.08	**-0.47**	0.17	-0.04	0.001	0.21	0.15	-0.03	0.01	0.10
14	-0.11	0.001	0.09	-0.23	-0.01	0.24	0.02	0.03	0.04	0.17	0.01	-0.04	**0.14**	-0.48	0.001	-0.23	-0.09	-0.03	-0.01	0.01
15	-0.02	0.001	-0.18	0.27	0.04	-0.07	-0.03	0.01	0.03	0.03	0.04	-0.11	0.02	**-0.03**	-0.02	0.15	0.14	-0.03	0.01	0.27
16	0.04	0.001	-0.12	0.19	0.06	-0.23	-0.02	-0.03	0.07	-0.19	0.08	-0.17	-0.05	0.19	**0.001**	0.56	0.29	-0.07	0.03	0.03
17	0.06	0.001	-0.14	0.26	0.08	-0.18	-0.02	-0.02	0.05	-0.18	0.11	-0.17	-0.08	0.10	-0.01	**0.41**	0.40	-0.09	0.03	0.16
18	0.02	0.001	-0.08	0.14	0.06	0.00	-0.01	-0.02	0.07	-0.10	0.10	-0.08	-0.06	-0.07	0.001	0.23	**0.22**	-0.17	0.04	0.10
19	0.04	0.01	-0.12	0.31	0.03	-0.12	-0.02	-0.02	0.04	-0.08	0.05	-0.07	-0.10	0.09	0.001	0.27	0.20	**-0.13**	0.06	0.09
20	0.04	-0.01	-0.15	0.41	0.04	0.02	-0.03	-0.01	0.07	-0.14	0.06	-0.11	-0.04	-0.01	-0.01	0.04	0.15	-0.04	**0.01**	0.42
21	-0.17	0.001	0.10	-0.38	-0.05	0.18	0.02	0.05	-0.02	0.33	-0.07	0.02	0.09	-0.31	0.001	-0.14	-0.14	0.02	-0.01	**-0.11**

(Residual effect: 0.028)

Size of the flower is an essential parameter which determines the quality of cut flower. In present study this trait was positively correlated with plant height, leaf length, stem length, bud length, stem diameter, number of flowers/plant, tepal length, bulb diameter and weight of bulb. Thus it becomes clear that for improving the flower size, it is possible to select genotypes through other characters such as plant height, stem length, size and weight of bulb *etc*.

These results corroborate the findings of Dhiman *et al*. (2015b), Kumar (2013) in *Lilium*; Balaram and Janakiram (2009), Kumar *et al*. in gladiolus and Sheela *et al*. (2006) in heliconia.

4.3.2 Path coefficient analysis over Katrain location

The pooled data over Katrain location (Table 4.3.25c) exhibited number of leaves per plant (0.67) had maximum positive direct effect on the number of flowers per plant followed by days to first flower (0.43), bulb diameter (0.41), leaf width (0.34), bud length (0.27), weight of bulb (0.22), stem diameter (0.17), tepal length (0.14), leaf length (0.13), days to flower bud formation (0.07), weight of bulblet (0.01), duration of flowering (0.001) and per cent bulb sprouting (0.15). In contrast, negative direct effect on number of flowers per plant was found to be associated with parameters such as per cent bulb sprouting (-0.02), tepal width (-0.03), stem length (-0.05), vase life (-0.11), number of bulblets per plant (-0.13), days taken for bulb sprout emergence (-0.17), plant height (-0.29) and size of the flower (-0.47).

Data presented in Table 4.3.25(c) also revealed that days taken for bulb sprout emergence (-0.17) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through number of leaves per plant (-0.38) followed by tepal width (-0.31), bulb diameter (-0.14), weight of bulb (-0.14), vase life (-0.11), stem diameter (-0.07), leaf length (-0.05), bud length (-0.02) and weight of bulblet (-0.01). However, higher magnitude of positive indirect effect of the trait was reported via traits such as days to first flower (0.33), leaf width (0.18), plant height (0.10), tepal length (0.09), days to flower bud formation (0.05), number of bulblets per plant (0.02), size of the flower (0.02), stem length (0.02), duration of flowering (0.001) and per cent bulb sprouting (0.001) nullified the negative direct and indirect effects of the trait.

Per cent bulb sprouting (-0.02) had fairly strong negative direct effect on number of flowers/plant along with maximum negative indirect effect through bulb diameter (-0.08) followed by stem diameter (-0.07), bud length (-0.05), days to first flower (-0.05), tepal length (-0.04), weight of bulblet (-0.02), plant height (-0.01) and leaf width (-0.01). However, higher magnitude of positive indirect effect of the trait through size of the flower (0.20), vase life (0.13), tepal width (0.04), number of bulblets per plant (0.02), weight of bulb (0.01), days to flower bud formation (0.01), number of leaves per plant (0.01), days taken for bulb sprout emergence (0.01), duration of flowering (0.001), stem length (0.001) and leaf length (0.001) nullified the negative direct and indirect effects of the trait.

Character such as plant height (-0.29) had negative direct effect on number of flowers/plant along with negative indirect effect through size of the flower (-0.28) followed by leaf width (-0.13), days to first flower (-0.11), stem length (-0.05), number of bulblets per plant (-0.05), days to flower bud formation (-0.01) and duration of flowering (-0.01). However, higher magnitude of positive indirect effect of the trait through number of leaves per plant (0.40), bulb diameter (0.24), vase life (0.22), weight of bulb (0.20), tepal width (0.15), bud length (0.15), stem diameter (0.08), leaf length (0.07),days taken for bulb sprout emergence(0.06), tepal length (0.04), weight of bulblet (0.02) and per cent bulb sprouting (0.001) nullified the negative direct and indirect effects of the trait.

Trait such as number of leaves/plant (0.67) exhibited high positive direct effect on number of flowers/plant along with maximum positive indirect effect through vase life (0.25) followed by weight of bulb (0.16), tepal width (0.16), bulb diameter (0.15), days taken for bulb sprout emergence (0.09), bud length (0.06), leaf length (0.06), stem diameter (0.04), weight of bulblet (0.03) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as duration of flowering (-0.01), days to flower bud formation (-0.03), stem length (-0.03), number of bulblets per plant (-0.04), tepal length (-0.11), size of the flower (-0.11), leaf width (-0.15), plant height (-0.17) and days to first flower (-0.23) which have enabled the trait to establish positive and significant association.

Leaf length (0.13) exhibited low positive direct effect on number of flowers/plant along with maximum positive indirect effect through number of leaves per plant (0.33) followed by weight of bulb (0.26), bulb diameter (0.25), vase life (0.15), stem diameter (0.12), bud length (0.12), days taken for bulb sprout emergence (0.07), tepal width (0.04), weight of bulblet (0.01), tepal length (0.001) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as duration of flowering (-0.01), days to flower bud formation (-0.03), stem length (-0.03), number of bulblets per plant (-0.09), leaf width (-0.09), plant height (-0.16), size of the flower (-0.21) and days to first flower (-0.26) which have enabled the trait to establish positive and significant association.

Leaf width (0.34) exhibited high positive direct effect on number of flowers/plant along with maximum positive indirect effect through days to first flower (0.15) followed by tepal length (0.12), plant height (0.11), bud length (0.05), days to flower bud formation (0.03), vase life (0.02), stem length (0.02), number of bulblets per plant (0.001), duration of flowering (0.001) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as weight of bulblet (-0.02), size of the flower (-0.02), stem diameter (-0.03), leaf length (-0.03), days taken for bulb sprout emergence (-0.09), weight of bulb (-0.22), number of leaves per plant (-0.29), tepal width (-0.35) and bulb diameter (-0.38) which have enabled the trait to establish positive and significant association.

Similarly character stem length (-0.05) also exhibited negative direct effect on number of flowers/plant along with negative indirect effect through traits such as plant height (-0.29) followed by size of the flower (-0.28), leaf width (-0.13), days to first flower (-0.11), number of bulblets per plant (-0.05), days to flower bud formation (-0.01) and duration of flowering (-0.01). On the other hand, higher magnitude of positive indirect effect of the trait through number of leaves per plant(0.40), bulb diameter (0.24), vase life (0.22), weight of bulb (0.20), tepal width (0.15), bud length (0.15), stem diameter (0.08), leaf length (0.07), days taken for bulb sprout emergence (0.06), tepal length (0.04), weight of bulblet (0.02) and per cent bulb sprouting(0.001) nullified the negative direct and indirect effects of the trait.

Character such as days to flower bud formation (0.07) exhibited negligible positive direct effect along with maximum positive indirect effect through days to first flower (0.37) followed by leaf width (0.14), tepal length (0.08), size of the flower (0.06), number of bulblets per plant (0.04), plant height (0.04), stem length (0.01), duration of flowering (0.001) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as weight of bulblet (-0.01), vase life (-0.05), bud length (-0.05), leaf length (-0.06), stem diameter (-0.09), days taken for bulb sprout emergence (-0.12), weight of bulb (-0.13), tepal width (-0.21), bulb diameter (-0.28) and number of leaves per plant (-0.30) which have enabled the trait to establish positive and significant association.

Bud length (0.27) exhibited moderate positive direct effect along with maximum positive indirect effect through bud length (0.27) followed by tepal length (0.17), bulb diameter (0.14), number of leaves per plant (0.14), vase life (0.11), weight of bulb (0.08), stem diameter (0.08), leaf width (0.07), leaf length (0.06), weight of bulblet (0.01), days taken for bulb sprout emergence (0.01), duration of flowering (0.001) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as days to flower bud formation (-0.01), stem length (-0.03), number of bulblets per plant (-0.05), tepal width (-0.06), days to first flower (-0.12), plant height (-0.16) and size of the flower (-0.42) which have enabled the trait to establish positive and significant association (Table 4.3.25c).

Days to first flower (0.43) exhibited high positive direct effect along with maximum positive indirect effect through size of the flower (0.11) followed by leaf width (0.11), plant height (0.07), days to flower bud formation (0.06), tepal length (0.50), number of bulblets per plant (0.04), stem length (0.01), duration of flowering (0.001) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as weight of bulblet (-0.01), stem diameter (-0.07), leaf length (-0.07), bud length (-0.08), days taken for bulb sprout emergence (-0.13), vase life (-0.14), weight of bulb (-0.17), tepal width (-0.19), bulb diameter (-0.24) and number of leaves per plant(-0.36) which have enabled the trait to establish positive and significant association.

Stem diameter (0.17) exhibited low positive direct effect along with maximum positive indirect effect through weight of bulb (0.26) followed by bulb diameter (0.25), number of leaves per plant (0.16), vase life (0.14), bud length (0.12), leaf length (0.09), days taken for bulb sprout emergence (0.06), weight of bulblet (0.02), tepal length (0.02), per cent bulb sprouting (0.01) and duration of flowering (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as tepal width (-0.02), stem length (-0.02), days to flower bud formation (-0.03), leaf width (-0.05), number of bulblets per plant (-0.10), plant height (-0.13), days to first flower (-0.19) and size of the flower (-0.22) which have enabled the trait to establish positive and significant association.

Size of the flower (-0.47) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through plant height (-0.17) followed by days to first flower (-0.10), tepal width (-0.04), stem length (-0.03), number of bulblets per plant (-0.03) and days to flower bud formation (-0.01). In contrast higher magnitude of positive indirect effects of the trait through bud length (0.24), bulb diameter (0.21), tepal length (0.17), weight of bulb (0.15),number of leaves per plant(0.15), vase life (0.01), stem diameter (0.08), leaf length (0.06), weight of bulblet (0.01), leaf width (0.01), per cent bulb sprouting (0.01), days taken for bulb sprout emergence (0.01) and duration of flowering (0.001) nullified the negative direct and indirect effects of the trait.

Tepal length (0.14) had low positive direct effect on number of flowers/plant along with maximum positive indirect effect through leaf width (0.24) followed by days to first flower (0.17), plant height (0.09), bud length (0.04), days to flower bud formation (0.03), stem length (0.02), vase life (0.01), stem diameter (0.01), duration of flowering (0.001) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as tepal width (-0.48), number of leaves per plant (-0.23), bulb diameter (-0.23), days taken for bulb sprout emergence (-0.11), weight of bulb (-0.09), size of the flower (-0.04), number of bulblets per plant (-0.03), leaf length (-0.01) and weight of bulblet (-0.01) which have enabled the trait to establish positive and significant association.

Tepal width (-0.03) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through traits such as plant height (-0.18) followed by size of the flower (-0.11), leaf width (-0.07), plant height (-0.18), stem length (-0.03), number of bulblets per plant (-0.03), days taken for bulb sprout emergence (-0.02) and duration of flowering (-0.02). In contrast higher magnitude of positive indirect effects of the trait through vase life (0.27), number of leaves per plant (0.27), bulb diameter (0.15), weight of bulb (0.14), stem diameter (0.04), leaf length (0.04), days to first flower (0.03), bud length (0.03), tepal length (0.02), weight of bulblet (0.01), days to flower bud formation (0.01) and per cent bulb sprouting (0.001) nullified the negative direct and indirect effects of the trait.

Duration of flowering (0.001) had negligible positive direct effect on number of flowers/plant along with maximum positive indirect effect through bulb diameter (0.56) followed by weight of bulb (0.29), tepal width (0.19),number of leaves per plant (0.19), stem diameter (0.08), bud length (0.07), leaf length (0.06), days taken for bulb sprout emergence (0.04), vase life (0.03), weight of bulblet (0.03) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as leaf width (-0.23), days to first flower (-0.19), size of the flower (-0.17), plant height (-0.12), number of bulblets per plant (-0.07), tepal length (-0.05), days to flower bud formation (-0.03) and stem length (-0.02) which have enabled the trait to establish positive and significant association.

Bulb diameter (0.41) recorded high positive direct effect on number of flowers/plant along with maximum positive indirect effect through weight of bulb (0.40) followed by number of leaves per plant (0.26), vase life (0.16), stem diameter (0.11), tepal width (0.10), leaf length (0.08), days taken for bulb sprout emergence (0.06), bud length (0.05), weight of bulblet (0.03) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as leaf width (-0.18), days to first flower (-0.18), size of the flower (-0.17), plant height (-0.14), number of bulblets per plant (-0.09), tepal length (-0.08), stem length (-0.02), days to flower bud formation (-0.02) and duration of flowering (-0.01) which have enabled the trait to establish positive and significant association.

Weight of bulb (0.22) had moderate positive direct effect on number of flowers/plant along with maximum positive indirect effect through bulb diameter (0.23) followed by number of leaves per plant (0.14), vase life (0.10), stem diameter (0.10), bud length (0.07), leaf length (0.06), weight of bulblet (0.04), days taken for bulb sprout emergence (0.02), duration of flowering (0.001), leaf width (0.001) and per cent bulb sprouting (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as number of bulblets per plant (-0.17), days to first flower (-0.10), plant height (-0.08), size of the flower (-0.08), tepal width (-0.07), tepal length (-0.06), days to flower bud formation (-0.02) and stem length (-0.01) which have enabled the trait to establish positive and significant association.

Number of bulblets/plant (-0.13) observed negative direct effect on number of flowers/plant along with negative indirect effect through other traits such as plant height (-0.12) followed by leaf width (-0.12), tepal length (-0.10), days to first flower (-0.08), size of the flower (-0.07), stem length (-0.02) and days to flower bud formation (-0.02). In contrast highest magnitude of positive indirect effects of the trait was observed through number of leaves per plant (0.31) followed by bulb diameter (0.27), weight of bulb (0.20), vase life (0.09), tepal width (0.09), stem diameter (0.05), weight of bulblet (0.06), bud length (0.04, days taken for bulb sprout emergence (0.04), leaf length (0.03), per cent bulb sprouting (0.001) and duration of flowering (0.001) nullified the negative direct and indirect effects of the trait.

Weight of bulblet (0.01) had negligible positive direct effect on number of flowers/plant along with maximum positive indirect effect through vase life (0.42) followed by number of leaves per plant (0.41), weight of bulb (0.15), bud length (0.07), stem diameter (0.06), bulb diameter (0.07), leaf length (0.04), days taken for bulb sprout emergence (0.04) and leaf width (0.02) which have masked the negative indirect effect on number of flowers/plant caused via traits such as plant height (-0.15), days to first flower (-0.14) which have enabled the trait to establish positive and significant association.

Vase life of flowers (-0.11) observed negative direct effect on number of flowers/plant along with negative indirect effect through other traits such as number of leaves per plant (-0.38) followed by tepal width (-0.31), days taken for bulb sprout emergence (-0.17), bulb diameter (-0.14), weight of bulb (-0.14), stem diameter (-0.07), leaf length (-0.05), bud length (-0.02) and weight of bulblet (-0.01). In contrast highest magnitude of positive indirect effects of the trait was observed through days to first flower (0.33) followed by leaf width (0.18), plant height (0.10), tepal length (0.09), days to flower bud formation (0.05), number of bulblets per plant (0.02), size of the flower (0.02), stem length (0.02), duration of flowering (0.001) and per cent bulb sprouting (0.001) nullified the negative direct and indirect effects of the trait.

The residual effect was estimated as 0.028 (2.80 %) indicating that all the characters contributed 98.20 % to the variability in number of flowers per plant.

Over Katrain location, path coefficient revealed that number of leaves per plant (0.67) had maximum positive direct effect on the number of flowers per plant followed by days to first flower (0.43), bulb diameter (0.41), leaf width (0.34), bud length (0.27), weight of bulb (0.22), stem diameter (0.17), tepal length (0.14), leaf length (0.13), days to flower bud formation (0.07), weight of bulblet (0.01), duration of flowering (0.001) and per cent bulb sprouting (0.15). This indicates that direct selection for these traits will be useful for further crop improvement. Moreover in our study, traits such as number of leaves per plant, leaf length, bud length, stem diameter, duration of flowering, bulb diameter, weight of bulb and weight of bulblet had positive correlation with number of flowers/plant. On the other hand characters leaf width, days to flower bud formation and days to first flower associated with negative genotypic correlation indicating selection of such traits will reduce the undesirable indirect effect.

Table 4.1.2.26(a): Pooled estimates of mean, genotypic and phenotypic coefficient of variability, heritability, genetic advance and genetic gain among 18 *Lilium* genotypes

Characters	Mean ± Standard error	Range	Coefficients of variability (%)		Heritability (%)	Genetic advance (%)	Genetic gain (%)
			PCV	GCV			
Days taken for bulb sprout emergence	110.55 ± 0.55	95.68 – 130.28	8.69	8.67	99.52	19.70	17.82
Per cent bulb sprouting (%)	99.21 ± 1.02	97.50 - 100.00	1.44	0.72	24.59	0.73	0.73
Plant height (cm)	72.32 ± 0.49	53.65 - 97.73	17.48	17.46	99.77	25.98	35.93
Number of leaves/plant	51.19 ± 0.68	18.07 - 83.62	34.01	33.97	99.77	35.78	69.90
Leaf length (cm)	10.42 ± 0.15	6.62 - 14.61	22.06	21.99	99.33	4.71	45.15
Leaf width (cm)	2.14 ± 0.05	1.42 - 3.51	25.70	25.52	98.56	1.12	52.19
Stem length (cm)	52.32 ± 0.49	33.65 - 77.73	24.16	24.14	99.77	25.98	49.66
Days to flower bud formation	58.04 ± 0.36	41.60 – 73.48	13.36	13.34	99.68	15.92	27.44
Bud length (cm)	9.50 ± 0.10	6.73 - 12.79	14.69	14.62	99.17	2.85	30.00
Days to first flower	87.13 ± 0.58	65.21 – 102.24	10.39	10.36	99.39	18.54	21.28
Stem diameter (cm)	0.66 ± 0.02	0.43 - 0.79	15.11	14.78	95.72	0.20	29.78
Size of the flower (cm)	16.46 ± 0.19	13.23 - 20.39	10.90	10.80	98.28	3.63	22.06
Number of flowers per plant	4.59 ± 0.14	2.33 - 7.98	34.18	33.96	98.77	3.19	69.54
Tepal length (cm)	9.45 ± 0.14	6.95 - 12.43	14.02	13.91	98.37	2.69	28.42
Tepal width (cm)	2.95 ±0.06	2.28 - 3.62	12.74	12.48	96.03	0.75	25.20
Duration of flowering (days)	17.38 ± 0.31	12.24 - 23.81	18.30	18.17	98.58	6.46	37.16
Bulb diameter (cm)	4.69 ± 0.19	3.33 - 5.75	13.94	13.02	87.19	1.17	25.04
Weight of bulb (g)	47.11 ± 0.39	22.15 - 64.05	24.22	24.20	99.83	23.46	49.80
Number of bulblets/plant	2.97 ± 0.13	1.40 - 7.20	51.10	50.81	98.88	3.09	104.08
Weight of bulblet (g)	1.91 ± 0.14	0.67 - 3.26	30.25	28.96	91.66	1.09	57.12
Vase life (days)	7.24 ± 0.22	6.22 - 10.28	13.40	12.87	92.20	1.84	25.45

Patra and Mohanty (2015), Kumar *et al*. (2015) and Gantait (2016) also reported similar results on direct and indirect effects of various traits in gladiolus.

4.1.4.1 Coefficients of variability

Pooled analysis of variance over four environments (E_1, E_2, E_3 and E_4) as presented in Table 4.1.2.26(a).shows that the treatment mean squares were significant for all the characters indicating the genotypic differences among the various characters studied. The widest range of variation was recorded for the number of leaves/plant (18.07 to 83.62) followed by plant height (53.65 to 97.73) and stem length (33.65 to 77.73). However, narrowest range for variability was observed for stem diameter (0.43 to 0.79) followed by tepal width (2.28 to 3.62) and bulb diameter (3.33 to 5.75).

Pooled analysis over environment also revealed the phenotypic coefficients of variability (PCV) higher than the genotypic coefficients of variability (GCV) for all the characters and thus indicating the role of environment in the expression of characters. High values for phenotypic coefficient of variability (PCV) recorded for number of bulblet/plant (51.10 %), number of flowers per plant (34.18 %), number of leaves/plant (34.01 %) and weight of bulblet (30.25 %) ; moderate values for characters such as leaf width (25.70 %), weight of bulb (24.22 %), stem length (24.16 %), leaf length (22.06 %), duration of flowering (18.30 %), stem diameter (15.11 %), and plant height (17.48 %) while low PCV values were observed for parameters like; days taken for bulb sprout emergence (8.69 %) per cent bulb sprouting (1.44 %), days to flower bud formation (13.36 %), bud length (14.69 %), days to first flower (10.39 %), size of the flower (10.90 %), tepal length (14.02 %), tepal width (12.74 %), bulb diameter (13.94 %) and vase life (13.40 %).

Studies on genotypic coefficient of variability (GCV) as presented in Table 4.1.2.26(a) revealed that characters such as number of bulblet per plant (50.81 %) followed by number of leaves/plant (33.97 %); and number of flowers/plant (33.96 %) recorded high values of GCV ; moderate values of GCV were observed for characters such as leaf width (25.52 %), stem length (24.14 %), leaf length (21.99 %), duration of flowering (18.17 %) and plant height (17.46 %) whereas low GCV values were observed for parameters such as days taken for bulb sprout emergence (8.67 %) per cent bulb sprouting (0.72 %), days to flower bud formation (13.34 %), bud length (14.62 %), days to first flower (10.36 %), stem diameter

(14.78 %), size of the flower (10.80 %), tepal length (13.91 %), tepal width (12.48 %), bulb diameter (13.02 %) and vase life (12.87 %).

Pooled analysis over four environments also revealed phenotypic coefficients of variability higher with very less differences in magnitude than genotypic coefficients of variability.

4.1.4.2 Heritability

Data presented in Table 4.1.2.26(a) clearly illustrates that character such as per cent bulb sprouting (24.59 %) recorded low heritability while rest of all characters *viz*., days taken for bulb sprout emergence (99.52 %), plant height (99.77 %), number of leaves/plant (99.77 %), leaf length (99.33 %), leaf width (98.56 %), stem length (99.77 %), days to flower bud formation (99.68 %), bud length (99.17 %), days to first flower (99.39 %), stem diameter (95.72 %), size of the flower (98.28 %), number of flowers per plant (98.77 %), tepal length (98.37 %), tepal width (96.03 %), duration of flowering (98.58 %), bulb diameter (87.19 %),weight of bulb (99.83 %), number of bulblet/plant (98.88 %), weight of bulblet (91.66 %) and vase life (92.20 %).

Pooled analysis over environments (E_1, E_2, E_3 and E_4) also revealed the similar results indicating high heritability estimates for all the characters except bulb sprout .These results corroborate the earlier findings of Negi *et al*. (1982), Singh and Singh (1983), Lal *et al*. (1985) in gladiolus, Jhon *et al*. (2006) in tulip and Dhiman *et al*. (2015b) in *Lilium*.

4.1.4.3 Genetic advance and genetic gain

It is evident from Table 4.1.2.26(a) that high heritability coupled with moderate genetic advance was observed for number of leaves/plant (35.78 %), plant height (25.98 %) and stem length (25.98 %) suggesting the involvement of both additive and non-additive gene action and simple selection will serve the purpose of selecting better genotypes. However, most of the parameters exhibited low genetic advance. High heritability along with low genetic advance recorded for traits such as days taken for bulb sprout emergence (19.70 %), leaf length (4.71 %), leaf width (1.12 %), days to flower bud formation (15.92 %), bud length (2.85 %), days to first flower (18.54 %), stem diameter (0.20 %), size of the flower (3.63 %), number of flowers per plant (3.19 %), tepal length (2.69 %), tepal width (0.75 %), duration of flowering (6.46 %), bulb diameter (1.17 %),weight of bulb (23.46 %), number of bulblet/plant (3.09 %), weight of bulblet (1.09 %) and vase life (1.84 %) indicating non-additive gene action and high heritability of characters is being exhibited due to favourable influence of environments rather than genotype and selection for such traits may not be rewarding.

Moderate heritability with highest genetic gain (104.08 %) was recorded for number of bulblet/plant followed by traits such as number of leaves per plant (69.90 %), leaf width (52.19 %), number of flowers/plant (69.54 %) and weight of bulblet (57.12 %) suggesting the involvement of both additive and non-additive gene action indicating that simple selection will serve the purpose of selecting better genotypes.

High heritability along with low genetic gain was recorded for traits like; days taken for bulb sprout emergence (17.82 %), per cent bulb sprouting (0.73 %), days to first flower (21.28 %) and size of the flower (22.06 %) indicating selection for these characters would not be effective for improvement.

4.2.1.5 Phenotypic correlations

i) Days taken for bulb sprout emergence

Analysis of pooled data of both locations (Table 4.2.26b) showed significant positive correlation of days taken for bulb sprout emergence with leaf width (0.72), days to flower bud formation (0.84), days to first flower (0.85), size of the flower (0.38), tepal length (0.40), tepal width (0.45). Characters such as number of leaves/plant (-0.58), leaf length (-0.67), stem diameter (-0.33), number of flower/plant (-0.38) and bulb diameter (-0.40) and weight of bulb (-0.32) observed significantly negative correlation with days taken for bulb sprout emergence.

ii) Per cent bulb sprouting

In case of per cent bulb sprouting, parameters *viz*., number of leaves/plant (0.11), leaf width (0.01) weight of bulb (0.07), number of bulblet/plant (0.20) and vase life (0.19) recorded positive non significant correlation with per cent bulb sprouting while characters such as days taken for bulb sprout emergence (-0.06), plant height (-001), leaf length (-0.01), stem length (-0.01), days to flower bud formation (-0.07), bud length (-0.09), leaf length (-0.01), leaf length (-0.02), leaf width (-0.01), bud length (-0.09), days to first flower (-0.14), stem diameter (-0.08), size of the flower (-0.17), number of flowers/plant (0.01), tepal length (-0.23), tepal width (-0.14), duration of flowering (-0.16), bulb diameter (-0.04) and number of bulblets/plant (-0.01) observed negative non significant correlation with per cent bulb sprouting.

iii) Plant height

Highly significant positive correlation of plant height was recorded with number of leaves/plant (0.56), leaf length (0.44), stem length (1.00), bud length (0.52), size of the flower (0.42), number of flowers/plant (0.59), tepal length (0.35), duration of flowering (0.51), bulb diameter (0.32), number of bulblet/plant (0.28) and vase life (0.52) while rest of all the other parameters observed non significant correlation with plant height.

iv) Number of leaves/plant

Number of leaves per plant recorded significant positive correlation with plant height (0.56), leaf length (0.74), stem length (0.56), stem diameter (0.28), number of flowers per plant (0.82), duration of flowering (0.54), bulb diameter (0.54), weight of bulb (0.57), number of bulblets/plant (0.45), weight of bulblet (0.48) and vase life (0.58) whereas significant negative correlation with days taken for bulb sprout emergence (-0.58), leaf width (-0.61), days to flower bud formation (-0.48), days to first flower (-0.45), tepal length (-0.33) and tepal width (-0.46).

v) Leaf length

This trait showed significant positive correlation with characters such as plant height (0.44), number of leaves/plant (0.74), stem length (0.44), stem diameter (0.48), number of flowers/plant (0.72), duration of flowering (0.39), bulb diameter (0.60), weight of bulb (0.58), number of bulblets/plant (0.51), weight of bulblet (0.27) and vase life (0.31) along with negative correlation with days taken for bulb sprout emergence (-0.61), leaf width (-0.47), days to flower bud formation (-0.64) and days to first flower (-0.68).

vi) Leaf width

Leaf width recorded significantly positive correlation with days taken for bulb sprout emergence (0.73), days to flower bud formation (0.55), bud length (0.34), days to first flower (0.50), size of the flower (0.44), tepal length (0.46) and tepal width (0.66) whereas traits such as number of leaves/plant (-0.61), leaf length (-0.47), number of flowers/plant (-0.32), bulb diameter (-0.49) and weight of bulb (-0.50) recorded significantly negative correlation with leaf width.

vii) Stem length

Significant positive correlation of this trait was recorded with plant height (1.00), number of leaves/plant (0.56), leaf length (0.44), bud length (0.52), size of the flower (0.42), number of flowers/plant (0.59), tepal length (0.35), duration of flowering (0.51), weight of bulb (0.32), weight of bulblet (0.28) and vase life (0.52) while rest of all the parameters showed non significant correlation with stem length.

viii) Days to flower bud formation

Character days to flower bud formation showed significant positive correlation with days taken for bulb sprout emergence (0.84), leaf width (0.55), days to first flower (0.92),size of the flower (0.30) and tepal length (0.37) while significant negative correlation was recorded with number of leaves/plant (-0.48), leaf length (-0.64), stem diameter (-0.57), number of flowers/plant (-0.30), bulb diameter (-0.38) and weight of bulb (-0.31).

ix) Bud length

Character bud length exhibited significant positive correlation with plant height (0.52), leaf width (0.34), stem length (0.52), stem diameter (0.33), size of the flower (0.90), tepal length (0.88) and tepal width (0.53) whereas all the other traits exhibited non significant correlation with bud length.

x) Days to first flower

It is clearly evident from the Table 4.2.26(b) that days to first flower was significantly positively correlated with days taken for bulb sprout emergence (0.85), leaf width (0.50), days to flower bud formation (0.92) and tepal length (0.29) while traits such as number of leaves/plant (-0.45), leaf length (-0.68), stem diameter (-0.53), number of flowers/plant (-0.36), bulb diameter (-0.41) and weight of the bulb (-0.37) recorded significant negative correlation with this trait.

Table 4.2.26(b): Pooled analysis of coefficients of correlation of phenotypic (above diagonal) and genotypic (below diagonal) among different characters in *Lilium* genotypes

C*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	-	-0.06	0.08	-0.58**	-0.67**	0.73**	0.08	0.84**	0.25	0.85**	-0.33*	0.38**	-0.38**	0.40**	0.45**	0.04	-0.40**	-0.32*	-0.19	-0.04	0.08
2	-0.10	-	-0.01	0.11	-0.01	0.01	-0.01	-0.07	-0.09	-0.14	-0.08	-0.17	-0.01	-0.23	-0.14	-0.16	-0.04	0.07	-0.01	0.2	0.19
3	0.08	-0.01	-	0.56**	0.44**	-0.04	1.00**	0.12	0.52**	0.10	0.16	0.42**	0.59**	0.35**	-0.08	0.51**	0.25	0.32*	0.18	0.28*	0.52**
4	-0.58**	0.21	0.56**	-	0.74**	-0.61**	0.56**	-0.48**	-0.08	-0.45**	0.28*	-0.24	0.82**	-0.33*	-0.46**	0.54**	0.54**	0.57**	0.45**	0.48**	0.58**
5	-0.67**	-0.05	0.45**	0.74**	-	-0.47**	0.44**	-0.64**	0.22	-0.68**	0.48**	0.04	0.72**	0.01	-0.06	0.39**	0.60**	0.58**	0.51**	0.27*	0.31*
6	0.74**	-0.002	-0.04	-0.62**	-0.48**	-	-0.04	0.55**	0.34*	0.50**	-0.08	0.44**	-0.32*	0.46**	0.66**	-0.14	-0.49**	-0.50**	-0.11	-0.13	0.09
7	0.08	-0.01	1.00**	0.56**	0.45**	-0.04	-	0.12	0.52**	0.10	0.16	0.42**	0.59**	0.35**	-0.08	0.51**	0.25	0.32*	0.18	0.28*	0.52**
8	0.85**	-0.12	0.12	-0.48**	-0.65**	0.56**	0.12	-	0.16	0.92**	-0.57**	0.30*	-0.30*	0.37**	0.20	0.07	-0.38**	-0.31*	-0.26	-0.11	0.05
9	0.25	-0.23	0.52**	-0.08	0.22	0.34*	0.52**	0.16	-	0.06	0.33*	0.90**	0.13	0.88**	0.53**	0.19	0.15	0.06	0.06	0.18	0.11
10	0.86**	-0.27*	0.10	-0.45**	-0.69**	0.50**	0.10	0.93**	0.06	-	-0.53**	0.24	-0.36**	0.29*	0.15	0.03	-0.41**	-0.37**	-0.21	-0.17	0.01
11	-0.33*	-0.09	0.16	0.29*	0.50**	-0.08	0.16	-0.58**	0.33*	-0.54**	-	0.23	0.39**	0.21	0.29*	0.25	0.51**	0.48**	0.49**	0.50**	0.28*
12	0.38**	-0.39**	0.42**	-0.24	0.04	0.45**	0.42**	0.30*	0.91**	0.25	0.23	-	0.03	0.93**	0.58**	0.20	-0.03	-0.17	-0.12	-0.01	0.04
13	-0.38**	0.05	0.59**	0.82**	0.73**	-0.33*	0.59**	-0.30*	0.13	-0.37**	0.40**	0.03	-	-0.03	-0.06	0.83**	0.68**	0.61**	0.55**	0.55**	0.70**
14	0.41**	-0.41**	0.36**	-0.33*	0.01	0.47**	0.36**	0.37**	0.89**	0.29*	0.22	0.95**	-0.03	-	0.59**	0.17	-0.02	-0.15	-0.02	-0.04	0.02
15	0.46**	-0.31*	-0.08	-0.46**	-0.06	0.68**	-0.08	0.21	0.54**	0.16	0.32*	0.60**	-0.06	0.60**	-	0.10	0.01	-0.08	0.24	0.08	0.02
16	0.04	-0.29*	0.52**	0.54**	0.39**	-0.15	0.52**	0.07	0.20	0.03	0.25	0.20	0.84**	0.17	0.10	-	0.57**	0.50**	0.47**	0.50**	0.67**
17	-0.44**	-0.11	0.27	0.57**	0.64**	-0.52**	0.27	-0.41**	0.16	-0.44**	0.57**	-0.03	0.72**	-0.02	0.01	0.63**	-	0.86**	0.57**	0.57**	0.22
18	-0.32*	0.14	0.32*	0.57**	0.58**	-0.51**	0.32*	-0.31*	0.06	-0.37**	0.49**	-0.17	0.62**	-0.15	-0.08	0.51**	0.91**	-	0.59**	0.69**	0.30*
19	-0.20	-0.05	0.18	0.45**	0.51**	-0.11	0.18	-0.26	0.06	-0.21	0.50**	-0.12	0.56**	-0.02	0.25	0.48**	0.61**	0.60**	-	0.54**	0.50**
20	-0.04	0.52**	0.30*	0.50**	0.28*	-0.13	0.30*	-0.12	0.19	-0.18	0.55**	0.01	0.58**	-0.05	0.08	0.54**	0.63**	0.72**	0.57**	-	0.64**
21	0.08	0.24	0.54**	0.60**	0.33*	0.10	0.54**	0.06	0.11	0.01	0.29*	0.04	0.72**	0.02	0.02	0.70**	0.25	0.31*	0.53**	0.70**	-

*Significant at 5% level of significance

**Significant at 1% level of significance

*C: Characters=1: Days taken for bulb sprout emergence; 2: Per cent bulb sprouting (%); 3: Plant height (cm); 4: Number of leaves/plant; 5: Leaf length (cm); 6: Leaf width (cm); 7: Stem length (cm); 8: Days to flower bud formation ; 9: Bud length (cm); 10: Days to first flower; 11: Stem diameter (cm); 12: Size of the flower (cm); 13: Number of flowers/plant; 14: Tepal length (cm); 15: Tepal width (cm); 16: Duration of flowering (days); 17: Bulb diameter (cm); 18: Weight of bulb (g); 19: Number of bulblets/plant; 20: Weight of bulblet (g); 21: Vase life (days)

xi) Stem diameter

Stem diameter showed significant positive correlation with characters such as number of leaves/plant (0.28), leaf length (0.48), bud length (0.33), number of flowers/plant (0.39), tepal width (0.29), bulb diameter (0.51), weight of bulb (0.48), number of bulblet/plant (0.49), weight of bulblet (0.50) and vase life (0.28) while traits such as days taken for bulb sprout emergence (-0.33), days to flower bud formation (-0.57) and days to first flower (-0.53) recorded negative significant correlation with stem diameter.

xii) Size of the flower

Size of the flower recorded significantly high positive correlation with days taken for bulb sprout emergence (0.38), plant height (0.42), leaf width (0.44), stem length (0.42), days to flower bud formation (0.30), bud length (0.90), tepal length (0.93) and tepal width (0.58) whereas rest of all other parameters observed non significant correlation with size of the flower.

xiii) Number of flowers/plant

Significant positive correlation of number of flowers/plant at phenotypic level was observed with plant height (0.59), number of leaves/plant (0.82), leaf length (0.72), stem length (0.59), stem diameter (0.39), duration of flowering (0.83), bulb diameter (0.68), weight of bulb (0.61), number of bulblets/plant (0.55), weight of bulblet (0.55) and vase life (0.70) while characters such as days taken for bulb sprout emergence (-0.38), leaf width (-0.32) and days to flower bud formation (-0.30) observed significantly negative correlation with number of flowers/plant.

xiv) Tepal length

Character tepal length recorded significantly high positive correlation with days taken for bulb sprout emergence (0.42), plant height (0.35), leaf width (0.46), stem length (0.35), days to flower bud formation (0.37), bud length (0.88), days to first flower (0.29), size of the flower (0.93) and tepal width (0.59) while number of leaves/plant (-0.33) recorded negative significant correlation with tepal length.

xv) Tepal width

Tepal width recorded significant positive correlation with days taken for bulb sprout emergence (0.45), leaf width (0.66), bud length (0.53), stem diameter (0.29), size of the flower (0.58) and tepal length (0.59). On the other hand significant negative correlation was observed with number of leaves/plant (-0.46).

xvi) Duration of flowering

Flowering duration observed significant positive correlation with plant height (0.51), number of leaves/plant (0.54), leaf length (0.39), stem length (0.51), number of flower/plant (0.83), bulb diameter (0.57), weight of bulb (0.50), number of bulblet/plant (0.47), weight of bulblet (0.50) and vase life (0.67) while rest of all the other characters showed non significant correlation with duration of flowering.

xvii) Bulb diameter

This trait recorded significant positive correlation with number of leaves/plant (0.54), leaf length (0.60), stem diameter (0.51), number of flowers/plant (0.68), duration of flowering (0.57), weight of bulb (0.86), number of bulblet/plant (0.57) and weight of bulblet (0.57) while characters such as days taken for bulb sprout emergence (-0.40), leaf width (-0.49), days to flower bud formation (-0.38) and days to first flower (-0.41) observed significant negative correlation with this trait.

xviii) Weight of bulb

Characters such as plant height (0.32), number of leaves/plant (0.57), leaf length (0.58), stem length (0.32), stem diameter (0.48), number of flowers/plant (0.61), duration of flowering (0.50), bulb diameter (0.86), number of bulblets/plant (0.59), weight of bulblet (0.69) and vase life (0.30) recorded significantly positive correlation while traits such as days taken for bulb sprout emergence (-0.32), leaf width (-0.50), days to flower bud formation (-0.31) and days to first flower (-0.37) recorded significantly negative correlation with weight of the bulb.

xix) Number of bulblet/plant

Number of bulblet/plant observed significantly positive correlation with number of leaves/plant (0.45), leaf length (0.51), stem diameter (0.49), number of flowers/plant (0.55), duration of flowering (0.47), bulb diameter (0.57), weight of bulb (0.59), weight of bulblet (0.54) and vase life (0.50) while rest of all the other traits recorded non significant correlation with number of bulblets/plant.

xx) Weight of bulblet

Characters such as plant height (0.28), number of leaves/plant (0.48), leaf length (0.27), stem length (0.28), stem diameter (0.50), number of flowers/plant (0.55), duration of flowering (0.50), bulb diameter (0.57), weight of bulb (0.69), number of bulblets/plant (0.54) and vase life (0.64) while trait days taken for bulb sprout emergence (-0.04 significantly negative correlation with weight of bulblet.

xxi) Vase life

Plant height (0.52), number of leaves/plant (0.58), leaf length (0.31), stem length (0.52), stem diameter (0.28), number of flowers/plant (0.70), duration of flowering (0.67), weight of bulb (0.30), number of bulblet per plant (0.50) and weight of bulblet (0.64) observed significantly positive correlation with vase life of the flowers while rest of all the characters exhibited significantly negative correlation with vase life.

4.2.1.6 Genotypic correlations

i) Days taken for bulb sprout emergence

Significantly positive correlation (Table 4.2.26b) of days taken for bulb sprout emergence in different *Lilium* genotypes was recorded with leaf width (0.74), days to flower bud formation (0.85), days to first flower (0.86), size of the flower (0.38), tepal length (0.41) and tepal width (0.46) whereas significant negative correlation was recorded with number of leaves per plant (-0.58), leaf length (-0.67), stem diameter (-0.33), number of flowers/plant (-0.38), bulb diameter (-0.44) and weight of bulb (-0.32).

ii) Per cent bulb sprouting

Per cent bulb sprouting was reported significantly positively correlated with weight of bulblet (0.52) whereas other traits such as days to first flower (-0.27), size of the flower (-0.39), tepal length (-0.41), tepal width (-0.31) and duration of flowering (-0.29) recorded significant negative correlation with per cent bulb sprouting.

iii) Plant height

Plant height recorded significant positive correlation with number of leaves per plant (0.56), leaf length (0.45), stem length (1.00), bud length (0.52), size of the flower (0.42), number of flowers per plant (0.59), tepal length (0.36), duration of flowering (0.52), weight of bulb (0.32), number of bulblet/plant (0.30) and vase life (0.54) whereas all the other parameters observed non significant correlation with plant height.

iv) Number of leaves/plant

Number of leaves per plant recorded significant positive correlation with plant height (0.56), leaf length (0.74), stem length (0.56), stem diameter (0.29), number of flowers/plant (0.82), duration of flowering (0.54), bulb diameter (0.57), weight of bulb (0.57), number of bulblets/plant (0.45), weight of bulblet (0.50) and vase life (0.60) while negative significant correlation was recorded with days taken for bulb sprout emergence (-0.58), leaf width (-0.62), days to bud formation (-0.48), days to first flower (-0.45), tepal length (-0.33) and tepal width (-0.46).

v) Leaf length

Significant positive correlation of leaf length was observed with plant height (0.45), number of leaves/plant (0.74), stem length (0.45), stem diameter (0.50), number of flowers/plant (0.73), duration of flowering (0.39), bulb diameter (0.64), weight of bulb (0.58), number of bulblets/plant (0.51), weight of bulblet (0.28) and vase life (0.33) whereas traits such as days taken for bulb sprout emergence (-0.58), leaf width (-0.62), days to flower bud formation (-0.48) and days to first flower (-0.45), tepal length (-0.33) and tepal width (-0.46) observed negative significant correlation with leaf length.

vi) Leaf width

This trait showed significant positive correlation with characters such days taken for bulb sprout emergence (0.74), days to flower bud formation (0.56), bud length (0.34), days to first flower (0.50), size of the flower (0.45), tepal length (0.47) and tepal width (0.68) whereas significant negative correlation was recorded with traits such as number of leaves/plant (-0.62), leaf length (-0.48), number of flowers per plant (-0.33), bulb diameter (-0.52) and weight of bulb (-0.51).

vii) Stem length

Significant positive correlation of this trait was recorded with plant height (1.00), number of leaves/plant (0.56), leaf length (0.45), bud length (0.52), size of the flower (0.42), number of flowers/plant (0.60), tepal length (0.36), duration of flowering (0.52), weight of bulb (0.32), number of bulblets/plant (0.30) and vase life (0.54) while character all the other characters reported non significant correlation with stem length.

viii) Days to flower bud formation

It is evident from data presented in Table 4.2.26(b) that character days to flower bud formation showed significant positive correlation with days taken for bulb sprout emergence (0.85), leaf width (0.56), days to first flower (0.93), size of the flower (0.30) and tepal length (0.37) while significant negative correlation was recorded with number of leaves/plant (-0.48), leaf length (-0.65), stem diameter (-0.58), number of flowers/plant (-0.30), bulb diameter (-0.41) and weight of bulb (-0.31).

ix) Bud length

Character bud length exhibited significant positive correlation with plant height (0.52), leaf width (0.34), stem length (0.52), stem diameter (0.33), size of the flower (0.91), tepal length (0.89) and tepal width (0.54) whereas all the other parameters recorded non significant correlation with bud length.

x) Days to first flower

It is clearly evident from the table that days to first flower was significantly positively correlated with days taken for bulb sprout emergence (0.86), leaf width (0.50), days to flower bud formation (0.93) and tepal length (0.29) while traits such as per cent bulb sprouting (-0.27), number of leaves per plant (-0.45), leaf length (-0.69), stem diameter (-0.54), number of flowers/plant (-0.37), bulb diameter (-0.44) and weight of the bulb (-0.37) recorded significant negative correlation with this trait.

xi) Stem diameter

Stem diameter showed significant positive correlation with characters such as number of leaves/plant (0.29), leaf length (0.50), bud length (0.33), number of flowers/plant (0.40), tepal length (0.32), bulb diameter (0.57), weight of bulb (0.49), number of bulblets/plant (0.50), weight of bulblet (0.55) and vase life (0.29) while traits such as days taken for bulb sprout emergence (-0.33), days to flower bud formation (-0.58) and days to first flower (-0.54) recorded negative significant correlation with stem diameter.

xii) Size of the flower

Significantly high positive correlation of size of the flower was recorded with days taken for bulb sprout emergence (0.38), plant height (0.42), leaf width (0.45), stem length (0.42), days to flower bud formation (0.30), bud length (0.91), tepal length (0.95) and tepal width (0.60). Characters such as per cent bulb sprouting (-0.39) showed significant negative correlation with this trait while rest all of the other parameters reported non significant correlation with size of the flower.

xiii) Number of flowers/plant

Number of flowers per plant recorded significant positive correlation with plant height (0.59), number of leaves per plant (0.82), leaf length (0.73), stem length (0.59), stem diameter (0.40), duration of flowering (0.84), bulb diameter (0.72), weight of bulb (0.62), number of bulblets/plant (0.56), weight of bulblet (0.58) and vase life (0.72) while characters such as days taken for bulb sprout emergence (-0.38), leaf width (-0.33), days to flower bud formation (-0.30) and days to first flower (-0.37) observed significant negative correlation with number of flowers/plant.

xiv) Tepal length

Tepal length recorded significantly high positive correlation with days taken for bulb sprout emergence (0.41), plant height (0.36), stem length (0.36), leaf width (0.47), das to bud formation (0.37), bud length (0.89), days to first flower (0.29), size of the flower (0.95) and tepal width (0.60) while characters per cent bulb sprouting (-0.41) and number of leaves/plant (-0.33) recorded negative significant correlation with tepal length.

xv) Tepal width

Significant positive correlation was associated with characters such as days taken for bulb sprout emergence (0.46), tepal length (0.60), leaf width (0.68), bud length (0.54), stem diameter (0.32) and size of the flower (0.60) while traits such as per cent bulb sprouting (-0.31) and number of leaves/plant (-0.46) showed significant negative correlation with tepal width while rest of all the other characters exhibited non significant correlation with tepal width.

xvi) Duration of flowering

Characters such as plant height (0.52), number of leaves/plant (0.54), leaf length (0.39), stem length (0.52), number of flowers/plant (0.84), bulb diameter (0.63), weight of bulb (0.51), number of bulblets/plant (0.48), weight of bulblet (0.54) and vase life (0.70) while traits such as per cent bulb sprouting (-0.29) exhibited significant negative correlation with duration of flowering.

xvii) Bulb diameter

This trait recorded significant positive correlation with number of leaves/plant (0.57), leaf length (0.64), stem diameter (0.57), number of flowers per plant (0.72), duration of flowering (0.63), weight of bulb (0.91), number of bulblets/plant (0.61) and weight of bulblet (0.63) while characters such as days taken for bulb sprout emergence (-0.44), leaf width (-0.52), days to flower bud formation (-0.41) and days to first flower (-0.44) observed negative significant correlation with this trait.

xviii) Weight of bulb

Significant positive correlation of weight of bulb was recorded with plant height (0.32), number of leaves/plant (0.57), leaf length (0.58), stem length (0.32), stem diameter (0.49), number of flowers/plant (0.62), duration of flowering (0.51), bulb diameter (0.91), number of bulblets/plant (0.60), weight of bulblet (0.72) and vase life (0.31) while characters such as days taken for bulb sprout emergence (-0.32), leaf width (-0.51), days to flower bud formation (-0.31) and days to first flower (-0.37) recorded negative significant correlation with this trait.

xix) Number of bulblet/plant

Number of bulblet/plant recorded significant positive correlation with characters such as number of leaves/plant (0.45), leaf length (0.51), stem diameter (0.50), number of flowers/plant (0.56), duration of flowering (0.48), bulb diameter (0.61), weight of bulb (0.60), weight of bulblet (0.57) and vase life (0.53) while rest of all the parameters recorded non significant correlation with number of bulblet/plant.

xx) Weight of bulblet

This trait recorded significant positive correlation with per cent bulb sprouting (0.52), plant height (0.30), number of leaves/plant (0.50), leaf length (0.28), stem length (0.30), stem diameter (0.55), number of flowers/plant (0.58), duration of flowering (0.54), bulb diameter (0.63), weight of bulb (0.72), number of bulblets/plant (0.57) and vase life (0.70) while rest of all the other parameters recorded significant negative correlation with weight of bulblet.

xxi) Vase life

Vase life recorded significant positive correlation with plant height (0.54), number of leaves/plant (0.60), leaf length (0.33), stem length (0.54) stem diameter (0.29), number of flowers/plant (0.72), duration of flowering (0.70), weight of bulb (0.31) number of bulblet/plant (0.53) and weight of bulblet (0.70) whereas rest of all the other parameters recorded non significant correlation with vase life.

Pooled analysis of correlation estimate over four location indicated that yield component that is number of flowers per plant recorded significant positive genotypic correlation with plant height, number of leaves per plant, leaf length, stem length, stem diameter, duration of flowering, bulb diameter, weight of bulb, number of bulblets/plant, weight of bulblet and vase life indicating that for improving the number of flower stems per plant, selection for plant height, stem length, stem diameter, larges sized bulb will be beneficial.

In contrast characters such as days taken for bulb sprout emergence, leaf width, days to flower bud formation and days to first flower observed significant negative correlation with number of flowers/plant.

These findings are in close conformity with the findings of Dhiman *et al*. (2015b), Rajiv (2013) in *Lilium*; Balaram and Janakiram (2009), Kumar *et al*. in gladiolus and Sheela *et al*. (2006) in heliconia.

4.3.3 Path coefficient analysis (pooled)

The pooled data over four environments (E_1, E_2, E_3 and E_4) as presented in Table 4.3.26(c) revealed traits such as stem length (24.10) exhibited very high positive direct effect on the number of flowers per plant followed by days to first flower (1.03), tepal length (0.99), bulb diameter (0.87), tepal width (0.81), weight of bulblet (0.70), duration of flowering (0.67), leaf length (0.63) and per cent bulb sprouting (0.30). However, parameters such as leaf width (-0.03), vase life (-0.08), stem diameter (-0.10), bud length (-0.17), number of leaves per plant (-0.36), days to flower bud formation (-0.59), number of bulblets per plant (-0.68), days taken for bulb sprout emergence (-0.78), weight of bulb (-1.14), size of the flower (-1.72) and plant height (-23.18) exhibited negative direct effect on number of flowers per plant.

It is evident from the data presented in Table 4.3.26(c) that days taken for bulb sprout emergence (-0.78) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through plant height (-1.80) followed by size of the flower (-0.66), days to flower bud formation (-0.50), leaf length (-0.43), bulb diameter (-0.38), bud length (-0.04), per cent bulb sprouting (-0.03), leaf width (-0.02), weight of bulblet (-0.02) and vase life (-0.01). However, higher magnitude of positive indirect effect of the trait was reported via traits such as stem length (1.87), days to first flower (0.88), tepal length (0.40), weight of bulb (0.37), tepal width (0.37), number of leaves per plant (0.21), number of bulblets per plant (0.13), stem diameter (0.04) and duration of flowering (0.03) nullified the negative direct and indirect effects of the trait.

Trait such as per cent bulb sprouting (0.30) had high strong positive direct effect on number of flowers/plant along with maximum positive indirect effect through size of the flower (0.67) followed by weight of bulblet (0.36), plant height (0.20), days taken for bulb sprout emergence (0.08), days to flower bud formation (0.07), bud length (0.04), number of bulblets per plant (0.03), stem diameter (0.01) and leaf width (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as tepal length (-0.40), days to first flower (-0.28), tepal width (-0.25), stem length (-0.21), duration of flowering (-0.19), weight of bulb (-0.16), bulb diameter (-0.10), number of leaves per plant (-0.08), leaf length (-0.03) and vase life (-0.02) which have enabled the trait to establish positive and significant association.

Plant height (-23.18) had negative direct effect on number of flowers/plant along with negative indirect effect through size of the flower (-0.73) followed by weight of bulb (-0.37), number of leaves per plant (-0.20), number of bulblets per plant (-0.12), bud length (-0.09), tepal width (-0.07), days to flower bud formation (-0.07), days taken for bulb sprout emergence (-0.06), vase life (-0.04) and stem diameter (-0.02). However, higher magnitude of positive indirect effect of the trait through stem length (24.10), tepal length (0.35), duration of flowering (0.35), leaf length (0.28), bulb diameter (0.23), weight of bulblet (0.21), days to

Table 4.3.26(c): Estimates of direct and indirect effects of different characters on number of flowers per plant among 18 *Lilium* genotypes (pooled)

*C	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
1	**-0.78**	-0.03	-1.80	0.21	-0.43	-0.02	1.87	-0.50	-0.04	0.88	0.04	-0.66	0.40	0.37	0.03	-0.38	0.37	0.13	-0.02	-0.01
2	0.08	**0.30**	0.20	-0.08	-0.03	0.001	-0.21	0.07	0.04	-0.28	0.01	0.67	-0.40	-0.25	-0.19	-0.10	-0.16	0.03	0.36	-0.02
3	-0.06	0.001	**-23.18**	-0.20	0.28	0.001	24.10	-0.07	-0.09	0.10	-0.02	-0.73	0.35	-0.07	0.35	0.23	-0.37	-0.12	0.21	-0.04
4	0.45	0.06	-12.97	**-0.36**	0.47	0.02	13.49	0.28	0.01	-0.46	-0.03	0.42	-0.33	-0.38	0.36	0.50	-0.65	-0.31	0.35	-0.05
5	0.52	-0.02	-10.35	-0.27	**0.63**	0.02	10.76	0.38	-0.04	-0.71	-0.05	-0.07	0.01	-0.05	0.26	0.56	-0.67	-0.35	0.20	-0.03
6	-0.57	0.001	0.91	0.22	-0.30	**-0.03**	-0.94	-0.33	-0.06	0.51	0.01	-0.77	0.47	0.55	-0.10	-0.45	0.58	0.08	-0.09	-0.01
7	-0.06	0.001	-23.18	-0.20	0.28	0.001	**24.10**	-0.07	-0.09	0.10	-0.02	-0.73	0.35	-0.07	0.35	0.23	-0.37	-0.12	0.21	-0.04
8	-0.66	-0.04	-2.72	0.17	-0.41	-0.02	2.83	**-0.59**	-0.03	0.95	0.06	-0.52	0.37	0.17	0.05	-0.35	0.35	0.18	-0.08	0.001
9	-0.20	-0.07	-12.01	0.03	0.14	-0.01	12.49	-0.09	**-0.17**	0.06	-0.03	-1.57	0.89	0.43	0.13	0.14	-0.06	-0.04	0.13	-0.01
10	-0.67	-0.08	-2.24	0.16	-0.44	-0.02	2.32	-0.55	-0.01	**1.03**	0.06	-0.42	0.29	0.13	0.02	-0.38	0.42	0.14	-0.12	0.001
11	0.26	-0.03	-3.80	-0.11	0.31	0.001	3.95	0.35	-0.06	-0.56	**-0.10**	-0.40	0.21	0.26	0.17	0.49	-0.56	-0.34	0.38	-0.02
12	-0.30	-0.12	-9.78	0.09	0.03	-0.02	10.17	-0.18	-0.15	0.25	-0.02	**-1.72**	0.95	0.48	0.14	-0.02	0.19	0.08	0.01	0.001
14	-0.32	-0.12	-8.24	0.12	0.01	-0.02	8.57	-0.22	-0.15	0.30	-0.02	-1.64	**0.99**	0.48	0.12	-0.02	0.18	0.02	-0.03	0.001
15	-0.36	-0.09	1.92	0.17	-0.04	-0.02	-2.00	-0.12	-0.09	0.16	-0.03	-1.03	0.59	**0.81**	0.07	0.01	0.09	-0.17	0.06	0.001
16	-0.03	-0.09	-11.98	-0.20	0.25	0.01	12.46	-0.04	-0.03	0.03	-0.03	-0.35	0.17	0.08	**0.67**	0.54	-0.58	-0.32	0.37	-0.06
17	0.34	-0.03	-6.18	-0.21	0.41	0.02	6.43	0.24	-0.03	-0.46	-0.06	0.05	-0.02	0.01	0.42	**0.87**	-1.04	-0.42	0.44	-0.02
18	0.25	0.04	-7.49	-0.21	0.37	0.02	7.79	0.18	-0.01	-0.38	-0.05	0.29	-0.15	-0.06	0.34	0.79	**-1.14**	-0.41	0.50	-0.03
19	0.15	-0.02	-4.24	-0.17	0.32	0.001	4.40	0.16	-0.01	-0.22	-0.05	0.20	-0.02	0.20	0.32	0.53	-0.68	**-0.68**	0.40	-0.04
20	0.03	0.16	-6.92	-0.18	0.18	0.001	7.20	0.07	-0.03	-0.18	-0.06	-0.01	-0.05	0.06	0.36	0.54	-0.82	-0.39	**0.70**	-0.06
21	-0.06	0.07	-12.57	-0.22	0.21	0.001	13.07	-0.03	-0.02	0.01	-0.03	-0.07	0.02	0.02	0.47	0.22	-0.36	-0.36	0.49	**-0.08**

(Residual effect: 0.159)

first flower (0.10), per cent bulb sprouting (0.001) and leaf width (0.001) nullified the negative direct and indirect effects of the trait.

Trait such as number of leaves/plant (-0.36) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through plant height (-12.97) followed by weight of bulb (-0.65), days to first flower (-0.46), tepal width (-0.38), tepal length (-0.33), number of bulblets per plant (-0.31), vase life (-0.05) and stem diameter (-0.03). On the other hand, higher magnitude of positive indirect effect of the trait through stem length (13.49) followed by bulb diameter (0.50), leaf length (0.47), days taken for bulb sprout emergence (0.45), size of the flower (0.42), duration of flowering (0.36), weight of bulblet (0.35), days to flower bud formation (0.28), per cent bulb sprouting (0.06), leaf width (0.02) and bud length (0.01) nullified the negative direct and indirect effects of the trait.

Leaf length (0.63) exhibited high positive direct effect on number of flowers/plant along with maximum positive indirect effect through stem length (10.76) followed by bulb diameter (0.56), days taken for bulb sprout emergence (0.52), days to flower bud formation (0.38), duration of flowering (0.26), weight of bulblet (0.20), leaf width (0.02) and tepal length (0.01) which have masked the negative indirect effect on number of flowers/plant caused through traits such as plant height (-10.35), days to first flower (-0.71), weight of bulb (-0.67), number of bulblets per plant (-0.35), number of leaves per plant (-0.27), size of the flower (-0.07), tepal width (-0.05), stem diameter (-0.05), bud length (-0.04), vase life (-0.03) and per cent bulb sprouting (-0.02) which have enabled the trait to establish positive and significant association.

Leaf width (-0.03) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through stem length (-0.94) followed by size of the flower (-0.77), days taken for bulb sprout emergence (0.57), bulb diameter (-0.45), days to flower bud formation (-0.33), leaf length (-0.30), duration of flowering (-0.10), weight of bulblet (-0.09), bud length (-0.06) and vase life (0.01). On the other hand, higher magnitude of positive indirect effect of the trait through plant height (0.91), weight of bulb (0.58), tepal width (0.55), days to first flower (0.51), tepal length (0.47), number of leaves per plant (0.22), number of bulblets per plant (0.08), stem diameter (0.01) and per cent bulb sprouting (0.001) nullified the negative direct and indirect effects of the trait.

Similarly character stem length (24.10) recorded very high positive direct effect along with positive indirect effect through traits like; tepal length (0.35) followed by duration of flowering (0.35), leaf length (0.28), bulb diameter (0.23), weight of bulblet (0.21), days to first flower (0.10), per cent bulb sprouting (0.001) and leaf width (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as plant height (-23.18), size of the flower (-0.73), weight of bulb (-0.37), number of leaves per plant (-0.20), number of bulblets per plant (-0.12), bud length (-0.09), tepal width (-0.07), days to flower bud formation (-0.07), days taken for bulb sprout emergence (-0.06), vase life (-0.04) and stem diameter (-0.02) which have enabled the trait to establish positive and significant association.

Character such as days to flower bud formation (-0.59) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through traits *viz*., plant height (-2.72) followed by days taken for bulb sprout emergence (-0.66), size of the flower (-0.52), leaf length (-0.41), bulb diameter (-0.35), weight of bulblet (-0.08), per cent bulb sprouting (-0.04),bud length(-0.03) and leaf width (-0.02). In contrast higher magnitude of positive indirect effects of the trait through stem length (2.83), days to first flower (0.95), tepal length (0.37), weight of bulb (0.35), number of bulblets per plant (0.18), number of leaves per plant (0.17), tepal width (0.17), stem diameter (0.06), duration of flowering (0.04) and vase life (0.001) nullified the negative direct and indirect effects of the trait.

Bud length (-0.17) exhibited negative direct effect on number of flowers/plant along with negative indirect effect through plant height (-12.01) followed by size of the flower (-1.57), days taken for bulb sprout emergence (-0.20), days to flower bud formation (-0.09), per cent bulb sprouting (-0.07), weight of bulb (-0.06), number of bulblets per plant (-0.04), stem diameter (-0.03), vase life (-0.01) and leaf width (-0.01). In contrast higher magnitude of positive indirect effects of the trait through stem length (12.49), tepal length (0.89), tepal width (0.43), leaf length (0.14), bulb diameter (0.14), duration of flowering (0.13), weight of bulblet (0.13), days to first flower (0.06) and number of leaves per plant (0.03) nullified the negative direct and indirect effects of the trait.

Days to first flower (1.03) exhibited very high positive direct effect along with maximum positive indirect effect through stem length (1.03) followed by weight of bulb (0.42), tepal length (0.29), number of leaves per plant (0.16), number of bulblets per plant

(0.14), tepal width (0.13), stem diameter (0.06), duration of flowering (0.02) and vase life (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as plant height (-2.24), days taken for bulb sprout emergence (-0.67), days to flower bud formation (-0.55), leaf length (-0.44), size of the flower (-0.42), bulb diameter (-0.38), weight of bulblet (-0.12), per cent bulb sprouting (-0.08), leaf width (-0.02) and bud length (-0.01) which have enabled the trait to establish positive and significant association.

Stem diameter (-0.10) reported negative direct effect on number of flowers/plant along with negative indirect effect through plant height (-3.80) followed by weight of bulb (-0.56), days to first flower (-0.56), size of the flower (-0.40), number of bulblets per plant (-0.34), number of leaves per plant (-0.11), bud length (-0.06), per cent bulb sprouting (-0.03) and vase life (-0.02) whereas higher magnitude of positive indirect effects of the trait through stem length (3.95), bulb diameter (0.49), weight of bulblet (0.38), days to flower bud formation (0.35), leaf length (0.35), days taken for bulb sprout emergence (0.26), tepal width (0.26), tepal length (0.21), duration of flowering (0.17) and leaf width (0.001) nullified the negative direct and indirect effects of the trait.

Size of the flower (-1.72) had negative direct effect on number of flowers/plant along with negative indirect effect through plant height (-9.8) followed by days taken for bulb sprout emergence (-0.30), days to flower bud formation (-0.18), bud length (-0.15), per cent bulb sprouting (-0.12), bulb diameter (-0.02), stem diameter (-0.02), and leaf width (-0.02). In contrast higher magnitude of positive indirect effects of the trait through stem length (10.17), tepal length (0.95), tepal width (0.48), days to first flower (0.25), weight of bulb (0.9), duration of flowering (0.14), number of leaves per plant (0.09), number of bulblets per plant (0.08), leaf length (0.03) weight of bulblet (0.01) and vase life (0.001) nullified the negative direct and indirect effects of the trait.

Tepal length (0.99) exhibited high positive direct effect along with maximum positive indirect effect through stem length (8.57) followed by tepal width (0.48), days to first flower (0.30), weight of bulb (0.18), number of leaves per plant (0.12), duration of flowering (0.12), number of bulblets per plant (0.02), leaf length (0.01) and vase life (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as plant height (-8.24), size of the flower (-1.64), days taken for bulb sprout emergence (-0.32), days to flower bud formation (-0.22), bud length (-0.15), per cent bulb sprouting (-0.12), weight of bulblet (-0.03), bulb diameter (-0.02), stem diameter (-0.02) and leaf width (-0.02) which have enabled the trait to establish positive and significant association.

Tepal width (0.81) also had high positive direct effect along with maximum positive indirect effect through plant height (1.92) followed by tepal length (0.59), number of leaves per plant (0.17), days to first flower (0.16), weight of bulb (0.09), duration of flowering (0.07), weight of bulblet (0.06), bulb diameter (0.01) and vase life (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as stem length (2.00), size of the flower (-1.03), days taken for bulb sprout emergence (-0.36), number of bulblets per plant (-0.17), days to flower bud formation (-0.12), bud length (-0.09), per cent bulb sprouting (-0.09), leaf length (-0.04), stem diameter (-0.03) and leaf width (-0.02) which have enabled the trait to establish positive and significant association.

Duration of flowering (0.67) had high positive direct effect along with maximum positive indirect effect through stem length (12.46) followed by bulb diameter (0.54), weight of bulblet (0.37), leaf length (0.25), tepal length (0.17), tepal width (0.08), days to first flower (0.03) and leaf width (0.01) which have masked the negative indirect effect on number of flowers/plant caused through traits such as plant height (-11.98), weight of bulb (-0.58), size of the flower (-0.35), number of bulblets per plant (-0.32), number of leaves per plant (-0.20), per cent bulb sprouting (-0.09), vase life (-0.06), days to flower bud formation (-0.04), stem diameter (-0.03), bud length (-0.03) and days taken for bulb sprout emergence (-0.03) which have enabled the trait to establish positive and significant association.

Bulb diameter (0.87) had high positive direct effect on number of flowers/plant along with maximum positive indirect effect through stem length (6.43) followed by weight of bulblet (0.44), duration of flowering (0.42), leaf length (0.41), days taken for bulb sprout emergence (0.34), days to flower bud formation (0.24), size of the flower (0.05), leaf width (0.02) and tepal width (0.01) which have masked the negative indirect effect on number of flowers/plant caused through traits such as plant height (-6.18), weight of bulb (-1.04), days to first flower (-0.46), number of bulblets per plant (-0.42), number of leaves per plant (-0.41), stem diameter (-0.06), bud length (-0.03), per cent bulb sprouting (-0.03), vase life (-0.02) and tepal length (-0.02) which have enabled the trait to establish positive and significant association.

Weight of bulb (-1.14) observed negative direct effect on number of flowers/plant along with negative indirect effect through other traits such as plant height (-7.49) followed by number of bulblets per plant (-0.41), days to first flower (-0.38), number of leaves per plant (-0.21), tepal length (-0.15), tepal width (-0.06), stem diameter (-0.05), vase life (-0.03) and bud length (-0.01). In contrast highest magnitude of positive indirect effects of the trait was observed through stem length (7.79) followed by bulb diameter (0.79), weight of bulblet (0.50), leaf length (0.37), duration of flowering (0.34), size of the flower (0.29), days taken for bulb sprout emergence (0.25), days to flower bud formation (0.18), per cent bulb sprouting (0.04) and leaf width (0.02) nullified the negative direct and indirect effects of the trait.

Number of bulblets/plant (-0.68) had negative direct effect on number of flowers/plant along with negative indirect effect through other traits such as plant height (-4.24) followed by weight of bulb (-0.68), days to first flower (-0.22), number of leaves per plant (-0.17), stem diameter (-0.05), vase life (-0.04), tepal length (-0.02), per cent bulb sprouting (-0.02) and bud length (-0.01). In contrast highest magnitude of positive indirect effects of the trait was observed through stem length (4.40) followed by bulb diameter (0.53), weight of bulblet (0.40), leaf length (0.32), duration of flowering (0.32), size of the flower (0.20), tepal width (0.20), days to flower bud formation (0.16), days taken for bulb sprout emergence (0.15) and leaf width (0.001) nullified the negative direct and indirect effects of the trait.

Weight of bulblet (0.70) recoded high positive direct effect on number of flowers/plant along with maximum positive indirect effect through stem length (7.20) followed by bulb diameter (0.54), duration of flowering (0.36), leaf length (0.18), per cent bulb sprouting (0.16), days to flower bud formation(0.07), tepal width (0.06), days taken for bulb sprout emergence (0.03) and leaf width (0.001) which have masked the negative indirect effect on number of flowers/plant caused through traits such as plant height (-6.92), weight of bulb (-0.82), number of bulblets per plant (-0.39), days to first flower (-0.18), number of leaves per plant (-0.18), vase life (-0.06), stem diameter (-0.06), tepal length (-0.05), bud length (-0.03) and size of the flower (-0.01) which have enabled the trait to establish positive and significant association.

Vase life of flowers (-0.08) observed negative direct effect on number of flowers/plant along with negative indirect effect through other traits such as plant height (-

12.57) followed by number of bulblets per plant (-0.36), weight of bulb (-0.36), number of leaves per plant (-0.22), size of the flower (-0.07), stem diameter (-0.03), days taken for bulb sprout emergence (-0.06), days to flower bud formation (-0.03) and bud length (-0.02). In contrast highest magnitude of positive indirect effects of the trait was observed through stem length (13.07) followed by weight of bulblet (0.49), duration of flowering (0.47), bulb diameter (0.22), leaf length (0.21), per cent bulb sprouting (0.07), tepal length (0.02), tepal width (0.02), days to first flower (0.01) and leaf width (0.001) nullified the negative direct and indirect effects of the trait.

The residual effect was estimated as 0.159 (15.90 %) indicating that all the characters contributed 84.10 % to the variability in number of flowers per plant.

The pooled data for path co-efficient analysis over four environments clearly demonstrated that stem length (24.10) exhibited very high positive direct effect on the number of flowers per plant followed by days to first flower (1.03), tepal length (0.99), bulb diameter (0.87), tepal width (0.81), weight of bulblet (0.70), duration of flowering (0.67), leaf length (0.63) and per cent bulb sprouting (0.30). These findings indicate that selection should be made on the basis of stem length by taking other traits into consideration, while making improvement in number of flowers per plant. Studies further revealed that bulb diameter and weight of bulblet also associated to have direct effect on number of flowers per plant. Moreover in present investigation, correlation studies associated with yield parameter (number of flowers/plant) also revealed the positive genotypic correlation between yield and stem length, bulb diameter, weight of bulblet, leaf length and duration of flowering indicating true relationship between them and direct selection for these trait will be useful for yield improvement.

Positive direct effect on number of flowers per plant due to stem length was also reported by Chauhan (2015) in carnation and Gantait *et al*. (2016) in gladiolus.

4.4 GENETIC DIVERGENCE

Genetic diversity is an essential component in crop improvement programme. It plays a major role in plant breeding because hybrids between lines of diverse origin, generally, display a greater heterosis than those between closely related parents.

In present study, a considerable amount of genetic divergence was reported among *Lilium* genotypes grown over different environments. On the basis of performance of various traits under different environments, the clustering of 18 diverse genotypes of *Lilium* under Nauni and Katrain location along with their pooled analysis was carried out and results with this regards has been presented in the tables below. All the genotypes were grouped into 4 clusters under both the locations and performance of characters among clusters was studied.

4.4.1 Genetic divergence under Nauni location

Studies conducted under Nauni location (E_1 & E_2) revealed that maximum numbers of 7 genotypes were accommodated in cluster-III, followed by cluster-II accommodating 5 genotypes and cluster-I with 4 genotypes whereas, cluster-IV included only two genotypes (Table 4.4.1.27(a). The genotypes falling in the same cluster are more closely related than those belonging to another cluster. Furthermore, distributions of genotypes in clusters were irrespective of their origin and hybrid groups thus ruling out the association of geographical location and genetic divergence. Similar cluster patterns for different morphological traits has also been reported by Zahor (2015) and Malik and Pal (2015) in gladiolus.

Table 4.4.1.27(a): Cluster pattern of 18 genotypes of *Lilium* on the basis of genetic divergence under Nauni condition

Cluster	Number of genotypes	Genotypes
I	4	Navona, Tresor, Best Seller, Pavia
II	5	Ceb Dazzle, Salmon Classic, Montego Bay, Viviana, Sapporo
III	7	Prato, Brunello, Pollyana, Elite, Eyeliner, Yelloween, Cilesta
IV	2	Shiraj, Ercolano

The average inter cluster distance among different genotypes grown at Nauni location has been presented in Table 4.4.1.27(b). Highest inter cluster distance (78.88) was recorded between cluster-III & cluster-IV followed by cluster-II & cluster-III (62.66) whereas, lowest (41.86) inter cluster distance was observed between cluster- II & cluster-IV followed by cluster-I & cluster-III (45.93).

Since maximum inter cluster distance has been recorded between cluster-III and cluster-IV, therefore crosses must be made between the genotypes of cluster-III and cluster-

IV to obtain new and desirable recombinants. Highly divergent genotypes would produce higher range of variability enabling further selection and improvement. These results of present findings are also supported by Bhatia *et al*. (2017) in tulip and Malik & Pal (2015) in gladiolus.

Table 4.4.1.27(b): Average inter cluster distance among *Lilium* genotypes based on D^2 analysis

Cluster	I	II	III	IV
I	0.00	51.12	45.93	56.9
II	51.12	0.00	62.66	41.86
III	45.93	62.66	0.00	78.88
IV	56.79	41.86	78.88	0.00

The cluster mean value of 4 clusters indicated considerable differences for the traits studied as presented in Table 4.4.1.27(c). The variation observed in different cluster means also indicates the degree of variability present among the genotypes. Performance of characters in clusters indicated that cluster-I exhibited earliness for days taken for bulb sprout emergence (39.81 days), days to flower bud formation (65.62 days) and days to first flower (97.20 days) while maximum was recorded in cluster-II i.e. 58.49 days, 76.33 days & 110.60 days, respectively. In case of per cent sprouting of bulbs, genotypes of cluster-II recorded maximum cluster mean (99.33 %) whereas minimum in cluster-I (97.08 %). The least plant height observed in cluster-I (58.87 cm) while maximum in cluster-III (82.13 cm). Number of leaves per plant observed maximum in cluster-III (63.90) and was least in cluster-II (31.69). Cluster mean value for leaf length was maximum in cluster-III (11.87 cm) while minimum in cluster-II (8.52 cm). Leaf width observed maximum in cluster-II (2.79 cm) whereas minimum in genotypes of cluster-I (1.76 cm). Genotypes grouped in cluster-III observed maximum stem length (62.66 cm) whereas minimum in cluster-I (37.06 cm).

Flowering traits such as bud length observed maximum in cluster-II (9.72 cm) whereas minimum (7.69 cm) in cluster-IV. As far as stem diameter is concerned, maximum cluster mean (0.61 cm) was observed in cluster-I while minimum in cluster-IV (0.50 cm). Size of the flower was observed maximum (16.90 cm) among genotypes of cluster-II while minimum in cluster-IV (14.91 cm). Genotypes of cluster-III recorded maximum mean value

(5.85) for number of flowers/plant whereas least in cluster-II (2.46). Tepal length (10.74 cm) was observed maximum among genotypes of cluster-II whereas minimum (8.90 cm) among genotypes of cluster-IV.

Genotypes of cluster-III recorded maximum cluster mean for tepal width (5.85 cm) while minimum (2.46 cm) in cluster-II. Genotypes of cluster-I (14.88 days) recorded maximum duration of flowering while minimum (12.75 days) observed among genotypes of cluster-IV.

Table 4.4.1.27(c): Cluster mean for different characters among *Lilium* genotypes under Nauni condition

Characters	Clusters			
	I	II	III	IV
Days taken for bulb sprout emergence	39.81	58.49	46.72	44.98
Per cent bulb sprouting	97.08	99.33	99.05	97.50
Plant height (cm)	58.87	67.83	82.13	66.75
Number of leaves/plant	45.86	31.69	63.90	40.51
Leaf length (cm)	9.63	8.52	11.87	10.27
Leaf width (cm)	1.76	2.79	1.89	1.80
Stem length (cm)	37.06	48.80	62.66	43.26
Days to flower bud formation	65.62	76.33	70.07	70.70
Bud length (cm)	8.14	9.72	9.45	7.69
Days to first flower	97.20	110.60	105.45	108.06
Stem diameter (cm)	0.61	0.57	0.55	0.50
Size of the flower (cm)	15.23	16.90	16.38	14.91
Number of flower/plant	3.51	2.46	5.85	2.86
Tepal length (cm)	9.62	10.74	10.22	8.90
Tepal width (cm)	3.17	2.46	5.85	2.86
Duration of flowering (days)	14.88	14.17	13.60	12.75
Bulb diameter (cm)	4.22	3.85	4.22	4.11
Weight of bulb (g)	26.69	21.58	27.70	25.72
Number of bulblets/plant	1.08	0.87	1.00	0.80
Weight of bulblet (g)	1.68	2.26	2.04	1.94
Vase life (days)	6.55	7.00	6.84	6.08
Stem sturdiness: 'A' grade	85.84	72.00	82.86	76.66
'B' grade	12.92	26.00	15.71	20.00
'C' grade	1.25	2.00	1.43	3.34
Grading of cut flowers: Grade '1'	42.71	18.97	56.77	5.00
Grade '2'	19.38	15.56	16.79	3.34
Grade '3'	5.42	23.84	11.19	12.92
Grade '4'	15.42	29.59	10.68	39.16
Grade '5'	17.08	12.03	4.57	39.58

In case of various bulb parameters, genotypes of cluster-I and cluster-III recorded maximum cluster mean (4.22 cm) for bulb diameter whereas minimum (3.85 cm) recorded in cluster-II. Genotypes of cluster-III recorded maximum cluster mean (27.70 g) for bulb weight while minimum among genotypes of cluster-II (21.58 g). Number of bulblets per plant recorded maximum (1.08) in cluster-I while minimum (0.87) in cluster-II. Cluster means for weight of bulblet (2.26 g) and vase life (7.00 days) recorded maximum in cluster-II while it was minimum in cluster-I (1.68 g) and cluster-IV (6.08 days), respectively.

'A' grade cut stem on the basis of stem strength were produced maximum in genotypes of cluster-I (85.84 %) while the genotypes of cluster-II and cluster-IV recorded maximum cluster mean (26.00 % and 3.34 %, respectively) for grade 'B' grade 'C' cut flower stems. In contrast cluster-II (72.00 %) and cluster-I (12.92 % & 1.25 %, respectively) recorded minimum cluster mean for grade 'A', grade 'B' and grade 'C', respectively.

Grading of cut flowers on the basis of stem length and number of flowers/plant indicated that maximum cluster mean for grade '1' cut flower stems were recorded in genotypes of cluster-III (56.77 %). However maximum cluster mean value for grade '2', grade '3', grade '4' and grade '5' cut flower stems were recorded in genotypes of cluster-I (19.38 %), cluster-II (23.84 %), cluster-IV (39.16 % & 39.58 %), respectively. Cluster-IV recorded minimum cluster means for grade '1'and grade '2'cut flowers (5.00 % & 3.34 %, respectively), cluster-I for grade '3'(5.42 %) and cluster-III for grade '4' and grade '5' (10.68 % & 4.57 %, respectively).

Cluster means helps in identifying the superior genotypes to be used for hybridization programme. The cluster means related to vegetative, flowering and bulb parameters indicated substantial amount of variability present among the genotypes.

Studies revealed that genotypes of cluster-II recorded earliness for days taken for sprout emergence and days to first flower which is a desirable trait in hybridization programme. Genotypes of this cluster also reported maximum cluster mean value for various desirable flowering traits such as bud length, size of the flower and vase life.

Genotypes of cluster-III recorded maximum cluster means for vegetative parameters like plant height, number of leaves/plant, leaf length and stem length. This cluster also produced maximum number of flowers/plant and large sized and vigorous bulbs which are desirable economic traits.

Cluster analysis using UPGMA method

Dendrogram depicts the taxonomic relatedness among different genotypes in a tree diagram. Studies conducted at Nauni location, Katrain location and pooled analysis of the clustering of 18 genotypes of *Lilium* over different environments using UPGMA method has been depicted in Fig.1, Fig. 2 and Fig. 3, respectively.

At Nauni location, the dendrogram grouped the 18 *Lilium* genotypes into 4 major clusters. Out of 4 clusters, the largest was Cluster I which comprised of 10 genotypes whereas Cluster II and Cluster IV comprised of solitary genotype (Fig. 1). Cluster I is having 10 genotypes which is further sub-divided into 2 sub-clusters, *viz*., Ia (4 genotypes) and Ib (6 genotypes). This indicates that these genotypes are having maximum similarity with each other. The genetic relatedness depicted from the dendrogram (Fig. 1) showed that among 4 genotypes ('Navona', 'Tresor', 'Prato', 'Pavia') falling under sub-cluster Ia, genotypes 'Navona' and 'Tresor' were maximum similar with each other, whereas, genotypes 'Prato' showed maximum similarity with these genotypes as compared to 'Prato'. Sub cluster Ib consisted of 6 genotypes ('Pollyana', 'Yelloween', 'Elite', 'Cilesta', 'Brunello' and 'Eyeliner') exhibited maximum similarity between genotypes 'Pollyana' and 'Yelloween' as compared to 'Brunello' and 'Eyeliner'. Cluster II comprised of solitary genotype 'Best Seller' found to be most dissimilar among different genotypes.

In case of Cluster III which possessed 6 genotypes ('Ercolano', 'Viviana', 'Ceb Dazzle', 'Salmon Classic', 'Montego Bay' and 'Sapporo'), which is again divided into 2 sub-clusters (IIIa and IIIb). Sub-cluster IIIa is having 5 genotypes, among which genotypes 'Ercolano' and 'Viviana' were sharing maximum similarity with each other, while, genotypes 'Ceb Dazzle' and 'Salmon Classic' were maximum similarity with each other and genotype 'Montego Bay' was found to be different among all the varieties falling under this group. However, sub-cluster IIIb comprised of only one genotype 'Sapporo' showing less similarity with all the genotypes falling under the same group.

Cluster IV possessed solitary genotype 'Shiraj' was found to be most dissimilar among all the genotypes under study.

4.4.2 Genetic divergence under Katrain location

Studies on genetic divergence conducted at Katrain location (E_3 & E_4) as presented in Table 4.4.2.28(a) revealed maximum numbers of 9 genotypes accommodated in cluster-II followed by cluster-I accommodating 6 genotypes and cluster-IV with 2 genotypes. However cluster III accommodated only one genotype. The formation of solitary clusters may be due to total isolation preventing the gene flow or intensive natural/human selection for diverse adaptive complexes. Bhajantri and Patil (2016) also reported solitary type means having single gladiolus genotype in cluster. They further concluded that the formation of distinct solitary clusters may be due to the fact that genotypes have recorded too high and too low cluster mean values.

Table 4.4.2.28(a): Clustering pattern of 18 genotypes of *Lilium* on the basis of genetic divergence under Katrain condition

Cluster	No. of genotypes	Genotypes
I	6	Navona, Shiraj, Ercolano, Ceb Dazzle, Best Seller, Salmon Classic
II	9	Prato, Brunello, Pollyana, Elite, Eyeliner, Pavia, Yelloween, Cilesta, Montego Bay
III	1	Tresor
IV	2	Viviana, Sapporo

Findings at Katrain location also showed the distributions of genotypes among clusters irrespective of their origin and hybrid groups thus ruling out the association of geographical location and genetic divergence. Furthermore clustering pattern produced by different genotypes at Nauni location differed from those obtained at Katrain location which might be due to high genotype and environment interaction. Results of present findings are in correspondence to Desh Raj and Misra (2000) and Pal *et al*. (2006) who reported the geographic diversity need not necessarily be related to the genetic diversity.

Table 4.4.2.28(b): Average inter cluster distance (D^2)

Cluster	I	II	III	IV
I	0.00	87.66	52.99	90.03
II	87.66	0.00	63.70	103.52
III	52.99	63.70	0.00	79.60
IV	90.03	103.52	79.60	0.00

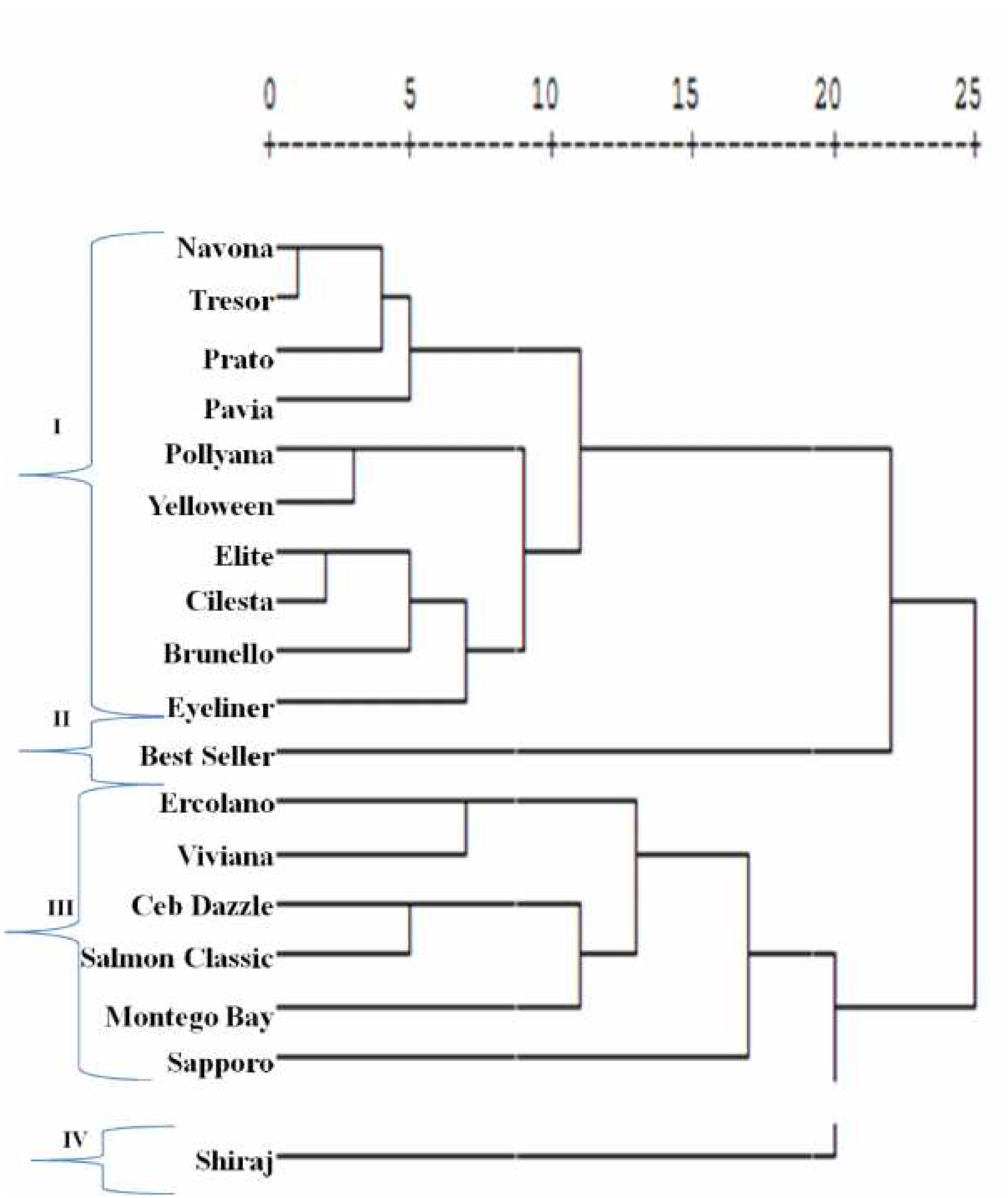


Fig. 1: Genetic relatedness among *Lilium* genotypes grown at Nauni location using UPGMA method

As far as average inter cluster distance among different genotypes at Katrain location is concerned (Table 4.4.2.28b), highest inter cluster distance (103.52) was recorded between cluster-II & cluster-IV followed by cluster-I & cluster-IV (90.03) whereas, lowest (52.99) inter cluster distance was exhibited by genotypes of cluster- I & cluster-III followed by cluster-II & cluster-III (63.70).

Table 4.4.2.28(c): Cluster mean for different characters among 18 genotypes of *Lilium* under Katrain condition

Characters		Clusters			
		I	II	III	IV
Days taken for bulb sprout emergence		166.27	169.79	176.84	192.24
Per cent bulb sprouting		100.00	99.72	99.58	99.65
Plant height (cm)		62.32	87.20	71.52	45.44
Number of leaves/plant		52.34	68.01	51.34	18.42
Leaf length (cm)		10.47	12.46	10.82	6.80
Leaf width (cm)		1.98	2.18	1.90	3.54
Stem length (cm)		42.32	67.20	51.34	18.42
Days to flower bud formation		40.52	45.84	45.00	57.60
Bud length (cm)		9.33	11.24	9.31	9.10
Days to first flower		60.68	63.98	73.52	82.22
Stem diameter (cm)		0.74	0.78	0.78	0.60
Size of the flower (cm)		15.67	17.72	16.38	15.11
Number of flowers/plant		4.22	8.35	5.77	3.00
Tepal length (cm)		8.05	9.53	8.44	10.56
Tepal width (cm)		2.52	2.71	2.72	3.47
Duration of flowering (days)		15.73	23.73	21.30	16.41
Bulb diameter (cm)		5.42	5.30	5.60	3.22
Weight of bulb (g)		69.85	67.66	69.70	19.55
Number of bulblets/plant		4.40	5.14	3.93	1.71
Weight of bulblet (g)		14.16	14.86	12.05	2.90
Vase life (days)		7.40	8.40	7.47	7.08
Stem sturdiness	**‘A’ grade**	55.80	81.31	67.05	65.79
	‘B’ grade	29.06	13.76	21.98	23.62
	‘C’ grade	18.61	6.97	12.79	13.04
Grading of cut flowers	**Grade ‘1’**	16.28	77.48	35.16	52.14
	Grade ‘2’	12.74	9.36	40.54	19.36
	Grade ‘3’	15.12	5.84	9.98	10.32
	Grade ‘4’	22.04	3.89	8.64	9.03
	Grade ‘5’	31.92	2.71	4.42	7.88

There was considerable amount of genetic divergence present in the experimental material used as evident from average inter cluster distances (Table 4.4.1.27b & Table 4.4.2.28b) reported among four clusters. Data further revealed that average inter cluster distance observed among genotypes of clusters over Katrain location was more as compared to Nauni location.

As data presented in Table 4.4.2.28(b) indicated that cluster-II and cluster-IV recorded maximum inter cluster distance therefore crosses must be made between the genotypes of these clusters to obtain new and desirable traits. Highly divergent genotypes would produce higher range of variability enabling further selection and improvement. Bhatia *et al*. (2017) while working with different genotypes of tulip at Katrain location concluded that average inter-cluster divergence can be utilized for the choice of parents to decide the cross combination in order to produce heterotic effect.

As far as cluster means of different genotypes for various traits at Katrain location is concerned, means of cluster-I exhibited earliness for days taken for bulb sprout emergence (166.27 days), days to flower bud formation (40.52 days), days to first flower (60.68 days) along with maximum cluster mean for per cent bulb sprouting (100.00 %) and weight of bulb (69.85 g). In contrast, genotypes of this cluster recorded minimum cluster means for traits such as tepal length (8.05 cm), tepal width (2.52 cm), duration of flowering (15.73 days), minimum grade 'A' (55.80 %) and grade '1' (16.28 %) cut flower stems. Genotypes of cluster-I also recorded maximum cluster mean (81.31 %, 29.06 % & 18.61 %, respectively) for grade 'A' grade 'B' and grade 'C' cut flower stems on the basis of stem strength.

On the other hand, cluster-II recorded maximum cluster means for vegetative parameters such as plant height (87.20 cm), number of leaves per plant (68.01), leaf length (12.46 cm), leaf width (2.18 cm), stem length (67.20 cm) and stem diameter (0.78 cm), flowering parameters like; bud length (11.24 cm), size of the flower (17.72 cm), number of flowers/plant (8.35), duration of flowering (23.73 days), vase life (14.86 days) and number of bulblet/plant (5.14). However same cluster recorded minimum cluster means for grade 'B' (13.76 %) and grade 'C' (6.97 %) cut flower stems on the basis of stem strength and grade '2' (9.36 %), grade '3' (5.84 %), grade '4' (3.89 %) and grade '5' (2.71 %) for grading of cut flowers.

As far as grading of cut flowers on the basis of stem length and number of flowers/plant is concerned, genotypes of cluster-II, cluster-III and cluster-I recorded maximum cluster mean (77.48 %, 40.54 % and 15.12 %, 22.04 %, 31.92 %, respectively) for grade '1', '2' and '3', '4', '5', respectively.

Cluster-III recorded maximum mean value for stem diameter (0.78 cm), bulb diameter (5.60 cm) and weight of bulblet (12.05 g) while same cluster recorded minimum cluster mean for per cent bulb sprouting (99.58 %).

Cluster-IV recorded maximum cluster mean for tepal length (10.56 cm), tepal width (3.47 cm) while genotypes of this cluster recorded minimum cluster means for parameters such as plant height (45.44 cm), number of leaves per plant (18.42), leaf length (6.80 cm), leaf width (3.54 cm), stem length (18.42 cm), bud length (9.10 cm), stem diameter (0.60 cm), number of flowers per plant (3.00), size of the flower (15.11 cm), bulb diameter (3.22 cm), weight of bulb (19.55 g), number of bulblet (1.71) and vase life (7.08 days). Genotypes of this cluster also recorded maximum days for bulb sprout emergence (192.24 days), days to flower bud formation (57.60 days) and days to flowering (82.22 days).

Cluster means of genotypes for different parameters indicated that maximum mean values for most of the vegetative and desirable floral traits were observed in genotypes of cluster-II indicating the possible use of genotypes of this cluster as valuable parent to develop superior cultivars. Studies further revealed that genotypes of cluster-I exhibited earliness to flowering which is essentially a desirable trait.

Similar cluster mean for various economically important traits among different genotypes has been reported by Pal *et al*. (2006) and Sheikh (2004) in gladiolus.

Cluster analysis using UPGMA method

Studies conducted at Katrain location and clustering of 18 genotypes of *Lilium* using UPGMA is depicted in Fig. 2. The dendrogram grouped the 18 genotypes into 4 major clusters. Out of 4 clusters, the largest was Cluster II which comprised of 9 genotypes followed by Cluster III with 6 genotypes. Cluster I is having only two genotypes ('Viviana' and 'Sapporo') which were most similar to each other. Cluster II is further sub-divided into 2 sub-clusters, *viz*., IIa (4 genotypes) and IIb (5 genotypes). This indicates that these genotypes are having maximum similarity with each other. The genetic relatedness depicted from the dendrogram (Fig. 2) showed that among 4 genotypes, ‘Prato’, ‘Eyeliner’ ‘Brunello’ ‘Pollyana’ falling under sub-cluster IIa, genotypes ‘Prato’ and ‘Eyeliner’ were maximum similar with each other, whereas, genotypes ‘Brunello’ and ‘Pollyana’ showed maximum similarity with each other. Sub-cluster IIb consisted of 5 genotypes *viz*., ‘Elite’, ‘Cilesta’, ‘Pavia’, ‘Yelloween’ and ‘Montego Bay’ where maximum similarity was noticed between genotypes ‘Elite’ and ‘Cilesta’ as compared to ‘Pavia’, ‘Yelloween’ and ‘Montego Bay’.

In case of Cluster III which consisted of 6 genotypes (‘Navona’, ‘Shiraj’, ‘Best Seller’, ‘Ercolano’, ‘Salmon Classic’ and ‘Ceb Dazzle’), which is again divided into 2 sub-clusters (IIIa and IIIb). Sub-cluster IIIa had 3 genotypes, among which genotypes ‘Navona’ and ‘Shiraj’ shared maximum similarity with each other as compared to ‘Best Seller’. Under same sub cluster genotypes ‘Ercolano’ and ‘Salmon Classic’ exhibited maximum similarity with each other. Sub-cluster IIIb of Cluster III also consisted of solitary genotype ‘Ceb Dazzle’ and found to be different among all the genotypes falling under this cluster.

Cluster IV possessed solitary genotype ‘Tresor’ and found to be most dissimilar among all the genotypes under study.

4.4.3 Genetic divergence (pooled)

Pooled analysis of genetic divergence over environments (E_1, E_2, E_3 & E_4) as presented in Table 4.4.3.29(a) revealed maximum 7 genotypes grouped in cluster-II, followed by cluster-III accommodating 5 genotypes and cluster-I with 4 genotypes. However cluster IV included minimum 2 genotypes.

Table 4.4.3.29(a): Clustering pattern of 18 genotypes of *Lilium* on the basis of genetic divergence (pooled)

Cluster	No. of genotypes	Genotypes
I	4	Navona, Shiraj, Ercolano, Best Seller,
II	7	Prato, Brunello, Pollyana, Elite, Eyeliner, Yelloween, Cilesta
III	5	Tresor, Ceb Dazzle, Pavia, Salmon Classic
IV	2	Viviana, Sapporo

Pooled analysis of data over four environments also showed considerable amount of variability with respect to various parameters. Maximum inter cluster distance observed

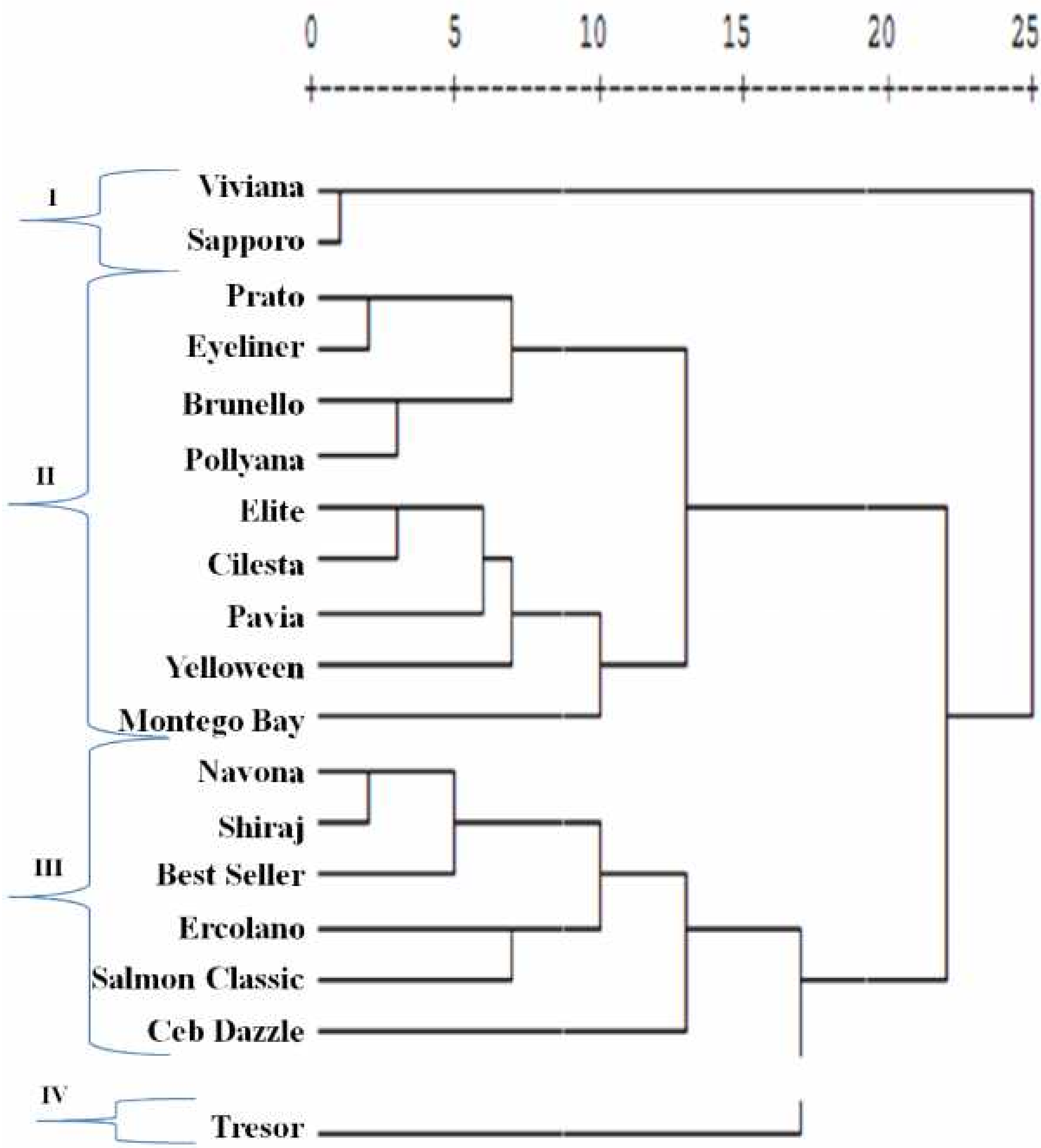


Fig. 2: Genetic relatedness among *Lilium* genotypes of grown at Katrain location using UPGMA method

between the genotypes of cluster-I and cluster-IV (85.09) followed closely by inter cluster distance between cluster-I & cluster-II (83.05) whereas, lowest (47.67) inter cluster distance was exhibited by cluster- II & cluster-III followed by cluster-I & cluster-III (48.02) (Table 4.4.3.29b).

Table 4.4.3.29(b): Average inter cluster distance (D^2)

Cluster	I	II	III	IV
I	0.00	83.05	48.02	85.09
II	83.05	0.00	47.67	55.97
III	48.02	47.67	0.00	51.25
IV	85.09	55.97	51.25	0.00

Genotypes of cluster-I recorded maximum cluster mean for most of the parameters such as plant height (87.24 cm), number of leaves per plant (66.22), leaf length (12.44 cm), stem length (67.24 cm), bud length (10.52 cm), stem diameter (0.68 cm), size of the flower (17.44 cm), number of flowers per plant (6.08), tepal length (10.25 cm), duration of flowering (19.76 days), bulb diameter (4.94 cm), weight of bulb (51.76 g), number of bulblet per plant (3.48), weight of bulblet (2.12 g) and vase life (8.00 days). Cluster-I also recorded maximum cluster mean for grade 'A' cut stems based on stem strength (82.03 %) and grade '1' cut flowers (69.98 %). In contrast genotypes of this cluster recorded minimum cluster mean for bud length (10.52 cm), grade 'B' and grade 'C' cut flower stems (14.13 % and 3.84 %, respectively) and grade '4' and grade '5' (6.94 % and 2.55 %, respectively).

Cluster-II observed earliness for days to flower bud formation (54.05 days) and recorded maximum cluster means for leaf width (2.82 cm) and tepal width (3.30 cm).In contrast cluster-II also took maximum days for bulb sprout emergence and flowering (123.57 days & 97.54 days, respectively). However genotype of this cluster observed minimum cluster mean for leaf length (7.94 cm), number of leaves per plant (27.60), stem diameter (0.61 cm), number of flowers per plant (2.94), bulb diameter (4.15 cm), bulb weight (41.48 g), weight of bulblet (1.75 g) and grade 'A' cut flower stems (59.30 %).

Genotypes of cluster-III recorded minimum cluster mean (98.89 %) for per cent bulb sprouting.

Genotypes of cluster-IV observed earliness for days taken for bulb sprout emergence (101.53 days), days to first flower (78.03 days) and maximum per cent bulb sprouting

(100.00 %). However this cluster also reported minimum cluster mean for parameters such as plant height (56.12 cm), leaf width (1.77 cm), stem length (36.12 cm), size of the flower (14.76 cm), tepal length (8.42 cm), tepal width (2.69 cm), number of bulblet (2.21), grade ‘1’, grade ‘2’ and grade ‘3’ cut flower stems (21.04 %, 8.26 % and 3.65 %, respectively).

Table 4.4.3.29(c): Cluster mean for different characters among 18 genotypes of *Lilium* (pooled)

Characters		Clusters			
		I	II	III	IV
Days taken for bulb sprout emergence		106.89	123.57	109.42	101.53
Per cent bulb sprouting		99.00	99.38	98.89	100.00
Plant height (cm)		87.24	67.25	71.36	56.12
Number of leaves/plant		66.22	27.60	57.32	45.30
Leaf length (cm)		12.44	7.94	10.66	9.90
Leaf width (cm)		1.99	2.82	2.00	1.77
Stem length (cm)		67.24	47.25	51.36	36.12
Days to flower bud formation		60.87	54.05	58.08	58.78
Bud length (cm)		10.52	9.75	9.08	8.33
Days to first flower		85.37	97.54	86.22	78.03
Stem diameter (cm)		0.68	0.61	0.68	0.63
Size of the flower (cm)		17.44	17.08	16.07	14.76
Number of flowers/plant		6.08	2.94	4.74	3.96
Tepal length (cm)		10.25	10.19	8.81	8.42
Tepal width (cm)		2.85	3.30	2.95	2.69
Duration of flowering (days)		19.76	15.56	17.72	15.14
Bulb diameter (cm)		4.94	4.15	4.81	4.71
Weight of bulb (g)		51.76	41.48	47.77	45.53
Number of bulblets/plant		3.48	2.64	3.15	2.21
Weight of bulblet (g)		2.12	1.75	1.91	1.76
Vase life (days)		8.00	6.92	7.14	6.59
Stem sturdiness	**‘A’ grade**	82.03	59.30	75.81	66.70
	‘B’ grade	14.13	29.27	19.16	23.82
	‘C’ grade	3.84	11.43	5.04	9.48
Grading of cut flowers	**Grade ‘1’**	69.98	20.04	34.46	21.04
	Grade ‘2’	11.86	14.67	25.48	8.26
	Grade ‘3’	8.31	25.96	13.83	3.65
	Grade ‘4’	6.94	24.08	16.21	24.18
	Grade ‘5’	2.55	10.62	9.35	42.56

Estimation of the divergence studies revealed that considerable divergence existed among the genotypes. The grouping of the genotypes under different environments revealed inter cluster distance was more among genotypes grown at Katrain location as compared to Nauni location. Clustering behaviour and mean performance of genotypes of individual cluster were not consistent over the environments because of substantial genotype × environment interaction.

Desh Raj & Misra (2000), Pal *et al*. (2006) and Bhajantri & Patil (2016) also observed the similar variation among different gladiolus genotypes.

Cluster analysis using UPGMA method (pooled)

Pooled analysis of data over four different environments revealed the clustering of 18 genotypes of *Lilium* using UPGMA as depicted in Fig. 3. The dendrogram grouped the 18 genotypes into 4 major clusters. Out of 4 clusters, the largest was Cluster III which comprised of 8 genotypes followed by Cluster I with 7 genotypes.

Cluster I consisted of seven genotypes and maximum similarity was exhibited between genotypes 'Elite', 'Cilesta' and 'Brunello' whereas least similarity was shown by 'Pollyana', 'Prato', 'Yelloween' and 'Eyeliner' with maximum least similarity.

Cluster II possessed only two genotypes ('Viviana' and 'Sapporo') which indicate that these genotypes are having maximum similarity with each other.

Cluster III in total consisted of 8 genotypes which were further sub-divided into 2 sub-clusters, *viz*., IIIa (4 genotypes) and IIIb (4 genotypes). The genetic relatedness depicted from the dendrogram (Fig. 3) showed that among 8 genotypes, 'Navona', 'Ercolano' 'Shiraj' and 'Best Seller' falling under sub-cluster IIIa and 'Tresor' and 'Pavia', 'Ceb Dazzle' and 'Salmon Classic' falling under sub-cluster IIIb. In case of sub-cluster IIIa, 'Navona' and 'Ercolano' were most similar to each other while 'Shiraj' and 'Best Seller' were least similar. Likewise in case of sub-cluster IIIb, 'Tresor' & 'Pavia' were maximum similar with each other followed by 'Ceb Dazzle'& 'Salmon Classic'.

Cluster IV possessed solitary genotype 'Montego Bay' and found to be most dissimilar among all the genotypes included under study.

4.5 STABILITY ANALYSIS

Identification of suitable, high yielding genotype-possessing stability over the seasons or varying environments for economically important characters is important for progressive but sustainable production. Knowledge of genotype × environment interaction is essential for the development of improved cultivars among crop plants. The most common practice followed in plant breeding work is determining the adaptability of different varieties by subjecting them to multi-location yield tests for a number of years that helps to identify genotypes, which gives superior performance over a wide range of environments. Therefore the present investigation was taken up to assess the stability of *Lilium* genotypes and their response to different environments with respect to 23 parameters.

Table 4.5.1.1: Estimation of stability parameters in 18 *Lilium* genotypes for days taken for bulb sprout emergence and per cent bulb sprouting

Genotypes	Days taken for bulb sprout emergence				Per cent bulb sprouting			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	103.57	-4.40	0.97	26.10	100.00	0.79	0.00	-1.98
Prato	101.37	-7.30	0.99	20.91	97.50	-1.71	0.46	1.73
Tresor	108.36	0.70	1.04	23.66	97.50	-1.71	2.31	1.73
Shiraj	105.33	-4.44	1.01	6.11	100.00	0.79	0.00	-1.98
Brunello	113.49	5.07	1.10	25.17	100.00	0.79	0.00	-1.98
Pollyana	102.32	-7.29	0.95	3.63	100.00	0.79	0.00	-1.98
Elite	108.86	-2.67	0.93	9.78	100.00	0.79	0.00	-1.98
Eyeliner	112.02	1.41	0.99	0.50	100.00	0.79	0.00	-1.98
Ercolano	108.16	-2.53	0.96	0.49	98.33	-0.88	2.77	-1.98
Ceb Dazzle	108.51	-1.12	1.04	8.72	100.00	0.79	0.00	-1.98
Best Seller	95.68	-12.79	0.96	10.18	100.00	0.79	0.00	-1.98
Pavia	108.92	-1.61	1.01	-0.03	97.50	-1.71	4.15	-1.98
Salmon Classic	108.74	-5.17	0.91	55.82	100.00	0.79	0.00	-1.98
Yelloween	116.36	4.89	0.98	11.06	98.33	-0.88	2.77	-1.98
Celesta	102.37	-8.76	0.94	4.05	99.17	-0.04	1.39	-1.98
Montego Bay	130.28	16.05	1.08	25.07	99.17	-0.04	1.39	-1.98
Viviana	128.26	14.98	1.08	18.07	98.33	-0.88	2.77	-1.98
Sapporo	127.23	14.96	1.06	7.05	100.00	0.79	0.00	-1.98
Overall mean	**110.54**	Standard Error (m) = 2.20 Standard Error (b) = 0.03			**99.21**	Standard Error (m) = 0.37 Standard Error (b) = 0.31		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

Although a number of models were developed to measure phenotypic stability on the basis of mean performance of test material by several researchers, the model suggested by

Eberhart and Russell (1966) has been widely used in stability analysis. In present investigation eighteen genotypes of *Lilium* were evaluated over four environments and the data was subjected for analysis by using Eberhart and Russell (1966) stability model.

In present study, eighteen *Lilium* genotypes were grown under four environments namely; Environment 1 (E_1): Experimental Farm, FLA, Nauni, 2016-17), Environment 2 (E_2): Experimental Farm, FLA, Nauni, 2017-18, Environment 3 (E_3): ICAR-IARI, Regional Station, Katrain, Kullu, 2016-17 and Environment 4 (E_4): ICAR-IARI, Regional Station, Katrain, Kullu, 2017-18. These genotypes exhibited large variations for various growth, flowering and bulb parameters under the influence of different environment. Genotypes × environments interaction measures the differential response of genotypes to change in all the environments. Interaction between genotypes and environment was significant for all the parameters included under study except Grade '5' of grading of cut flowers. Therefore no stability estimates were measured for this parameter. Analysis of variance for stability estimates of each parameter has been presented in Appendices-VII.

Three stability parameters as per Eberhart and Russell (1966), i.e. mean performance (m), regression coefficient (b_i) and squared deviation from regression coefficient(S^2_{di}) were estimated for all the characters separately in each genotype.

According to the stability parameters proposed by Eberhart and Russell (1966), the most stable variety should have significantly high mean (m) than overall mean and unit regression (b_i=1) or regression near to unity and zero or near deviation from regression (S^2_{di}).

4.5.1.1 Days taken for bulb sprout emergence

Among 18 different *Lilium* genotypes, 'Best Seller' recorded as early genotypes with regard to sprouting while 'Yelloween' 'Montego Bay' 'Viviana' and 'Sapporo' were late with respect to sprouting, however these genotypes were not stable over environments.

Out of 18 different genotypes, only one genotype 'Eyeliner' found to be most stable genotype over all four environments with regards to days taken to bulb sprouting (Table 4.5.1.1).

4.5.1.2 Per cent bulb sprouting (%)

Genotypes such as 'Navona' 'Shiraj', 'Brunello', 'Pollyana', 'Elite', 'Eyeliner' 'Ceb Dazzle', 'Best Seller', 'Salmon Classic', 'Sapporo' recorded 100 % bulb sprouting. However none of the genotypes were stable with respect to per cent sprouting of bulbs as these genotypes did not satisfy the stability criterion of mean performance (m), regression coefficient (b_i) and squared deviation from regression coefficient(S^2_{di}) as presented in Table 4.5.1.1.

4.5.1.3 Plant height (cm)

Analysis of data with respect to stability parameters as presented in Table 4.5.1.2 showed that genotypes 'Prato' (80.72 cm), 'Pollyana' (82.40 cm), 'Elite' (84.77 cm), 'Salmon Classic' (74.75 cm), 'Yelloween' (97.73 cm), and 'Cilesta' (87.29 cm) recorded significantly high value than overall mean (72.31 cm) however these genotypes were unstable with respect to plant height.

Table 4.5.1.2: Estimation of stability parameters in 18 *Lilium* genotypes for plant height (cm) and number of leaves/plant

Genotypes	Plant height (cm)				Number of leaves/plant			
	Mean	**P_i**	**b_i**	**S^2_{di}**	**Mean**	**P_i**	**b_i**	**S^2_{di}**
Navona	56.59	-15.73	-0.28	0.30	46.11	-5.07	-0.72	82.55
Prato	80.72	8.40	3.82	3.78	58.98	7.80	3.58	44.39
Tresor	57.60	-14.72	1.69	11.63	56.60	5.42	1.90	13.53
Shiraj	58.13	-14.19	-1.50	13.60	48.68	-2.50	1.70	19.84
Brunello	78.71	6.39	1.40	24.95	63.80	12.62	-1.68	10.52
Pollyana	82.40	10.08	-0.90	12.59	68.06	16.88	6.30	-0.04
Elite	84.77	12.45	3.24	9.68	65.22	14.04	-0.19	1.72
Eyeliner	88.07	15.75	-0.50	7.57	83.62	32.44	1.70	18.69
Ercolano	66.37	-5.95	-0.86	27.29	50.45	-0.73	4.89	119.82
Ceb Dazzle	66.63	-5.69	-2.49	8.87	42.27	-8.91	-0.09	1.34
Best Seller	53.65	-18.67	2.26	1.12	41.11	-10.07	1.49	2.06
Pavia	65.94	-6.38	4.14	3.23	43.62	-7.56	-0.52	11.53
Salmon Classic	74.75	2.43	2.64	15.72	64.22	13.04	1.33	0.43
Yelloween	97.73	25.41	3.41	12.46	49.89	-1.29	-2.95	29.09
Celesta	87.29	14.97	3.57	6.63	70.56	19.38	-0.66	12.15
Montego Bay	71.82	-0.50	-1.72	29.71	31.33	-19.85	1.47	7.65
Viviana	65.59	-6.73	-1.25	5.41	18.07	-33.11	0.20	3.20
Sapporo	64.97	-7.35	1.35	1.73	18.73	-32.45	0.26	3.06
Overall mean	**72.31**	Standard Error (m) = 1.95 Standard Error (b) = 2.16			**51.18**	Standard Error (m) = 2.72 Standard Error (b) = 0.88		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

Genotype 'Brunello' recorded high value of regression coefficient (1.40), phenotypic index (6.39) and squared deviation from regression coefficient (24.95) thus regarded as rich environment over all the four environments with significantly high mean value (78.71 cm) than overall mean.

4.5.1.4 Number of leaves/plant

Significantly high mean value than overall mean (51.18) was observed in genotypes such as 'Prato' (58.98), 'Tresor' (56.50), 'Brunello' (63.80), 'Pollyana' (68.06), 'Elite' (65.22), 'Eyeliner' (83.62) and 'Cilesta' (70.56) indicating these genotypes produced more number of leaves per plant. However in terms of stability over four environments, 'Salmon Classic' observed as most stable genotype with respect to number of leaves per plant with significantly high mean value (64.22) than overall mean (51.18) (Table 4.5.1.2).

4.5.1.5 Leaf length (cm)

Stability analysis with respect to leaf length has been presented in Table 4.5.1.3. Genotypes such as 'Prato' (14.61 cm), 'Tresor' (10.58 cm), 'Brunello' (11.09 cm), 'Pollyana' (10.95 cm), 'Elite' (11.11 cm), 'Eyeliner' (13.47 cm), 'Ercolano' (10.67 cm), 'Ceb Dazzle' (11.27 cm), 'Best Seller' (12.92 cm), 'Salmon Classic' (11.74 cm) and 'Cilesta' (11.67 cm) exhibited high mean values than overall mean with regards to leaf length but these genotypes were not stable whereas in terms of stability, 'Yelloween' recorded as most stable genotype with significantly high mean (11.51 cm) than overall mean (10.42 cm).

Table 4.5.1.3: Estimation of stability parameters in 18 *Lilium* genotypes for leaf length (cm) and leaf width (cm)

Genotypes	Leaf length (cm)				Leaf width (cm)			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	8.64	-1.78	-5.06	0.89	1.63	-0.51	1.07	0.00
Prato	14.61	4.19	4.20	0.33	1.99	-0.15	1.68	0.20
Tresor	10.58	0.15	11.38	-0.01	1.42	-0.72	0.77	0.01
Shiraj	8.14	-2.28	-8.03	3.32	1.58	-0.56	-0.53	0.26
Brunello	11.09	0.67	0.21	0.37	2.20	0.06	1.43	0.05
Pollyana	10.95	0.53	-3.27	0.00	1.87	-0.27	1.82	0.16
Elite	11.11	0.69	-0.04	0.89	1.86	-0.28	0.35	0.12
Eyeliner	13.47	3.05	4.24	0.29	2.28	0.14	3.77	0.17
Ercolano	10.67	0.25	-1.82	0.08	2.08	-0.06	2.08	0.14
Ceb Dazzle	11.27	0.85	2.31	0.01	1.93	-0.21	0.61	0.13
Best Seller	12.92	2.50	8.76	0.98	2.09	-0.05	0.64	0.11
Pavia	8.75	-1.67	-2.34	1.07	2.27	0.13	1.09	0.03
Salmon Classic	11.74	1.32	0.07	0.48	2.15	0.01	1.64	0.06
Yelloween	11.51	1.09	1.07	0.47	1.91	-0.23	-0.29	0.11
Celesta	11.67	1.25	3.18	0.14	1.92	-0.22	2.85	0.02
Montego Bay	6.92	-3.50	2.42	-0.02	2.42	0.28	-1.47	0.09
Viviana	6.94	-3.48	1.19	-0.01	3.51	1.37	0.89	0.04
Sapporo	6.62	-3.80	-0.48	0.01	3.44	1.30	-0.41	-0.01
Overall mean	10.42	Standard Error (m) = 0.43 Standard Error (b) = 2.19			2.14	Standard Error (m) = 0.18 Standard Error (b) = 1.54		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

4.5.1.6 Leaf width (cm)

Data presented in Table 4.5.1.3 exhibited that in terms of stability parameters, genotypes ‘Brunello’, ‘Pavia’ and ‘Viviana’ were most stable as they satisfied the entire criterion for stability along with significantly high mean values (2.20 cm, 2.27 cm and 3.51 cm, respectively) than overall mean (2.14 cm). However significantly higher mean (3.44 cm) reported in ‘Sapporo’ but not found to stable with regards to leaf width.

4.5.1.7 Stem length (cm)

Stability analysis with respect to stem length (cm) as been presented in Table 4.5.1.4 revealed that out of eighteen *Lilium* genotypes, ‘Salmon Classic’ recorded as most stable genotype with significantly high mean (54.75 cm) than overall mean (52.32 cm). In contrast genotypes such as ‘Yelloween’ (77.73 cm) and ‘Eyeliner’ (68.07 cm) exhibited higher mean value for stem length than overall mean yet these were highly unstable with respect to stem length.

Table 4.5.1.4: Estimation of stability parameters in 18 *Lilium* genotypes for stem length (cm) and days to flower bud formation

Genotypes	Stem length (cm)				Days to flower bud formation			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	36.59	-15.73	-0.49	0.09	55.69	1.80	0.64	27.56
Prato	60.72	8.40	2.94	10.06	57.19	4.32	1.29	74.90
Tresor	37.60	-14.72	0.72	14.46	55.77	-1.92	1.00	138.34
Shiraj	38.13	-14.19	-0.55	15.97	60.13	4.49	0.84	62.64
Brunello	58.71	6.39	1.79	22.99	58.16	-3.74	1.44	130.14
Pollyana	62.40	10.08	-0.42	13.34	60.41	11.56	0.96	-1.12
Elite	64.77	12.45	2.74	12.40	54.74	0.29	0.98	42.73
Eyeliner	68.07	15.75	-0.83	6.95	59.72	0.51	0.62	14.37
Ercolano	46.37	-5.95	0.39	28.01	55.91	6.91	0.93	56.36
Ceb Dazzle	46.63	-5.69	-1.44	13.68	57.01	5.91	1.23	29.55
Best Seller	33.65	-18.67	1.86	2.72	41.60	-4.21	0.85	4.42
Pavia	45.94	-6.38	3.22	10.26	53.13	-1.80	0.93	4.50
Salmon Classic	54.75	2.43	1.35	21.88	47.29	0.29	0.84	226.59
Yelloween	77.73	25.41	2.51	18.25	60.96	-0.94	0.95	27.91
Celesta	67.29	14.97	3.23	8.18	53.07	-1.48	0.84	28.62
Montego Bay	51.82	-0.50	-0.12	33.36	73.48	-5.64	1.20	23.24
Viviana	45.59	-6.73	-0.46	7.05	71.08	-7.88	1.30	20.61
Sapporo	44.97	-7.35	1.56	0.67	55.69	-8.51	1.16	4.42
Overall mean	**52.32**	Standard Error (m) = 2.15 Standard Error (b) = 2.27			**54.19**	Standard Error (m) = 4.19 Standard Error (b) = 0.22		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

4.5.1.8 Days to flower bud formation

Among all the eighteen genotypes 'Pollyana' observed as most stable with respect to days to flower bud formation. However 'Best Seller' (41.60 days) took minimum days for flower bud formation but found to be unstable over the environments. Genotype such as 'Tresor' was stable with unit regression for this character but rest of the two parameters was not satisfied by the same genotype. Late flowering genotypes such as 'Montego Bay' and 'Viviana' were also not stable for this trait (Table 4.5.1.4).

4.5.1.9 Bud length (cm)

Trait bud length observed significantly high mean (10.01 cm, 9.93 cm and 12.79 cm, respectively) than overall mean (9.50 cm). Moreover these genotypes also recorded most stability for bud length over the environments. Other genotypes such as 'Prato' (10.50 cm), 'Brunello' (10.42 cm), 'Ercolano' (9.86 cm), 'Best Seller' (10.04 cm), 'Pavia' (9.68 cm) and 'Sapporo' (10.94 cm) recorded significantly high mean value than overall mean (9.50 cm) but these genotypes were unstable for bud length (4.5.1.5).

4.5.1.10 Days to first flower

Perusal of data presented in Table 4.5.1.5 revealed that genotypes such as 'Montego Bay' and 'Sapporo' recorded as most stable genotypes however they were late flowering under all the environments. On the other hand genotypes, 'Tresor', 'Ceb Dazzle', 'Pavia', 'Salmon Classic' and 'Yelloween' exhibited stability with unit regression for this character but rest of the two stability parameters were not satisfied by these genotypes. 'Best Seller' recorded as stable genotypes but was unstable for days to first flowering.

4.5.1.11 Stem diameter (cm)

Perusal of data presented in Table 4.5.1.5 indicates that genotypes, 'Best Seller', 'Pavia' and 'Salmon Classic' found to be stable genotypes with respect to stem diameter as these genotypes exhibited more mean (0.75 cm, 0.79 cm and 0.77 cm, respectively) than overall mean (0.65 cm), near to unity regression coefficient (0.69, 0.80, 0.99, respectively) and also fulfilled the requirement of phenotypic index and showed zero deviation from regression.

Table 4.5.1.5: Estimation of stability parameters in 18 *Lilium* genotypes for bud length (cm), days to first flower and stem diameter (cm)

Genotypes	Bud length (cm)				Days to first flower				Stem diameter (cm)			
	Mean	**P_i**	**b_i**	**S^2_{di}**	**Mean**	**P_i**	**b_i**	**S^2_{di}**	**Mean**	**P_i**	**b_i**	**S^2_{di}**
Navona	8.22	-1.28	0.93	0.34	79.91	-0.25	0.61	3.041	0.69	0.04	0.78	0.01
Prato	10.50	1.00	2.11	0.32	79.67	-3.15	0.85	62.64	0.72	0.07	2.11	0.01
Tresor	7.61	-1.90	1.48	-0.01	89.08	-8.54	1.07	115.19	0.60	-0.05	1.58	0.00
Shiraj	6.72	-2.78	1.57	0.13	87.60	-0.20	1.12	2.10	0.44	-0.22	0.74	0.00
Brunello	10.42	0.92	2.28	0.22	85.95	-17.08	1.20	63.41	0.60	-0.05	1.21	0.00
Pollyana	10.01	0.51	1.69	0.48	87.43	3.63	0.96	11.58	0.55	-0.10	0.26	0.00
Elite	7.68	-1.82	1.23	2.33	88.97	-1.56	0.88	26.99	0.64	-0.01	1.17	0.00
Eyeliner	9.93	0.43	1.23	0.20	86.22	-5.29	0.89	11.32	0.74	0.09	1.27	0.00
Ercolano	9.86	0.36	1.80	0.52	86.56	1.14	0.69	44.36	0.67	0.02	0.93	0.01
Ceb Dazzle	9.11	-0.39	0.42	1.02	86.37	1.58	1.03	54.62	0.67	0.02	0.93	0.01
Best Seller	10.04	0.54	1.79	0.52	63.73	-7.31	0.82	2.56	0.75	0.10	0.69	0.00
Pavia	9.68	0.18	2.68	0.23	86.59	-1.45	1.03	9.38	0.79	0.14	0.80	0.00
Salmon Classic	9.22	-0.28	0.65	1.79	73.47	1.96	1.04	100.27	0.77	0.12	0.99	0.00
Yelloween	12.79	3.29	1.14	0.06	89.40	11.39	1.06	2.69	0.64	-0.01	1.18	0.00
Celesta	9.39	-0.11	1.09	0.89	79.11	-8.03	0.72	35.61	0.75	0.10	1.33	0.01
Montego Bay	10.10	0.60	-0.81	0.26	101.32	12.14	1.37	0.00	0.62	-0.03	1.50	0.00
Viviana	8.84	-0.66	-1.55	0.02	99.63	11.35	1.40	18.05	0.49	-0.16	0.62	0.00
Sapporo	10.94	1.44	-1.73	0.36	99.29	9.69	1.24	1.01	0.65	0.00	-0.08	0.00
Overall mean	**9.50**	Standard Error (m) = 0.43 Standard Error (b) = 0.82			**86.13**	Standard Error (m) = 3.28 Standard Error (b) = 0.12			**0.65**	Standard Error (m) = 0.37 Standard Error (b) = 0.31		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

4.5.1.12 Size of the flower (cm)

As far as size of the flowers of different genotypes are concerned, 'Yelloween' produced large sized flowers with maximum mean value (20.39 cm) than overall mean (16.46 cm) and found to be stable over all the environments (Table 4.5.1.6). Genotype 'Sapporo' also recorded high mean value (20.20 cm) than overall mean but recorded unstable performance over the environment.

4.5.1.13 Number of flowers/plant

Data presented in Table 4.5.1.6 shows that maximum number of flowers/plant recorded in genotype 'Eyeliner' (7.97) than overall mean (4.58). This genotype also fulfilled the criteria of stability parameter except regression coefficient thus indicating that genotype is average performer. 'Salmon Classic' with high mean value (5.28 cm) than population mean (4.58) also recorded stable performance with respect to number of flowers/plant. Genotypes such as 'Prato' (7.43), 'Brunello' (6.28), 'Elite' (5.26) and 'Cilesta' (5.89) recorded comparatively higher mean value indicating more yield than overall mean but found unstable over environments with regards to number of flowers/plant.

4.5.1.14 Tepal length (cm)

Data related to tepal length depicts that genotype 'Viviana' found to be most stable genotype with regard to tepal length (Table 4.5.1.7). However genotypes 'Prato', 'Yelloween' and 'Sapporo' exhibited higher mean (10.92 cm, 12.43 cm and 11.90 cm, respectively) yet regression coefficient was low for this parameter indicating the average performance of these genotypes over four different environments.

4.5.1.15 Tepal width (cm)

With regards to tepal width, genotypes 'Brunello' and 'Montego Bay' were found to be most stable genotype with comparatively higher mean values (3.37 cm and 3.21 cm, respectively) than overall mean (2.95 cm). However genotype 'Sapporo' recorded maximum mean value (3.62 cm) indicating average performance of the genotype over environment (Table 4.5.1.7).

Table 4.5.1.6: Estimation of stability parameters in 18 *Lilium* genotypes for size of the flower (cm) and number of flowers per plant

Genotypes	Size of the flower (cm)				Number of flowers/plant			
	Mean	**P_i**	**b_i**	**S^2_{di}**	**Mean**	**P_i**	**b_i**	**S^2_{di}**
Navona	15.07	-1.38	1.72	-0.01	3.97	-0.61	0.08	0.03
Prato	18.51	2.06	2.81	0.62	7.43	2.85	1.47	1.00
Tresor	15.03	-1.42	0.96	0.00	4.23	-0.36	0.92	0.33
Shiraj	13.23	-3.22	1.26	0.00	3.90	-0.68	0.73	0.20
Brunello	17.24	0.79	0.75	-0.05	6.28	1.70	2.22	0.33
Pollyana	16.45	0.00	2.23	0.34	4.74	0.16	1.79	0.22
Elite	14.83	-1.62	2.82	0.23	5.26	0.68	1.84	0.58
Eyeliner	15.94	-0.51	1.47	0.30	7.97	3.39	2.07	-0.03
Ercolano	16.64	0.19	2.10	0.02	2.86	-1.73	0.03	0.06
Ceb Dazzle	15.41	-1.05	0.85	-0.05	3.06	-1.52	0.22	0.06
Best Seller	15.97	-0.48	0.04	-0.03	4.02	-0.56	-0.38	1.64
Pavia	16.77	0.32	2.82	0.56	4.52	-0.06	0.09	-0.04
Salmon Classic	15.89	-0.56	2.29	0.87	5.28	0.70	1.31	0.42
Yelloween	20.39	3.94	0.55	0.05	4.37	-0.21	1.23	0.32
Celesta	15.91	-0.54	-1.87	1.10	5.89	1.31	2.20	-0.02
Montego Bay	16.80	0.35	0.36	0.36	3.72	-0.86	1.34	0.20
Viviana	15.91	-0.54	-3.00	1.17	2.33	-2.26	0.26	0.04
Sapporo	20.20	3.75	-0.15	0.04	2.67	-1.91	0.59	-0.02
Overall mean	**16.46**	Standard Error (m) = 0.35 Standard Error (b) = 0.99			**4.58**	Standard Error (m) = 0.34 Standard Error (b) = 0.22		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

4.5.1.16 Duration of flowering (days)

Data related to duration of flowering depicts that among different genotypes maximum duration of flowering (23.81 days) recorded in genotype ‘Eyeliner’ however, performance of this genotype was unstable over the environments. Data further revealed that ‘Salmon Classic’ was most stable genotype with respect to duration of flowering. Genotypes such as ‘Prato’ (22.82 days) and ‘Brunello’ (20.93 days) exhibited comparatively more duration of flowering as compared to overall mean (17.37 days) yet their performance was unstable over environment (Table 4.5.1.8).

4.5.1.17 Bulb diameter (cm)

Table 4.5.1.8 revealed that genotypes ‘Navona’, ‘Brunello’, ‘Elite’ and ‘Eyeliner’ exhibited stable performance with respect to bulb diameter over the environments. Furthermore, ‘Prato’, ‘Pavia’ and ‘Montego Bay’ recorded high mean values (5.75 cm, 5.17

cm and 5.10 cm) than overall mean yet these genotypes showed unstable performance with respect to bulb diameter over different environments.

Table 4.5.1.7: Estimation of stability parameters in 18 *Lilium* genotypes for tepal length (cm) and tepal width (cm)

Genotypes	Tepal length (cm)				Tepal width (cm)			
	Mean	**P_i**	**b_i**	S^2_{di}	**Mean**	**P_i**	**b_i**	S^2_{di}
Navona	8.94	-0.51	1.16	0.81	2.50	-0.45	0.62	0.06
Prato	10.92	1.47	-0.80	0.05	3.36	0.41	0.28	0.00
Tresor	8.43	-1.02	0.34	-0.01	2.72	-0.23	0.48	0.11
Shiraj	6.95	-2.50	-0.72	0.00	2.38	-0.57	0.68	0.10
Brunello	9.51	0.06	1.64	0.26	3.37	0.42	0.67	0.02
Pollyana	9.21	-0.24	1.67	0.03	2.28	-0.67	0.57	-0.01
Elite	7.88	-1.57	-0.76	-0.03	2.46	-0.49	-0.50	-0.01
Eyeliner	9.61	0.16	2.03	-0.03	2.93	-0.02	0.50	0.02
Ercolano	9.30	-0.15	1.84	1.17	3.00	0.05	1.53	0.02
Ceb Dazzle	9.37	-0.08	2.57	0.13	3.13	0.18	1.54	0.05
Best Seller	9.37	-0.08	0.94	-0.03	3.18	0.23	2.60	0.01
Pavia	9.69	0.24	1.77	1.12	3.15	0.20	1.64	-0.01
Salmon Classic	8.04	-1.41	1.77	0.97	2.99	0.04	2.41	0.11
Yelloween	12.43	2.98	-0.11	-0.03	2.85	-0.10	2.62	0.04
Celesta	9.09	-0.36	1.47	0.03	2.81	-0.14	1.64	0.00
Montego Bay	9.85	0.40	2.48	0.04	3.21	0.26	1.15	-0.01
Viviana	9.65	0.20	0.93	0.36	3.22	0.27	0.28	0.03
Sapporo	11.90	2.45	-0.21	-0.03	3.62	0.67	-0.69	-0.01
Overall mean	**9.45**	Standard Error (m) = 0.32 Standard Error (b) = 0.51			**2.95**	Standard Error (m) = 0.11 Standard Error (b) = 0.43		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di} Squared deviation from regression coefficient

4.5.1.18 Weight of bulb (g)

Perusal of data presented in Table 4.5.1.9 indicated that maximum weight of bulb recorded in genotype ‘Navona’ (50.40 g), ‘Prato’ (60.80 g), ‘Ceb Dazzle’ (58.26 g), ‘Salmon Classic’ (58.11 g) and ‘Montego Bay’ (61.34 g) as compared to overall mean (47.11 g) however, these genotypes found unstable under different environment. Among different genotypes, ‘Elite’ and ‘Eyeliner’ observed as rich environment as these genotype recorded high mean (49.19 g and 64.05 g, respectively) than overall mean (47.11 g),high phenotypic index (2.08 and 16.94, respectively), regression coefficient (1.23 and 1.15, respectively) was greater than unity and high deviation from linearity (1.53 and 3.17, respectively). It indicated that these genotypes were suitable to rich environment, below average stability.

4.5.1.19 Number of bulblets per plant

With regards to number of bulblets per plant, genotypes such as 'Salmon Classic' and 'Cilesta' recorded as stable genotypes. Data presented in Table 4.5.1.9 indicated that significantly maximum number of bulblet per plant recorded in 'Eyeliner' (7.20), phenotypic index greater than zero, high value of regression coefficient (2.69) and low value of deviation from linearity (0.04) indicated this genotype as average performer over different environment.

Table 4.5.1.8: Estimation of stability parameters in 18 *Lilium* genotypes for duration of flowering (days) and bulb diameter (cm)

Genotypes	Duration of flowering (days)				Bulb diameter (cm)			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	17.02	-0.35	0.77	-0.11	5.01	0.33	1.14	-0.04
Prato	22.82	5.45	0.49	2.28	5.75	1.07	1.72	0.20
Tresor	19.40	2.03	1.47	2.07	4.42	-0.26	1.41	0.03
Shiraj	15.39	-1.98	1.39	0.41	4.22	-0.46	1.76	0.30
Brunello	20.93	3.56	1.76	3.40	5.15	0.47	1.17	0.10
Pollyana	15.95	-1.42	1.08	2.29	4.41	-0.27	0.58	0.94
Elite	16.81	-0.56	1.95	1.73	4.76	0.08	0.99	0.03
Eyeliner	23.81	6.44	1.39	4.14	5.54	0.86	0.70	-0.05
Ercolano	12.24	-5.13	0.10	14.41	4.55	-0.13	0.79	0.02
Ceb Dazzle	13.69	-3.68	0.42	5.36	4.77	0.09	0.79	0.03
Best Seller	13.00	-4.37	-0.91	4.84	4.90	0.22	1.42	0.11
Pavia	18.38	1.01	-1.03	1.06	5.17	0.49	1.41	0.15
Salmon Classic	18.53	1.16	1.43	-0.14	4.81	0.13	1.27	0.04
Yelloween	18.66	1.29	1.31	8.61	4.65	-0.03	1.45	-0.04
Celesta	17.57	0.20	2.13	4.15	4.36	-0.32	0.06	0.10
Montego Bay	18.56	1.19	2.62	0.28	5.10	0.42	1.49	0.03
Viviana	14.70	-2.68	0.97	8.58	3.33	-1.35	-0.03	-0.03
Sapporo	15.28	-2.09	0.67	0.80	3.41	-1.27	-0.12	0.02
Overall mean	**17.37**	Standard Error (m) = 1.13 Standard Error (b) = 0.38			**4.68**	Standard Error (m) = 0.23 Standard Error (b) = 0.31		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

4.5.1.20 Weight of bulblet (g)

It is evident from data presented in Table 4.5.1.10 that genotypes 'Eyeliner' and 'Pavia' found to be most stable genotype with respect to weight of bulblet. Genotypes such as 'Brunello' (2.07 g), 'Salmon Classic' (2.62 g), 'Cilesta' (2.15 g) and 'Montego Bay' (2.76 g) recorded high mean value than overall mean (1.91 g) however, these genotypes were unstable with respect to their performance under different environments.

Table 4.5.1.9: Estimation of stability parameters in 18 *Lilium* genotypes for weight of bulb (g) and number of bulblets/plant

Genotypes	Weight of bulb (g)				Number of bulblets/plant			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	50.40	3.29	0.91	69.86	1.83	-1.14	0.19	0.04
Prato	60.80	13.69	2.00	60.83	3.70	0.73	1.49	0.78
Tresor	40.26	-6.85	0.81	6.57	2.82	-0.15	-0.19	0.17
Shiraj	40.61	-6.50	0.95	0.81	1.97	-1.00	0.42	-0.02
Brunello	48.29	1.18	0.65	64.85	3.70	0.73	1.80	1.16
Pollyana	42.81	-4.30	0.64	10.27	1.53	-1.45	0.08	0.09
Elite	49.19	2.08	1.23	1.53	1.99	-0.98	0.34	-0.03
Eyeliner	64.05	16.94	1.15	3.17	7.20	4.23	2.69	0.04
Ercolano	44.48	-2.63	0.75	5.71	2.60	-0.37	0.71	0.17
Ceb Dazzle	58.26	11.15	1.75	24.42	5.27	2.30	2.84	0.02
Best Seller	45.58	-1.53	0.98	28.21	2.84	-0.13	1.19	-0.01
Pavia	46.27	-0.84	1.13	75.24	4.73	1.76	2.57	0.11
Salmon Classic	58.11	11.00	1.82	49.49	3.05	0.08	1.51	-0.02
Yelloween	45.23	-1.88	0.97	62.97	1.83	-1.15	0.28	0.26
Celesta	45.91	-1.20	0.45	16.28	3.14	0.17	1.31	0.05
Montego Bay	61.34	14.23	1.64	46.86	2.17	-0.80	0.52	0.07
Viviana	24.18	-22.93	0.04	19.20	1.73	-1.24	0.23	0.23
Sapporo	22.15	-24.96	0.13	22.21	1.83	-1.14	0.19	0.04
Overall mean	47.11	Standard Error (m) = 3.27 Standard Error (b) = 0.17			3.00	Standard Error (m) = 0.26 Standard Error (b) = 0.18		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

4.5.1.21 Vase life (days)

With regards to vase life, genotype ‘Eyeliner’ (10.28 days) and ‘Sapporo’ (7.54 days) recorded maximum mean value than overall mean (7.24 days) and also observed as stable genotype over different environments (Table 4.5.1.10).

Genotypes such as ‘Navona’, ‘Pollyana’ and ‘Ercolano’ recorded phenotypic index (-0.65, -0.14 and -1.02, respectively) less than zero, regression coefficient (1.04, 1.10 and 1.02, respectively) greater than one and low deviation from linearity (0.26, 0.45 and 0.00) indicating that these genotypes were suitable for average environments.

Table 4.5.1.10: Estimation of stability parameters in 18 *Lilium* genotypes for weight of bulblets (g) and vase life (days)

Genotypes	Weight of bulblets (g)				Vase life (days)			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	1.91	0.00	1.79	0.04	6.59	-0.65	1.04	0.26
Prato	1.81	-0.10	1.65	0.21	7.25	0.01	1.56	0.86
Tresor	1.47	-0.44	1.02	0.40	7.19	-0.05	0.62	1.11
Shiraj	1.60	-0.31	0.68	0.16	6.83	-0.41	1.12	0.08
Brunello	2.07	0.16	-0.05	0.20	7.45	0.21	1.76	0.45
Pollyana	1.86	-0.05	2.18	0.40	7.10	-0.14	1.10	-0.06
Elite	1.57	-0.34	1.42	0.18	7.24	0.00	0.73	0.00
Eyeliner	3.26	1.35	1.02	0.07	10.28	3.04	0.62	0.68
Ercolano	1.70	-0.21	0.13	0.00	6.22	-1.02	1.02	0.00
Ceb Dazzle	1.78	-0.13	0.19	0.11	6.27	-0.97	1.14	0.25
Best Seller	1.78	-0.13	0.72	0.75	6.36	-0.88	0.95	0.04
Pavia	2.02	0.11	0.75	0.21	6.81	-0.43	0.73	0.14
Salmon Classic	2.62	0.71	2.56	1.63	7.93	0.69	2.41	0.61
Yelloween	1.51	-0.40	0.47	0.09	6.94	-0.30	0.49	0.07
Celesta	2.15	0.24	1.52	0.14	8.42	1.18	-0.04	0.50
Montego Bay	2.76	0.85	0.90	6.01	7.15	-0.09	1.43	-0.06
Viviana	0.67	-1.24	0.03	-0.03	6.73	-0.51	0.32	0.32
Sapporo	1.80	-0.11	1.03	0.20	7.54	0.30	1.01	0.60
Overall mean	1.91	Standard Error (m) = 0.46 Standard Error (b) = 1.32			7.24	Standard Error (m) = 0.38 Standard Error (b) = 0.42		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

4.5.1.22 Stem strength (%)

Grading of genotypes on the basis of stem strength indicated that genotypes ‘Prato’ (94.32 %) and ‘Eyeliner’ (95.64 %) produced maximum grade ‘A’ cut stems. However none of these genotypes exhibited stability with regards to stem strength over different environments (Table 4.5.1.11).

In case of grade ‘B’ cut stems, none of the genotypes exhibited stability. Results with regard to grade ‘C’ cut stems revealed that none of the genotypes exhibited stability over different environments. However, genotype ‘Sapporo’ recorded phenotypic index (11.62) i.e. more than zero, regression coefficient near unity (0.98) and high deviation from linearity (34.09) indicating this genotype as rich environment.

Table 4.5.1.11: Estimate of stability parameters in 18 *Lilium* genotypes for stem strength (%)

Genotypes	A grade				B Grade				C Grade			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	73.95	3.62	3.22	77.43	16.43	-4.72	3.24	104.03	9.62	1.11	1.82	31.78
Prato	94.32	23.99	0.12	14.74	4.54	-16.61	0.47	4.85	1.14	-7.37	-0.15	1.23
Tresor	74.60	4.27	1.43	71.65	15.20	-5.95	0.40	24.79	10.20	1.69	2.11	7.39
Shiraj	55.63	-14.71	0.03	119.03	32.96	11.81	-0.12	0.20	11.42	2.91	0.78	96.99
Brunello	82.85	12.52	-0.10	2.75	14.81	-6.34	0.15	3.66	2.34	-6.17	-0.39	0.02
Pollyana	75.35	5.02	-1.24	137.13	23.42	2.27	-0.81	250.90	1.24	-7.27	-0.10	2.43
Elite	74.78	4.45	0.05	125.35	18.50	-2.65	0.24	115.14	6.72	-1.79	0.05	18.91
Eyeliner	95.64	25.31	0.35	12.26	3.72	-17.43	0.77	7.08	0.64	-7.87	-0.17	-0.95
Ercolano	77.96	7.63	-0.42	630.54	12.99	-8.16	-1.39	31.01	9.05	0.54	1.25	260.91
Ceb Dazzle	51.72	-18.61	1.01	59.70	38.94	17.79	1.37	80.92	9.34	0.83	1.97	132.68
Best Seller	67.83	-2.50	1.60	437.69	22.78	1.63	0.57	472.27	9.39	0.88	1.80	35.70
Pavia	68.70	-1.63	2.00	624.95	24.87	3.72	3.81	161.78	6.43	-2.08	0.57	48.49
Salmon Classic	59.65	-10.68	1.29	83.41	30.92	9.77	3.65	28.31	9.43	0.92	-0.19	43.31
Yelloween	63.47	-6.86	0.69	8.98	22.52	1.37	0.28	11.16	14.00	5.49	1.16	0.31
Cilesta	76.04	5.71	2.41	59.46	16.89	-4.26	2.44	81.02	7.07	-1.44	1.05	41.44
Montego Bay	62.80	-7.53	-0.20	139.34	29.74	8.59	-1.10	150.68	7.46	-1.05	1.30	7.59
Viviana	51.26	-19.07	3.46	524.84	22.62	1.47	2.01	83.35	26.12	17.61	4.16	223.12
Sapporo	59.46	-10.87	2.30	94.15	28.92	7.77	2.02	275.95	11.62	3.11	0.98	34.09
Overall mean	**70.33**	Standard Error (m) = 7.76 Standard Error (b) = 1.00			**21.15**	Standard Error (m) = 5.91 Standard Error (b) = 1.25			**8.51**	Standard Error (m) = 4.31 Standard Error (b) = 1.01		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di} Squared deviation from regression coefficient

4.5.1.23 Grading of cut flowers (%)

In present investigation, cut flowers were graded on the basis of stem length and number of flowers per plant into grade '1', grade '2', grade '3', grade '4' and grade '5'. Stability analysis for different grades as presented in Table 4.5.1.12(a) and Table 4.5.1.12(b) shows that in case of Grade '1' cut flowers, 'Eyeliner' (85.83 %), 'Pollyana' (71.98 %), and 'Prato' (66.76 %) produced maximum grade '1' cut flowers however, these genotypes were unstable in performance under different environment. Among different genotypes, 'Pavia' found to be stable genotype over different environments however; there was significantly less difference between mean value (38.97 %) and overall mean (38.88 %).

Table 4.5.1.12(a): Estimate of stability parameters in 18 *Lilium* genotypes for grading of cut flowers (%)

Genotypes	Grade 1				Grade 2			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	25.75	-13.13	-5.58	662.41	14.98	-1.24	-1.61	191.06
Prato	66.76	27.88	5.63	304.43	15.70	-0.52	-7.18	58.70
Tresor	27.08	-11.80	-0.49	367.74	48.04	31.82	7.74	649.17
Shiraj	7.67	-31.21	2.79	54.28	3.21	-13.01	1.36	-2.93
Brunello	50.43	11.55	4.48	663.11	16.71	0.49	-4.26	11.61
Pollyana	71.98	33.10	2.88	415.42	11.42	-4.80	-1.70	37.80
Elite	49.83	10.95	-2.57	206.02	31.13	14.91	3.36	127.26
Eyeliner	85.83	46.95	3.24	189.40	5.83	-10.39	-1.28	22.79
Ercolano	16.43	-22.45	2.86	100.39	6.42	-9.80	2.54	-3.27
Ceb Dazzle	20.69	-18.19	0.81	105.61	10.99	-5.23	1.20	19.10
Best Seller	29.70	-9.18	4.25	2551.05	6.54	-9.68	1.97	63.51
Pavia	38.97	0.10	0.90	0.20	34.10	17.88	3.83	109.06
Salmon Classic	24.01	-14.87	-0.28	40.01	16.46	0.24	-0.89	113.48
Yelloween	68.86	29.98	-6.02	604.54	8.16	-8.06	3.10	-1.27
Celesta	56.46	17.58	-0.56	353.71	18.19	1.97	-0.67	-3.83
Montego Bay	35.68	-3.20	5.88	62.82	18.25	2.03	1.32	14.83
Viviana	9.16	-29.72	-1.00	35.18	2.88	-13.34	0.60	10.45
Sapporo	14.61	-24.27	0.79	5.33	22.90	6.68	8.56	1364.02
Overall mean	38.88	Standard Error (m) = 11.20 Standard Error (b) = 4.05			16.22	Standard Error (m) = 16.22 Standard Error (b) = 4.19		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

In case of grade '2' cut flowers, genotypes such as 'Tresor' (48.04 %), 'Elite' (31.13 %) and 'Pavia' (34.10 %) produced maximum grade '2' cut flowers as they exhibited significantly high mean values than overall mean (16.22 %) but these genotypes were not stable performer over environments.

Significantly lower mean value over overall mean is an indication of less percentage of low grade cut flowers such as grade '3' and grade '4'. In case of grade '3' cut flowers, no stable genotypes were found. Similarly with regards to grade '4' 'Eyeliner' recorded phenotypic index (-15.23) i.e. less than zero, regression coefficient near unity (1.04) and low deviation from linearity (-1.87) indicating this genotype as average environment (Table 4.5.1.12b).

Table 4.5.1.12(b): Estimate of stability parameters in 18 *Lilium* genotypes for grading of cut flowers (%)

Genotypes	**Grade 3**				**Grade 4**			
	Mean	**P_i**	**b_i**	S^2_{di}	**Mean**	**P_i**	**b_i**	S^2_{di}
Navona	4.27	-8.62	-3.18	6.18	25.78	8.05	1.71	163.58
Prato	10.78	-2.11	3.01	53.38	6.03	-11.70	1.73	-0.08
Tresor	6.68	-6.21	1.05	4.55	11.57	-6.16	1.46	95.73
Shiraj	4.09	-8.80	-0.31	-0.42	36.08	18.35	3.33	540.18
Brunello	11.34	-1.56	4.34	6.36	10.99	-6.74	3.14	108.65
Pollyana	10.33	-2.56	5.36	69.91	5.89	-11.84	1.40	8.19
Elite	8.99	-3.90	-0.29	2.12	6.75	-10.98	-0.04	-2.46
Eyeliner	2.50	-10.39	1.64	8.21	2.50	-15.23	1.04	-1.87
Ercolano	20.13	7.24	0.19	9.75	37.03	19.30	-0.70	409.01
Ceb Dazzle	35.96	23.07	-5.38	577.41	19.47	1.74	1.57	458.18
Best Seller	3.51	-9.38	-4.20	-0.38	10.68	-7.05	-0.07	24.50
Pavia	13.91	1.02	-1.61	28.45	8.86	-8.87	-1.53	20.47
Salmon Classic	25.99	13.10	9.87	140.22	22.08	4.35	2.65	256.08
Yelloween	6.45	-6.45	-5.83	18.46	13.88	-3.85	4.60	286.78
Celesta	13.30	0.41	4.05	38.52	6.42	-11.31	0.02	31.33
Montego Bay	21.22	8.33	6.90	153.65	16.77	-0.96	2.07	37.32
Viviana	24.24	11.35	3.13	85.73	57.15	39.42	-1.27	157.07
Sapporo	8.37	-4.52	-0.73	2.81	21.25	3.52	-3.11	154.38
Overall mean	**12.89**	Standard Error (m) = 12.89 Standard Error (b) = 4.03			17.73	Standard Error (m) = 7.19 Standard Error (b) = 2.40		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di}: Squared deviation from regression coefficient

Genotype × environment interaction found to be non-significant with respect to grade '5' cut flowers (Appendices-VI).

Genotype environment interaction is very important to the plant breeders in developing improved varieties. The genotypes grown in multi-environmental trials may react differently to a range of climate conditions, soil characteristics or technical practices. In order to develop improved and stable genotypes in crop plants, comprehensive knowledge of genotype × environment interaction is necessary. It is important to select a stable genotype that interacts less with the environments in which they are grown to realize yield uniformity. In present study eighteen genotypes of *Lilium* were grown under four different environments viz., E1, E2, E3 and E4 and performance of these genotypes for different vegetative, flowering and bulb parameters were studied. For stability analysis, Eberhart and Russell model (1966) was used which indicates that a stable genotype is one which confirms to the following three conditions of stability parameters i.e. (phenotypic index) $P_i > 0$, (regression coefficient) $b_i \cong 1$ and (squared deviation from linearity) S^2_{di} is low.

In respect of characters such as days taken for bulb sprout emergence, days taken for flower bud formation and days to first flower, lowest mean was considered desirable whereas rest of the parameters such as per cent bulb sprouting, plant height, number of leaves per plant, leaf length, leaf width, stem length, bud length, stem diameter, size of the flower, number of flowers per plant, tepal length, tepal width, duration of flowering, bulb diameter, weight of bulb, number of bulblets per plant, weight of bulblet and vase life, high means were desirable. In case of stem strength and grading of cut flowers, high mean value of grade ‘A’ and grade ‘1’ were desirable, respectively.

With regards to stability of different genotype, ‘Eyeliner’ exhibited stability for most of the parameters like days taken to bulb sprout emergence, bud length, number of flowers/stem, weight of bulblets, number of bulblets and vase life whereas genotype ‘Yelloween’ exhibited stability for parameters such as leaf length, bud length and size of flower and days to first flower. Parameterwise stability of *Lilium* genotypes has been presented in Table 4.5.1.13.

Similar studies and results were also reported by Desh Raj and Misra (1998a) in gladiolus; Vaidya (2006), Priyanka (2012) and Kumar *et al*. (2018) in chrysanthemum; Patil *et al*. (2011) in marigold.

Table 4.5.1.13: Parameter wise stable genotype of *Lilium*

Parameters	Genotypes	Conclusion
Days taken for bulb sprout emergence	Navona, Prato, Shiraj, Pollyana, Best Seller, Cilesta , Salmon Classic	Early genotypes
	Eyeliner	Stable genotype
Per cent bulb sprouting	Ercolano, Yelloween, Viviana	Average environments
		Stable genotypes : None
Plant height (cm)	Brunello	Rich environments
		Stable genotypes : None
Number of leaves/plant	Salmon Classic	Stable genotype
Leaf length (cm)	Yelloween	Stable genotype
Leaf width (cm)	Brunello, Pavia and Viviana	Stable genotypes
Stem length (cm)	Salmon Classic	Rich environments
Days to flower bud formation	Navona, Prato, Shiraj, Pollyana, Best Seller, Cilesta, Salmon Classic, Elite	Early genotypes
	Pollyana	Stable genotype
Bud length (cm)	Pollyana, Eyeliner, Yelloween	Stable genotype
Days to first flower	Best Seller, Cilesta	Early varieties
	Yelloween, Sapporo	Stable genotypes
Stem diameter (cm)	Pavia, Best Seller, Salmon Classic	Stable genotype
Size of the flower (cm)	Yelloween, Brunello	Stable genotype
	Sapporo	Low sensitivity to environments
Number of flower/stem	Eyeliner, Salmon Classic	Stable genotype
Tepal length (cm)	Viviana	Stable genotype
	Prato, Yelloween, Sapporo	Poor environments
Tepal width (cm)	Brunello, Montego Bay	Stable genotype
	Sapporo	Poor environments
Duration of flowering (days)	Salmon Classic	Stable genotype
	Eyeliner	Rich environments
	Prato	Poor environments
Bulb diameter(cm)	Navona, Brunello, Elite, Eyeliner	Stable genotype
Weight of bulb (g)	Eyeliner, Elite	Rich environments
	Stable genotype	None
Number of bulblets/stem	Salmon Classic, Celesta	Rich environments
	Eyeliner	Average environments
Weight of bulblet (g)	Eyeliner, Pavia	Stable genotype
Vase life (days)	Eyeliner	Stable genotype
Stem sturdiness 'A' grade		No stable genotype
'B' grade		No stable genotype
'C' grade	Sapporo	Rich environments and no stable genotype
Grading of cut flowers Grade '1'	Pavia	Stable genotype
Grade '2'		No stable genotype
Grade '3'		No stable genotype
Grade '4'	Eyeliner	Average environments

4.6 DUS CHARACTERIZATION OF GENOTYPES

In present investigation characterization of twenty six *Lilium* genotypes along with *Lilium tigrinum* (Tiger lily) was done on the basis of 40 morphological characters (Plate 1a & 1b). The evaluation for DUS testing was done as per the description prescribed by the UPOV guidelines for DUS testing in *Lilium* (UPOV, 2010) and genotypes were grouped accordingly as given in the Table 4.6.1. DUS descriptors for some of the parameters studied in the present study are shown in Plate 6.

Table 4.6.1 Morphological characteristics for different *Lilium* genotypes

S. No.	Characteristics	State of expression	Notes	Example Varieties
1. (*) QN	Plant height (cm)	Short (<50 cm)	1	
		Medium (50-75 cm)	3	Navona, Tresor, Shiraj, Ercolano, Ceb Dazzle, Best Seller, Pavia, Salmon Classic, Montego Bay, Viviana, Sapporo, *Lilium tigrinum*
		Tall (75-100 cm)	5	Pollyana, Elite, Eyeliner, Yelloween, Cilesta, Sorbonne, Signum, Justina, Prato, Brunello
		Very tall (> 100 cm)	7	Nashville, Blackout, Crystal Blanca, Acapulco
2. (*) QN (a)	Stem: distribution of anthocyanins colouration	Even	3	Viviana, Sapporo, Yelloween, Best Seller, Nashville, Crystal Blanca, Signum, Sorbonne, Blackout, Shiraj, Pollyana, Prato
		Speckled	5	Cilesta, Ceb Dazzle
		Striped	7	Acapulco, Eyeliner, Pavia, Navona, Tresor, Brunello, Elite, Salmon Classic, Justina, Montego Bay, Ercolano, *Lilium tigrinum*
3. QN (a)	Stem: number of leaves	Few (<25)	3	Viviana, Sapporo
		Medium (25-50)	5	Navona, Ercolano, Shiraj, Ceb Dazzle, Best Seller, Pavia, , Crystal Blanca, Justina, Sorbonne, Signum, Acapulco, Yelloween, Montego Bay, *Lilium tigrinum*
		Many (>50)	7	Prato, Tresor, Brunello, Pollyana, Elite, Eyeliner, Salmon Classic, Ceb Dazzle, Cilesta, Nashville, Blackout

Acapulco

Justina

Signum

Sorbonne

Crystal Blanca

Blackout

Nashville

Lilium tigrinum

Plate 1(b): *Lilium* genotype selected for experiment

4. (*) QL (+)	Leaf: arrangement	Alternate	1	All the genotypes
		Decussate	2	
		Whorled	3	
5. QN (a)	Leaf: length	Short (<7 cm)	3	Viviana, Sapporo
		Medium (7-14 cm)	5	Navona, Tresor, Shiraj, Pollyana, Brunello, Elite, Ercolano, Ceb Dazzle, Best Seller, Pavia, Salmon Classic, Yelloween, Cilesta, Nashville, Sorbonne, Signum, Blackout, Crystal Blanca, Justina, Acapulco, Montego Bay, *Lilium tigrinum*
		Long (>14 cm)	7	Prato
6. QN (+) (a)	Leaf: width	Narrow (<1.5 cm)	3	Pollyana, Navona, Blackout, Tresor
		Medium (1.5-3.0 cm)	5	Prato, Shiraj, Brunello, Elite, Ercolano, Ceb Dazzle, Best Seller, Pavia, Eyeliner, Salmon Classic, Yelloween, Cilesta, Nashville, *Lilium tigrinum*
		Broad (>3.0 cm)	7	Viviana, Sapporo, Sorbonne, Signum, Crystal Blanca, Justina, Acapulco
7. (*) QL (a)	Leaf: variegation	Absent	1	Absent in all the genotypes
		Present	9	
8. QN (a)	Leaf: glossiness of upper side	Absent	3	Yelloween, Viviana, Sapporo, Justina, Sorbonne, Signum, Acapulco
		Weak	5	
		Medium	7	Navona, Prato, Shiraj, Ercolano, Ceb Dazzle, Salmon Classic, Montego Bay, Brunello, Cilesta, , Elite, Pavia, Blackout, Crystal Blanca, *Lilium tigrinum*
		Strong	9	Pollyana, Tresor, Eyeliner, Best Seller, Nashville
9. QL (+) (a)	Leaf: cross section	Flat	1	Brunello, Pollyana, Shiraj, Elite, Prato, Cilesta, Blackout, Tresor, Ceb Dazzle, Nashville, Navona, *Lilium tigrinum*
		V-shaped	2	Yelloween, Viviana, Sapporo, Ercolano, Salmon Classic, Montego Bay, Pavia, Eyeliner, Best Seller, Crystal Blanca, Justina, Acapulco, Sorbonne, Signum

10. PQ (+)	Flower bud: main colour	White	1	Sapporo, Ceb Dazzle, Crystal Blanca, Signum,
		Green	2	
		Yellow green	3	Navona,, Ercolano, Sorbonne, Yelloween
		Yellow	4	Eyeliner, Pavia, Pollyana, Nashville
		Orange	5	Prato, Tresor, Brunello, Elite, Best Seller, Salmon Classic, Cilesta, *Lilium tigrinum*
		Orange pink	6	
		Pink	7	Shiraj, Acapulco, Justina, Viviana,
		Red	8	Blackout
		Purple red	9	
		Purple	10	
		Purple brown	11	Montego Bay
11. (*) (+) QL	Inflorescence: type of branching	Only racemose	1	Navona, Prato, Tresor, Shiraj, Eyeliner, Ercolano, Ceb Dazzle, Cilesta, Best Seller, Pavia, Montego Bay, Viviana, Sapporo, , Nashville, Sorbonne, Signum, crystal Blanca, Justina, Acapulco, Brunello, Pollyana, Elite, Salmon Classic, Yelloween, Elite, Salmon Classic, Yelloween, *Lilium tigrinum*
		Umbellate and racemose	2	Blackout
12. QN	Inflorescence: number of flowers	Very few (<5)	1	Navona, Tresor, Shiraj, Ercolano, Ceb Dazzle, Best Seller, Pavia, Montego Bay, Viviana, Sapporo, , Nashville, Sorbonne, Signum, Blackout, Crystal Blanca, Justina, Acapulco, *Lilium tigrinum*
		Medium (5-10)	3	Brunello, Pollyana, Elite, Salmon Classic, Yelloween
		Many (>10)	5	Prato, Eyeliner, Cilesta
13. QL	Inflorescence: pubescence	Absent	1	Navona, Prato, Elite, Shiraj, Brunello, Pollyana, Eyeliner, Ercolano, Ceb Dazzle, Pavia, Salmon Classic, Yelloween, Cilesta, Viviana, Sapporo, Montego Bay, Nashville, Crystal Blanca, Justina, Sorbonne, Blackout, Acapulco, Signum, *Lilium tigrinum*
		Weak	3	Tresor
		Medium	5	
		Strong	7	
		Very strong	9	Best Seller

14. QN (+)	Flower: type	Single	1	All the genotypes
		Semi-double	3	Justina
		Double	5	
15. (*) (+) QL	Flower: attitude of perianth (excluding pedicel)	Erect	1	Cilesta, Elite, Viviana, Tresor, Acapulco, Signum, Justina
		Erect to horizontal	3	Ceb Dazzle, Ercolano, Eyeliner, Montego Bay, Navona, Pollyana, Prato, Salmon Classic, Shiraj, Yelloween, Sorbonne, Blackout, Nashville, Brunello, Best Seller, Pavia, Sapporo
		Horizontal (outward facing)	5	Crystal Blanca
		Drooping	7	*Lilium tigrinum*
16. (*) (+) PQ	Flower: shape of perianth (excluding pedicel)	Trumpet	1	Yelloween
		Bowl	2	Cilesta, Ceb Dazzle, Eyeliner, Salmon Classic, Prato, Pavia, Navona, Tresor, Shiraj, Brunello, Elite, Ercolano, Salmon Classic, Acapulco, Blackout, Signum, Nashville, Viviana, Montego Bay, Crystal Blanca, Sapporo, Pollyana, Best Seller
		Flat	3	Justina
		Recurved	4	*Lilium tigrinum*
17. (*) QL	Flower: fragrance	Absent or weak	1	Navona, Prato, Tresor, Shiraj, Brunello, Pollyana, Elite, Eyeliner, Ercolano, Ceb Dazzle, Pavia, Salmon Classic, Cilesta, Blackout, *Lilium tigrinum*
		Medium	3	Montego Bay, Crystal Blanca, Nashville, Best Seller
		Strong	5	Yelloween, Sapporo, Viviana, Acapulco, Justina, Sorbonne, Signum
18. QL (d)	Tepal: ribbing	Absent or weak	1	Tresor, Shiraj, Ercolano, Eyeliner, Salmon Classic, Nashville, *Lilium tigrinum*
		Medium	3	Elite, Best Seller, Pavia, Cilesta, Navona, Crystal Blanca, Justina, Sorbonne, Signum
		Strong	5	Brunello, Pollyana, Prato, Sapporo, Yelloween, Montego Bay, Ceb Dazzle, Viviana, Acapulco, Blackout

19. QN (b)	Tepal: length	Short (<8 cm)	3	Shiraj
		Medium (8-10 cm)	5	Eyeliner, Ercolano, Ceb Dazzle, Pavia, Tresor, Elite, Pollyana, Salmon Classic, Cilesta, Viviana, , Navona, Blackout, Best Seller, Montego Bay, *Lilium tigrinum*
		Long (>10 cm)	7	Prato, Brunello,, Yelloween, Nashville, Sorbonne, Signum, Crystal Blanca, Justina, Acapulco, Sapporo
20. QN (b)	Tepal: width	Narrow (<3.0 cm)	3	Pollyana, Elite, Tresor, Shiraj, Pollyana, Navona, Eyeliner, Yelloween, Salmon Classic, Cilesta, *Lilium tigrinum*
		Medium (3.0-4.0 cm)	5	Prato, Brunello, Ceb Dazzle, Best Seller, Blackout, Crystal Blanca, Ercolano, Viviana, Pavia, Montego Bay, Sapporo, Nashville, Acapulco
		Broad (>4.0 cm)	7	Sorbonne, Signum, Justina
21. QL (+) (b)	Tepal: undulation of margin	Absent or Weak	1	Navona, Prato, Tresor, Shiraj, Brunello, Sapporo, Montego Bay, Elite, Eyeliner, Ercolano, Ceb Dazzle, Pavia, Best Seller, Cilesta, Salmon Classic, , Viviana, Nashville, Blackout, *Lilium tigrinum*
		Medium	2	Pollyana, Yelloween, Crystal Blanca, Sorbonne
		Strong	3	Sapporo, Justina, Signum
		Very strong	4	Acapulco
22. (+) (b) PQ	Tepal: type of undulation of margin	Fine	1	Sapporo
		Fine and coarse	2	Sorbonne, Signum
		Coarse only	3	Cilesta, Ceb Dazzle, Eyeliner, Sapporo, Navona, Tresor, Brunello, Elite, Best Seller, Salmon Classic, Prato, Pavia, Ercolano, Viviana, Montego Bay, Shiraj, Sorbonne, Justina, Crystal Blanca, Signum, Blackout, Nashville, Acapulco, *Lilium tigrinum*
23. (*) (+) QN	Tepal: degree of recurving	Weak (>40^0)	1	Navona, Ceb Dazzle, Best Seller, Salmon Classic, Cilesta, Nashville, Blackout
		Medium (20^0-40^0)	3	Viviana, Montego Bay, Prato, Tresor, Shiraj, Elite, Ercolano, Eyeliner, Pavia, Yelloween
		Strong (<20^0)	5	Sapporo, Pollyana, Brunello, Sorbonne, Justina, Signum, Acapulco, Crystal Blanca, *Lilium tigrinum*

24. (*) (+) (c) PQ	Tepal: main colour of central part; as per RHS colour chart (indicate reference number)	Greyed Purple group 183A	1	Blackout
		Greyed Orange group 169C	2	*Lilium tigrinum*
		Orange group 26A	3	Salmon Classic
		Orange group 26B	4	Cilesta
		Orange group 28A	5	Tresor, Brunello
		Orange group 28B	6	Elite
		Red group 46A	7	Montego Bay
		Red group 55C	8	Shiraj
		Red Purple group 62 A	9	Acapulco
		Red Purple group 70A	10	Viviana
		Red Purple group 62 B	11	Sorbonne
		Red Purple group 62 C	12	Justina
		White group 155B	13	Signum, Crystal Blanca
		Yellow group 2D	14	Ceb Dazzle
		Yellow group 4D	15	Ercolano, Sapporo
		Yellow group 6B	16	Yelloween
		Yellow group 7A	17	Nashville
		Yellow group 8C	18	Navona
		Yellow group12A	19	Eyeliner, Pavia
		Yellow Orange group 15B	20	Pollyana
		Yellow Orange group 19B	21	Best Seller
		Yellow Orange group 22A	22	Prato
25. (*) (+) (c) PQ	Tepal: main colour of basal part; As per RHS colour chart (indicate reference number)	Greyed Orange group 169C	1	*Lilium tigrinum*
		Greyed Purple group 183B	2	Blackout
		Orange group 24C	3	Cilesta
		Orange group 26A	4	Salmon Classic
		Orange group 26B	5	Elite
		Orange group 28B	6	Tresor, Brunello
		Red group 38D	7	Shiraj
		Red Purple group 62C	8	Sorbonne
		Red Purple group 62D	9	Viviana
		Red Purple group 65A	10	Acapulco
		Red Purple group 69C	11	Justina
		White group 155B	12	Crystal Blanca
		White group 155D	13	Signum
		Yellow Orange group 19C	14	Best Seller
		Yellow group 7A	15	Pavia
		Yellow group 2D	16	Navona
		Yellow group 3D	17	Ercolano
		Yellow group 4A	18	Nashville
		Yellow group 4D	19	Sapporo
		Yellow group 6A	20	Yelloween
		Yellow group 8B	21	Eyeliner
		Yellow group 8C	22	Montego Bay
		Yellow group 9D	23	Ceb Dazzle
		Yellow Orange group 14A	24	Pollyana
		Yellow Orange group 24B	25	Prato
		Orange group 28B	26	Tresor
		Yellow Orange group 19C	27	Best Seller

26. (*) (+) (c) PQ	Tepal: colour of zone bordering on nectar furrow	White	1	Shiraj
		Green	2	
		Yellow	3	Eyeliner, Sapporo, Justina, Pavia, Ceb Dazzle, Navona, Ercolano, Yelloween, Montego Bay, Nashville, Crystal Blanca, Signum
		Orange	4	Cilesta, Prato, Tresor, Brunello, Elite, Pollyana, Best Seller, Salmon Classic, *Lilium tigrinum*
		Orange pink	5	Acapulco, Sorbonne
		Red	6	
		Purple red	7	Viviana
		Purple brown	8	Blackout
27. (*) (+) (c) PQ	Tepal: main colour of distal part; As per RHS colour chart (indicate reference number)	Greyed Red group 180A	1	Blackout
		Greyed Orange group 171B	2	*Lilium tigrinum*
		Orange group 26A	3	Salmon Classic
		Orange group 26B	4	Cilesta
		Orange group 28A	5	Tresor, Brunello, Elite
		Red group 55C	6	Shiraj
		Red Purple group 65A	7	Acapulco
		Red Purple group 62B	8	Justina
		Red Purple group 69A	9	Sorbonne
		Red Purple group 70B	10	Viviana
		White group 155B	11	Signum
		White group 155D	12	Crystal Blanca
		Yellow group 2D	13	Ceb Dazzle
		Yellow group 4D	14	Navona, Sapporo
		Yellow group 6D	15	Yelloween
		Yellow group 7A	16	Pollyana
		Yellow group 11D	17	Ercolano
		Yellow group 12A	18	Eyeliner, Pavia, Nashville
		Yellow Orange group 18B	19	Montego Bay
		Yellow Orange group 20C	20	Best Seller
		Yellow Orange group 22A	21	Prato
28. (*) (+) (c) PQ	Tepal: main colour of marginal zone; As per RHS colour chart (indicate reference number)	Green Yellow group 1D	1	Ercolano
		Greyed Purple group 183B	2	Blackout
		Greyed Orange group 169D	3	*Lilium tigrinum*
		Orange group 24D	4	Best Seller
		Orange group 25B	5	Salmon Classic
		Orange group 25C	6	Cilesta
		Orange group 28A	7	Tresor, Brunello, Elite
		Red group 51D	8	Shiraj
		Red Purple group 62D	9	Sorbonne
		Red Purple group 65A	10	Acapulco
		Red Purple group 69A	11	Justina
		Red Purple group 70B	12	Viviana
		White group 155D	13	Signum, Crystal Blanca
		Yellow group 12A	14	Eyeliner
		Yellow group 4D	15	Sapporo
		Yellow group 6B	16	Yelloween

		Yellow group 7A	17	Pavia, Nashville
		Yellow group 8C	18	Montego Bay
		Yellow group 8D	19	Navona
		Yellow group 9B	20	Pollyana
		Yellow group 9D	21	Ceb Dazzle
		Yellow Orange group 24A	22	Prato
29. (+) (c) PQ	Tepal: main colour of outer side of inner tepal; As per RHS colour chart (indicate reference number	Green Yellow group 1D	1	Ceb Dazzle
		Greyed Orange group 169D	2	*Lilium tigrinum*
		Orange group 24C	3	Prato
		Orange group 28B	4	Tresor
		Orange group 26A	5	Elite
		Orange group 26B	6	Salmon Classic, Brunello
		Orange group 26C	7	Cilesta
		Orange group 27B	8	Best Seller
		Orange Red 34B	9	Blackout
		Red group 56C	10	Shiraj
		Red Purple group 62C	11	Viviana, Sorbonne, Acapulco
		Red Purple group 69A	12	Justina
		White group 155B	13	Signum, Crystal Blanca
		Yellow group 3B	14	Nashville
		Yellow group 4D	15	Ercolano, Sapporo
		Yellow group 6C	16	Eyeliner
		Yellow group 6D	17	Yelloween
		Yellow group 8A	18	Pollyana
		Yellow group 8D	19	Navona
		Yellow group 10B	20	Pavia
		Yellow group 11C	21	Montego Bay
30. (+) PQ	Tepal: colour of nectar furrow	White	1	Ercolano
		Green	2	Acapulco, Sorbonne, Montego Bay, Viviana
		Yellow green	3	Crystal Blanca, Signum, Justina, Ercolano, Navona, Viviana, Sapporo, Yelloween, Shiraj
		Yellow	4	Eyeliner, Pavia, Pollyana, Nashville, Ceb Dazzle, *Lilium tigrinum*
		Orange	5	Cilesta, Salmon Classic, Prato, Elite, Brunello, Tresor, Best Seller
		Orange pink	6	
		Pink	7	
		Red	8	
		Purple red	9	
		Purple	10	
		Purple brown	11	Blackout
31. (*) (+) (d) QN	Tepal: number of papillae and/or spots	Absent or very few (<25)	1	Brunello, Pavia, Yelloween, Cilesta, Shiraj, Sapporo, Ceb Dazzle, Eyeliner, Viviana, Justina, Nashville, Pavia, Navona, Ercolano, Crystal Blanca, Signum, Elite

		Few (25-50)	3	Tresor, Prato, Pollyana, , Salmon Classic, Montego Bay
		Medium (50-75)	5	Best Seller
		Many (>75)	7	Acapulco, Sorbonne, Blackout, *Lilium tigrinum*
32. (*) (d) QN	Tepal: size of area with papillae and/or spots	Absent or very small (<3 cm^2)	1	Brunello, Pavia, Yelloween, Cilesta, Shiraj, Sapporo, Ceb Dazzle, Eyeliner, Justina, Nashville, Navona, Ercolano, Crystal Blanca, Signum
		Small (3-6 cm^2)	3	Pollyana, Elite, Tresor, Viviana
		Medium (6-9 cm^2)	5	Salmon Classic, Best Seller, Montego Bay
		Large (>9 cm^2)	7	Acapulco, Sorbonne, Prato, Blackout, *Lilium tigrinum*
33. (*) (+) (d) PQ	Tepal: colour of papillae and/or spots	White	1	Sapporo, Signum, Justina, Crystal Blanca, Shiraj
		Yellow	2	
		Brown yellow	3	
		Brown	4	Elite, Tresor, Best Seller, Eyeliner, Salmon Classic, Prato, Pollyana, *Lilium tigrinum*, Ercolano, Blackout
		Pink	5	Sorbonne, Acapulco, Viviana
		Red brown	6	Blackout, Montego Bay
		Red	7	
		Purple red	8	Viviana
34. QN	Stamen: length	Short (<5 cm)	3	Shiraj
		Medium (5-10 cm)	5	Navona, Prato, Shiraj, Tresor, Elite, Brunello, Best Seller, Pollyana, Ceb Dazzle, Ercolano, Pavia, Eyeliner, Cilesta, Salmon Classic, Yelloween, Viviana, Montego Bay, Sapporo, Nashville, Justina, Blackout, Acapulco, Sorbonne, Signum, *Lilium tigrinum*
		Long (>10 cm)	7	
35. (*) (+) PQ	Stamen: main colour of filaments	White	1	Shiraj, Navona
		Green	2	Acapulco, Sorbonne, Yelloween
		Yellow green	3	Ceb Dazzle, Justina, Sapporo, Signum, Crystal Blanca, Viviana
		Yellow	4	Cilesta, Eyeliner, Pavia, Ercolano Pollyana, Montego Bay, Nashville, Best Seller
		Orange	5	Salmon Classic, Elite, Tresor, Brunello, Prato, *Lilium tigrinum*

		Orange pink	6	
		Pink	7	
		Red	8	
		Purple red	9	
		Purple	10	
		Purple brown	11	Blackout
36. (*) PQ	Stamen: colour of anther	Orange	1	Sapporo, Viviana, Justina
		Orange yellow	2	Ercolano
		Reddish brown	3	Blackout, Eyeliner, Acapulco, Signum, Sorbonne
		Brown	4	Cilesta, Ceb Dazzle, Crystal Blanca, Montego Bay, Elite, Pollyana, Best Seller, Prato, Pavia, Navona, Tresor, Brunello, Nashville, Salmon Classic, Shiraj, Yelloween, *Lilium tigrinum*
		Purple	5	
		Purple red	6	
37. PQ	Pollen: colour	Light yellow	1	
		Medium yellow	2	
		Orange	3	Justina, Signum, Sorbonne, Crystal Blanca, Sapporo
		Light brown	4	
		Orange brown	5	Acapulco, Elite, Viviana, Cilesta, Eyeliner, Salmon Classic, Shiraj, Ercolano, Ceb Dazzle, Pollyana, Montego Bay, Yelloween, Nashville
		Red brown	6	Blackout
		Dark brown	7	Prato, Pavia, Tresor, Brunello, Best Seller, Navona, *Lilium tigrinum*
38. (*) PQ	Style: main colour	White	1	
		Green	2	Acapulco, Viviana, Sapporo, Sorbonne
		Yellow green	3	Pavia, Eyeliner, Ercolano, Ceb Dazzle, Navona, Justina, Sorbonne, Shiraj, Signum, Crystal Blanca
		Yellow	4	Pollyana, Yelloween, Montego Bay, Nashville
		Orange	5	Cilesta, Best Seller, Salmon Classic, Prato, Elite, Brunello, Tresor, *Lilium tigrinum*
		Orange pink	6	
		Pink	7	
		Red	8	
		Purple red	9	
		Purple	10	
		Purple brown	11	Blackout

39. PQ	Stigma: colour	Grey	1	Viviana, Navona, Montego Bay, Justina, Sorbonne, Crystal Blanca
		Grey green	2	Sapporo, Acapulco
		Green	3	Yelloween
		Yellow	4	Eyeliner, Pavia, Shiraj, Pollyana, Nashville
		Orange	5	Cilesta, Salmon Classic, Prato, *Lilium tigrinum*
		Purple red	6	
		Purple	7	Signum
		Dark purple	8	Elite
		Brown	9	Ceb Dazzle, Ercolano, Signum, Blackout, Best Seller, Brunello, Tresor
40. (*) PQ	Time of flowering	Very early (<50 days)	1	Best Seller
		Early (50-75 days)	3	Cilesta, Prato
		Medium (75-100 days)	5	Eyeliner, Pavia, Shiraj, Pollyana, Brunello, Elite, Tresor, Salmon Classic
		Late (100-125 days)	7	Ercolano, Ceb Dazzle, Navona, Yelloween, Blackout, Nashville, Justina, *Lilium tigrinum*
		Very late (>125 days)	9	Montego Bay, Viviana, Sapporo, Crystal Blanca, Signum, Sorbonne, Acapulco

Explanations for individual characteristics

- Explanation covering several characteristics

Unless otherwise indicated below, all observations should be made at the time of anther dehiscence of the first flower. Characteristics containing the following key in the first column of the Table of Characteristics were examined as indicated below:

Symbols	Plant part used	Methodology used
(a)	Stem	Examined on middle third of the stem.
(b)	Tepal	Observations were made on outer tepals.
(c)	Tepal	Observations on colour were made on the inner side of the inner tepal, excluding papillae, spots and nectar furrow.
(d)	Tepal	Observations on papillae and/or spots and ribbing should be made on the inner side of the inner tepal.

Flower bud: main colour	The main colour is the colour with the largest surface area. The main colour should be observed just before the opening of the flower.
Inflorescence: type of branching	In the case of varieties with umbellate and racemose branching, the first (lowest) branches are umbellate and the upper (higher) branches are racemose.
Flower type	1-6 tepals were described as single. 7-11 tepals were classified as semi-double. >12 tepals were described as double.
Stigma/stamen: main colour	The main colour of a part or zone is the colour with the largest surface area on the part or zone concerned.

Characteristic 2. Stem: distribution of anthocyanin colouration

Even

Speckled

Striped

Characteristic 4. Leaf: arrangement

Leaf arrangement: Alternate arrangement in all the groups

Asiatic group

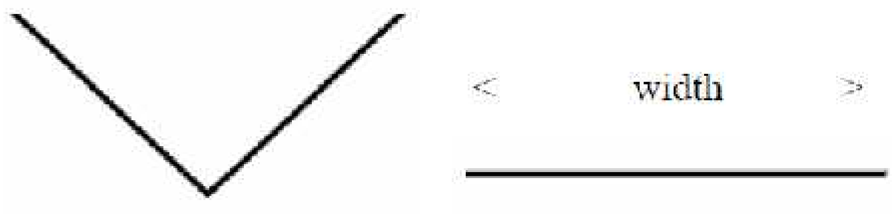
LA group

Oriental group

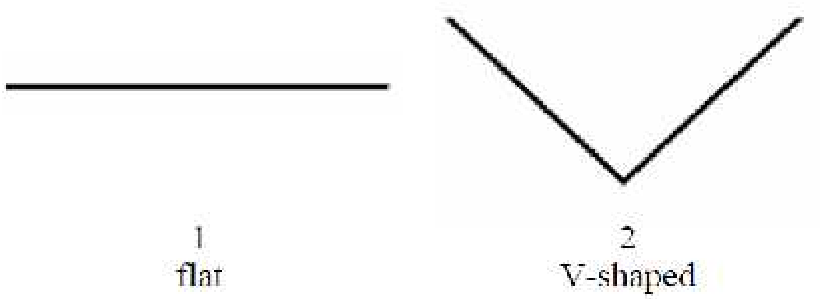
OT group

Characteristic 6. Leaf: width

The width of V-shaped leaves was observed when held flat



Characteristic 9. Leaf: cross section



Characteristic 10. Flower bud: main colour

The main color is the color with the largest surface area. The main color observed just before the opening of the flower

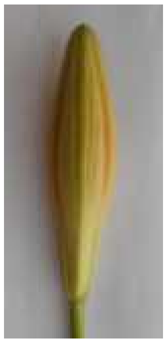

White


Yellow green


Yellow


Pink

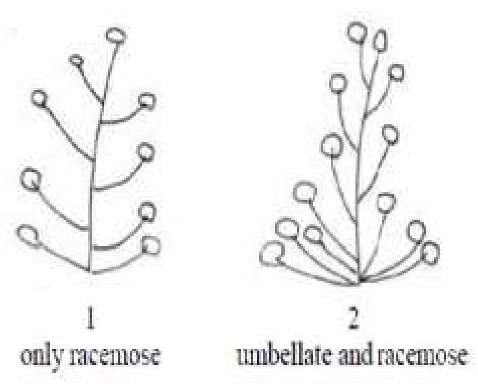

Red


Orange


Purple brown

Characteristic 11. Inflorescence: type of branching

In the case of genotypes with umbellate and racemose branching, the first (lowest) branches are umbellate and the upper (higher) branches are racemose




Only racemose


Umbellate and racemose

Characteristic 13. Inflorescence: pubescence


Absent


Weak


Very Strong

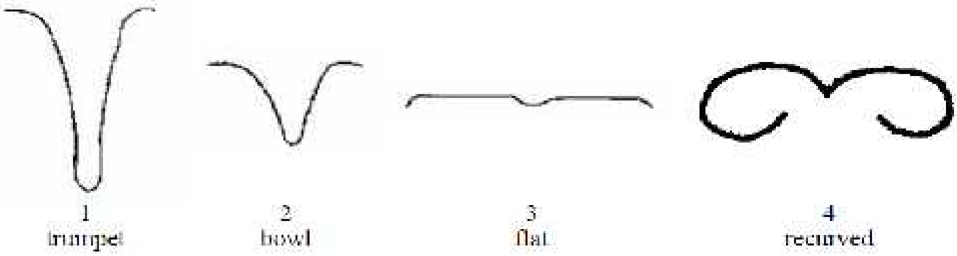
Characteristic 14. Flower type: single, semi-double, double

Single **Semi-double**

Characteristic 15. Flower: attitude of perianth (excluding pedicel)

Erect **Erect to horizontal** **Horizontal (outward facing)** **Drooping**

Characteristic 10. Flower: shape of perianth (excluding pedicel)



Trumpet **Bowl** **Flat** **Recurved**

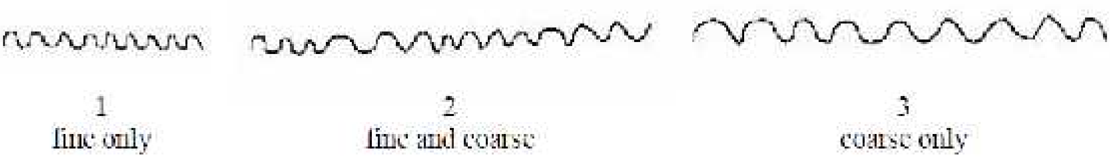
Characteristic 19. Tepal: length

Characteristic 20. Tepal: width

Characteristic 21. Tepal: undulation of margin

Weak **Medium** **Strong** **Very Strong**

Characteristic 22. Tepal: type of undulation of margin

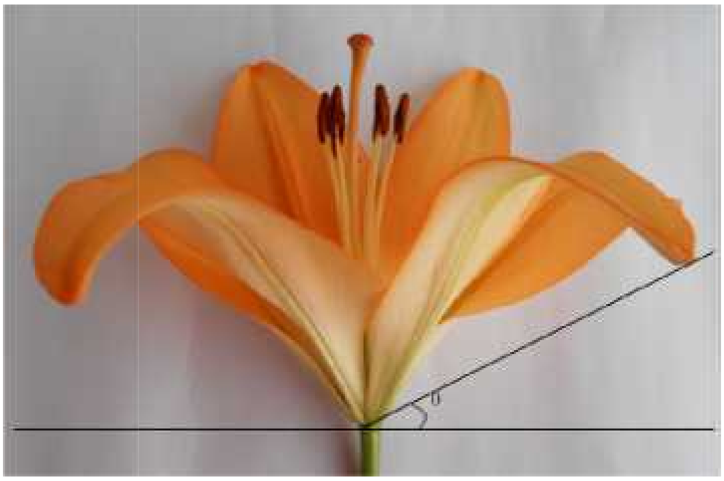


Fine only

Fine and coarse

Coarse only

Characteristic 23. Tepal: degree of recurving



Characteristic 24.Teapl: main colour of central part

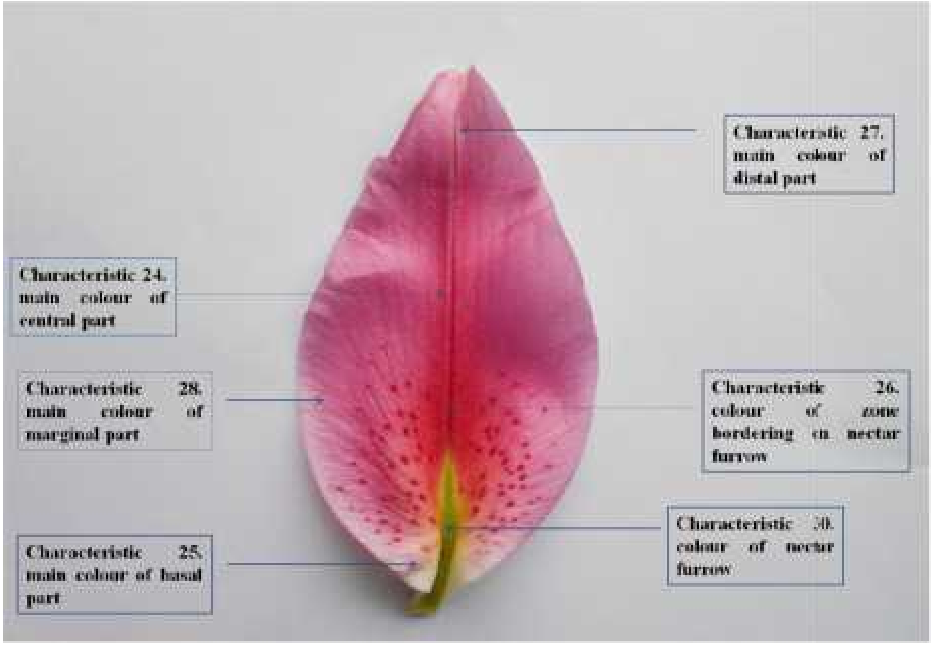
Characteristic 25. Tepal: main colour of basal part

Characteristics 26. Tepal: colour of zone bordering on nectar furrow

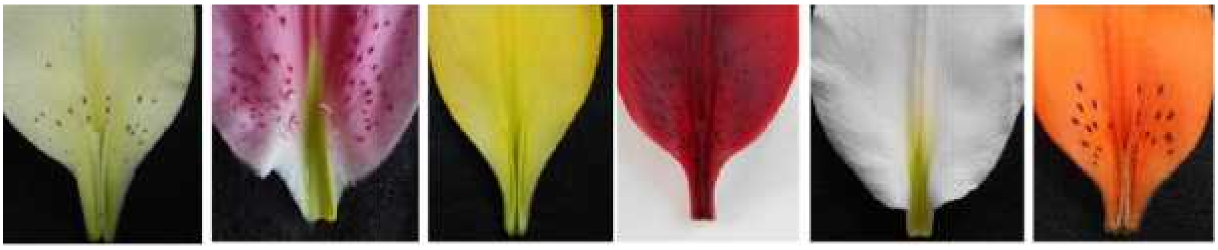
Characteristic 27. Tepal: main colour of distal part

Characteristic 28. Tepal: main colour of marginal part

The main color of a part or zone is the color with the largest surface area on the part or zone concerned.



Characteristic 30.Tepal: colour of nectar furrow

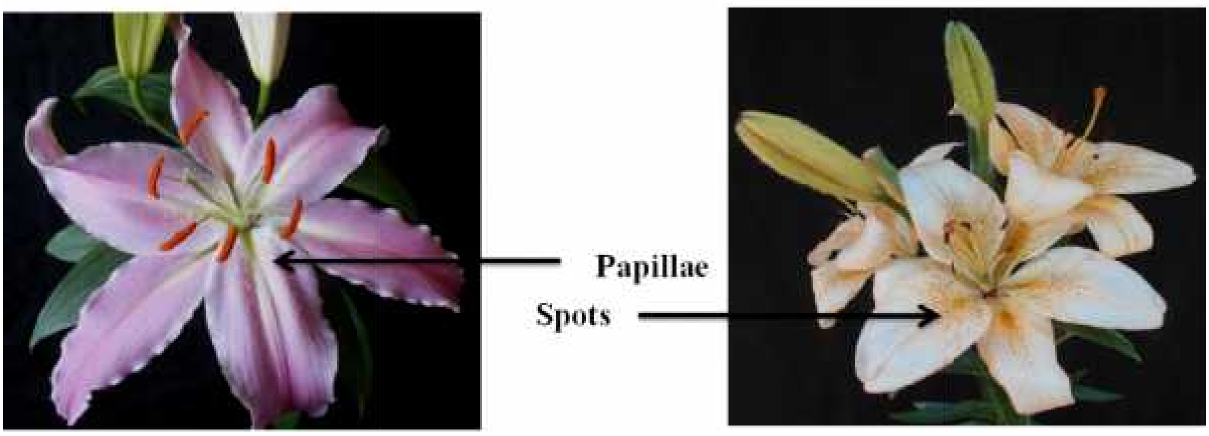


White **Green** **Yellow** **Purple red** **Yellow green** **Orange**

Characteristic 31. Tepal: number of papillae and/or spots

Characteristics 33. Tepal: colour of papillae and/or spots

Papillae: pimpled, with small, rounded, soft to firm, unequal bumps while spots are small areas of another color other than the background color



Characteristic 34. Stamen: length

Characteristic 35. Stamen: main colour of filament

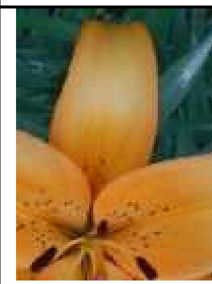
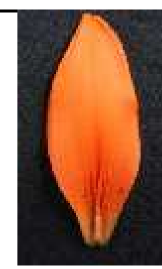
Green	Yellow green	Yellow	White	Orange	Purple red

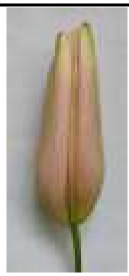
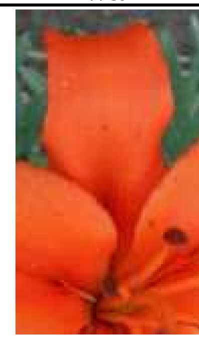
List of essential characters

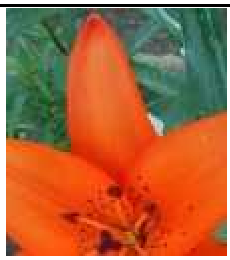
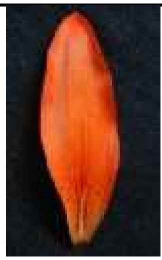
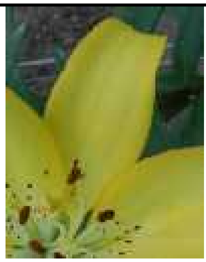
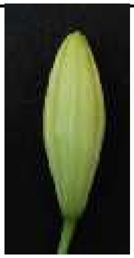
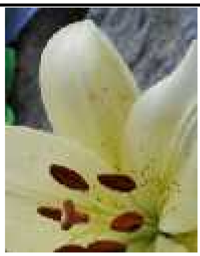
- Plant height (cm)
- Stem: distribution of anthocyanin colouration
- Leaf: arrangement
- Leaf: variegation
- Inflorescence: type of branching
- Flower: attitude of perianth (excluding pedicel)
- Flower: shape of perianth (excluding pedicel)
- Flower: fragrance
- Tepal: degree of recurving
- Tepal: main colour of central part as per RHS colour chart
- Tepal: main colour of basal part as per RHS colour chart
- Tepal: colour of zone bordering on nectar furrow
- Tepal: main colour of distal part as per RHS colour chart
- Tepal: main colour of marginal zone as per RHS colour chart
- Tepal: number of papillae and/or spots

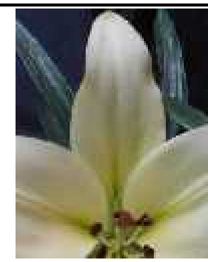
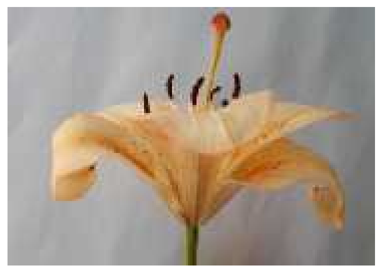
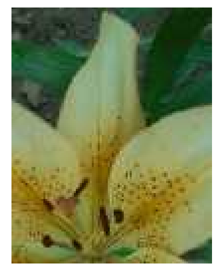
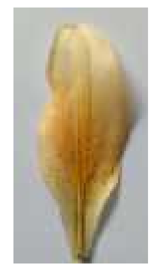
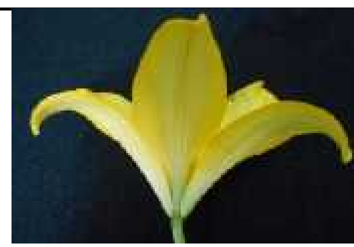
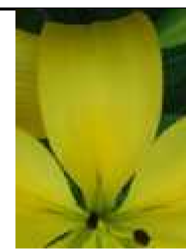
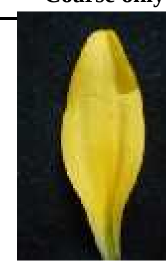
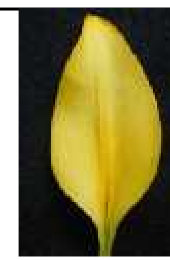
- Tepal: size of area with papillae and/or spots
- Tepal: colour of papillae and/or spots
- Stamen: main colour of filaments
- Stamen: colour of anther
- Style: main colour
- Time of flowering

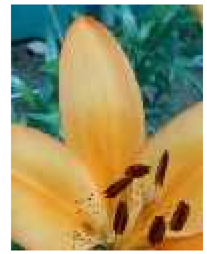
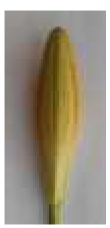
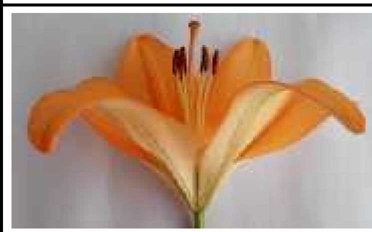
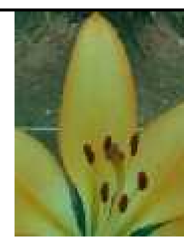
Plate 6. Morphological characterization of different *Lilium* genotypes

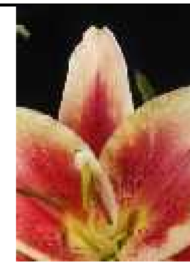
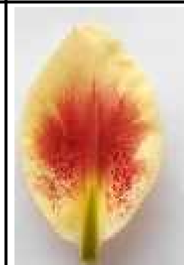
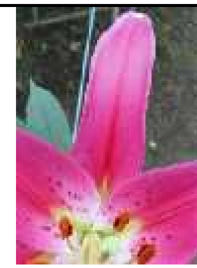
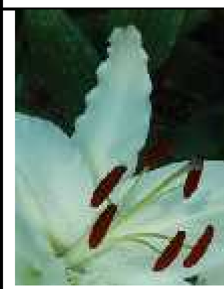
Genotypes	Morphological characterization					
	Flower bud: main colour	Inflorescence: type of branching	Flower: shape of perianth	Tepal: undulation of margin	Tepal: type of undulation of margin	Tepal: colour of papillae and/or spots
Navona	 Yellow green	 Only racemose	 Bowl	 Weak	 Coarse only	 Absent
Prato	 Orange	 Only racemose	 Bowl	 Weak	 Coarse only	 Brown
Tresor	 Orange	 Only racemose	 Bowl	 Weak	 Coarse only	 Brown

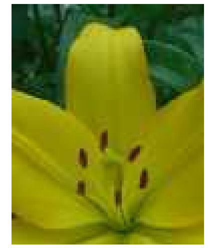
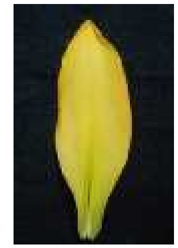
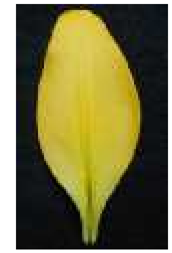
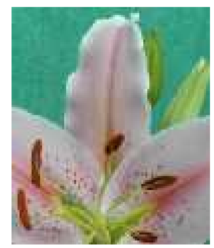
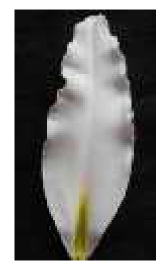
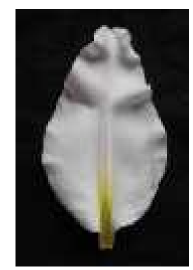
Genotypes	Morphological characterization					
	Flower bud: main colour	**Inflorescence: type of branching**	**Flower: shape of perianth**	**Tepal: undulation of margin**	**Tepal: type of undulation of margin**	**Tepal: colour of papillae and/or spots**
Shiraj	 **Pink**	 **Only racemose**	 **Bowl**	 **Weak**	 **Coarse only**	 **White**
Brunello	 **Orange**	 **Only racemose**	 **Bowl**	 **Weak**	 **Coarse only**	 **Absent**
Pollyana	 **Yellow**	 **Only racemose**	 **Bowl**	 **Medium**	 **Fine and coarse**	 **Brown**

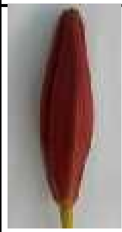
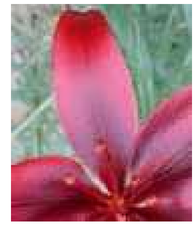
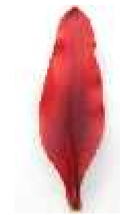
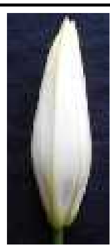
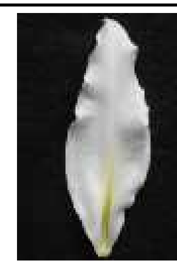
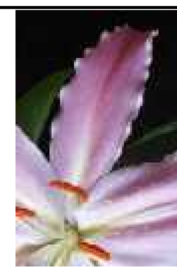
Genotypes	Morphological characterization					
	Flower bud: main colour	Inflorescence: type of branching	Flower: shape of perianth	Tepal: undulation of margin	Tepal: type of undulation of margin	Tepal: colour of papillae and/or spots
Elite	 Orange	 Only racemose	 Bowl	 Weak	 Coarse only	 Brown
Eyeliner	 Yellow	 Only racemose	 Bowl	 Weak	 Coarse only	 Brown
Ercolano	 Yellow green	 Only racemose	 Bowl	 Weak	 Coarse only	 Brown

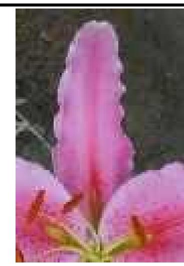
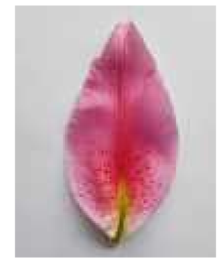
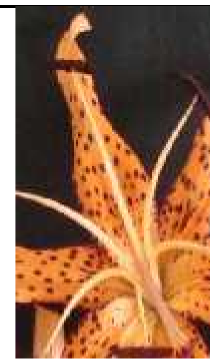
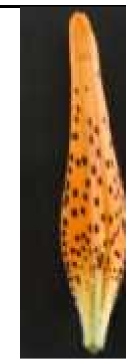
Genotypes	Morphological characterization					
	Flower bud: main colour	Inflorescence: type of branching	Flower: shape of perianth	Tepal: undulation of margin	Tepal: type of undulation of margin	Tepal: colour of papillae and/or spots
Ceb Dazzle	 White	 Only racemose	 Bowl	 Weak	 Coarse only	 Absent
Best Seller	 Orange	 Only racemose	 Bowl	 Weak	 Coarse only	 Brown
Pavia	 Yellow	 Only racemose	 Bowl	 Weak	 Coarse only	 Absent

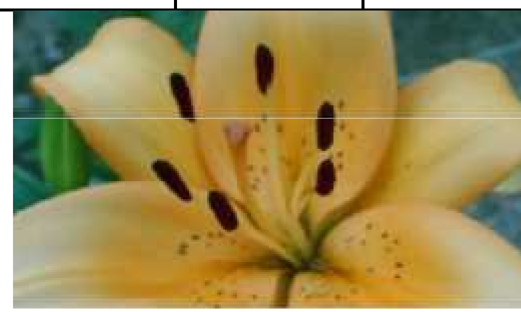
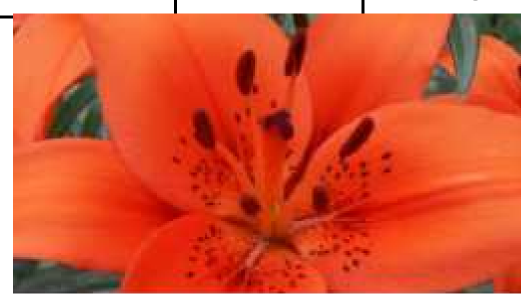
Genotypes	Morphological characterization					
	Flower bud: main colour	Inflorescence: type of branching	Flower: shape of perianth	Tepal: undulation of margin	Tepal: type of undulation of margin	Tepal: colour of papillae and/or spots
Salmon Classic	 Orange	 Only racemose	 Bowl	 Weak	 Coarse only	 Brown
Yelloween	 Yellow green	 Only racemose	 Trumpet	 Medium	 Coarse only	 Absent
Cilesta	 Orange	 Only racemose	 Bowl	 Weak	 Coarse only	 Absent

Genotypes	Morphological characterization					
	Flower bud: main colour	Inflorescence: type of branching	Flower: shape of perianth	Tepal: undulation of margin	Tepal: type of undulation of margin	Tepal: colour of papillae and/or spots
Montego Bay	 Purple brown	 Only racemose	 Bowl	 Weak	 Coarse only	 Red brown
Viviana	 Pink	 Only racemose	 Bowl	 Weak	 Coarse only	 Pink
Sapporo	 White	 Only racemose	 Bowl	 Strong	 Fine	 White

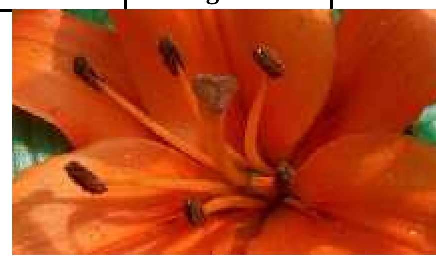
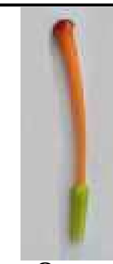
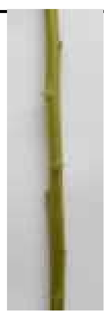
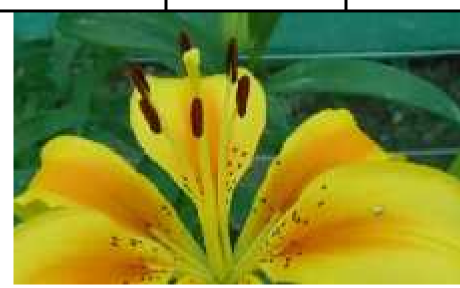
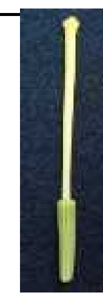
Genotypes	Morphological characterization					
	Flower bud: main colour	Inflorescence: type of branching	Flower: shape of perianth	Tepal: undulation of margin	Tepal: type of undulation of margin	Tepal: colour of papillae and/or spots
Nashville	 Yellow	 Only racemose	 Bowl	 Weak	 Coarse only	 Absent
Sorbonne	 Yellow	 Only racemose	 Bowl	 Medium	 Fine and Coarse	 Pink
Signum	 White	 Only racemose	 Bowl	 Strong	 Fine and Coarse	 White

Genotypes	Morphological characterization					
	Flower bud: main colour	Inflorescence: type of branching	Flower: shape of perianth	Tepal: undulation of margin	Tepal: type of undulation of margin	Tepal: colour of papillae and/or spots
Blackout	 Red	 Umbellate	 Bowl	 Weak	 Coarse only	 Brown
Crystal Blanca	 White	 Only racemose	 Bowl	 Medium	 Coarse only	 White
Justina	 Pink	 Only racemose	 Flat	 Strong	 Coarse only	 White

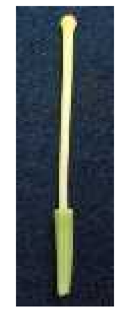
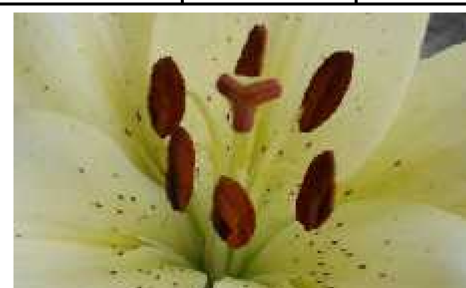
Genotypes	Morphological characterization					
	Flower bud: main colour	**Inflorescence: type of branching**	**Flower: shape of perianth**	**Tepal: undulation of margin**	**Tepal: type of undulation of margin**	**Tepal: colour of papillae and/or spots**
Acapulco	 **Pink**	 **Only racemose**	 **Bowl**	 **Very strong**	 **Coarse only**	 **Pink**
Lilium tigrinum	 **Orange**	 **Only racemose**	 **Flat**	 **Weak**	 **Coarse only**	 **Brown**

Genotypes	Morphological characterization						
	*Stem:	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Navona	 Striped	 Erect to horizontal	 Brown	Dark brown	Grey	 White	 Yellow green
Prato	 Even	 Erect to horizontal	 Brown	Dark brown	Orange	 Orange	 Orange
Tresor	 Striped	 Erect	 Brown	Dark brown	Brown	 Orange	 Orange

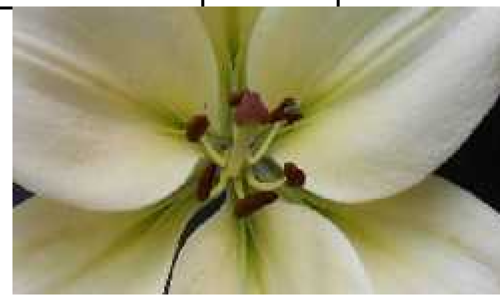
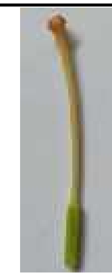
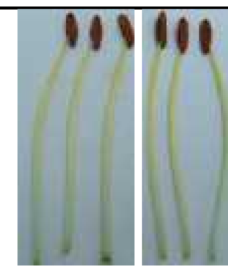
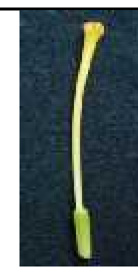
*Stem: distribution of anthocyanin colouration

Genotypes	Morphological characterization						
	*Stem:	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Shiraj	 Even	 Erect to horizontal	 Brown	Orange brown	Yellow	 White	 Yellow green
Brunello	 Striped	 Erect to horizontal	 Brown	Dark brown	Brown	 Orange	 Orange
Pollyana	 Even	 Erect to horizontal	 Brown	Orange brown	Yellow	 Yellow	 Yellow

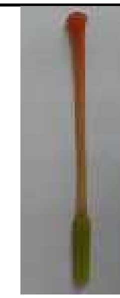
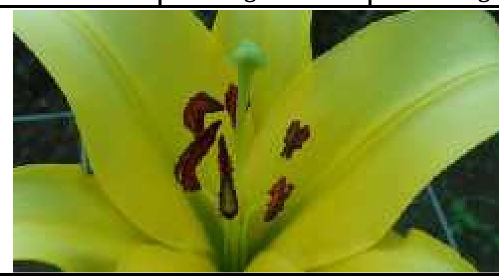
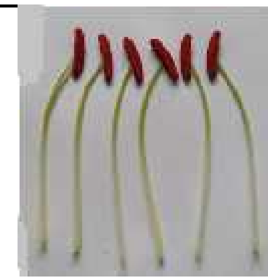
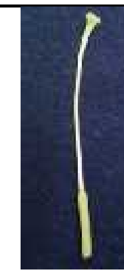
*Stem: distribution of anthocyanin colouration

Genotypes	Morphological characterization						
	*Stem:	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Elite	 Striped	 Erect	 Brown	Orange brown	Dark Purple	 Orange	 Orange
Eyeliner	 Striped	 Erect to horizontal	 Reddish brown	Orange brown	Yellow	 Yellow	 Yellow
Ercolano	 Striped	 Erect to horizontal	 Orange yellow	Orange brown	Brown	 Yellow	 Yellow green

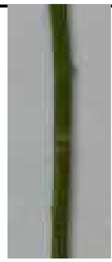
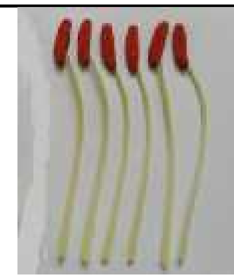
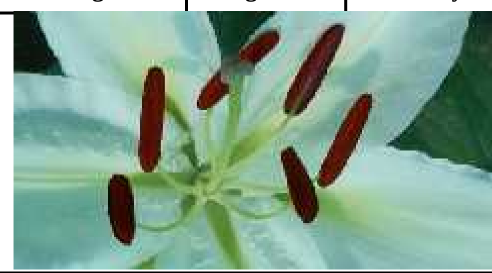
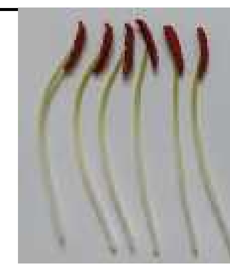
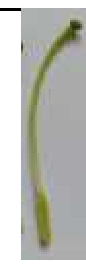
*Stem: distribution of anthocyanin colouration

Genotypes	Morphological characterization						
	*Stem:	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Ceb Dazzle	 Speckled	 Erect to horizontal	 Brown	Orange brown	Brown	 Yellow green	 Yellow
Best Seller	 Even	 Erect to horizontal	 Brown	Dark brown	Brown	 Yellow	 Orange
Pavia	 Striped	 Erect to horizontal	 Brown	Dark brown	Yellow	 Yellow	 Yellow

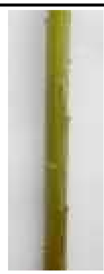
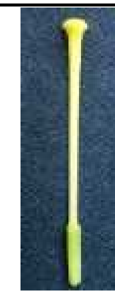
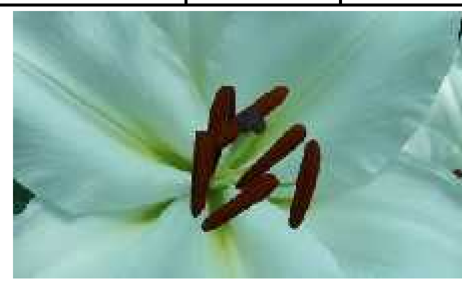
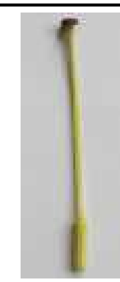
*Stem: distribution of anthocyanin colouration

Genotypes	Morphological characterization						
	*Stem	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Salmon Classic	 Striped	 Erect to horizontal	 Brown	Orange brown	Orange	 Orange	 Orange
Yelloween	 Even	 Erect to horizontal	 Brown	Orange brown	Green	 Green	 Yellow
Cilesta	 Speckled	 Erect	 Brown	Orange brown	Orange	 Orange	 Orange

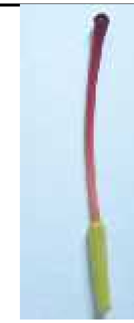
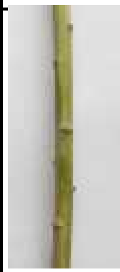
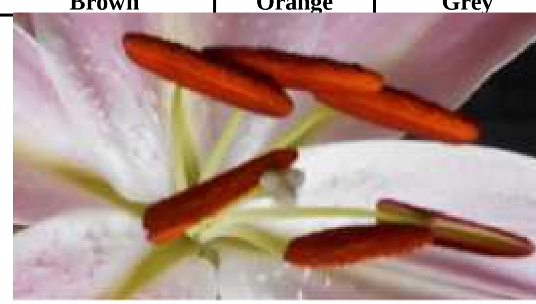
*Stem: distribution of anthocyanin colouration

Genotypes	Morphological characterization						
	*Stem	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Montego Bay	 Striped	 Erect to horizontal	 Brown	Orange brown	Grey	 Yellow	 Yellow
Viviana	 Even	 Erect	 Orange	Orange brown	Grey	 Yellow green	 Green
Sapporo	 Even	 Erect to horizontal	 Orange	Orange	Grey green	 Yellow green	 Green

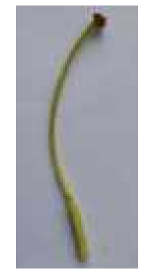
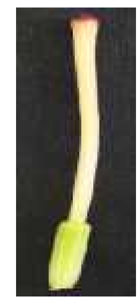
*Stem: distribution of anthocyanin colouration

Genotypes	Morphological characterization						
	*Stem	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Nashville	 Even	 Erect to horizontal	 Brown	Orange brown	Yellow	 Yellow	 Yellow
Signum	 Even	 Erect	 Reddish brown	Orange	Purple	 Yellow green	 Yellow green
Sorbonne	 Even	 Erect to horizontal	 Reddish brown	Orange	Grey	 Green	 Green

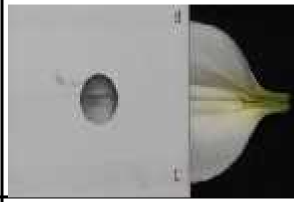
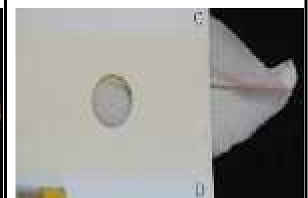
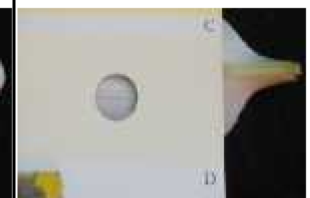
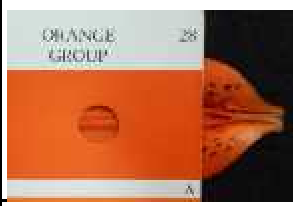
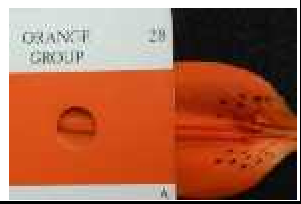
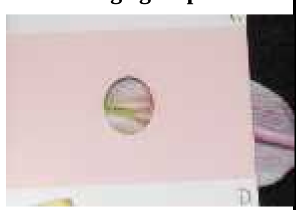
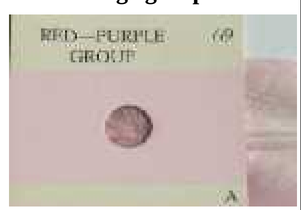
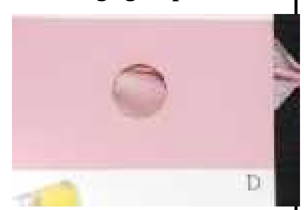
*Stem: distribution of anthocyanin colouration

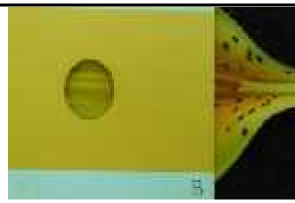
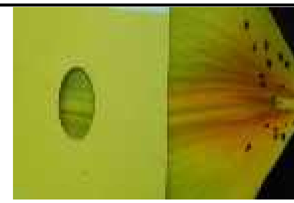
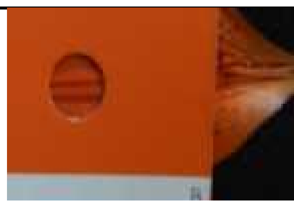
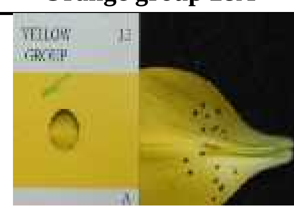
Genotypes	Morphological characterization						
	*Stem	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Blackout	 Even	 Erect to horizontal	 Reddish brown	Red brown	Brown	 Purple brown	 Purple brown
Crystal Blanca	 Even	 Horizontal (outward facing)	 Brown	Orange	Grey	 Yellow green	 Yellow green
Justina	 Striped	 Erect	 Brown	Orange	Grey	 Yellow green	 Yellow green

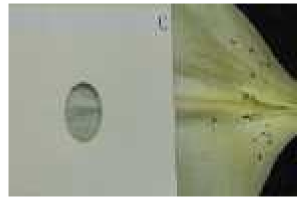
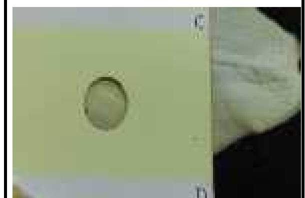
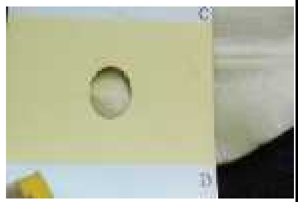
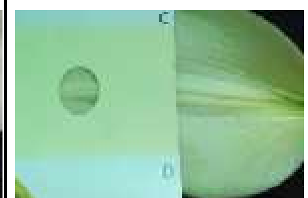
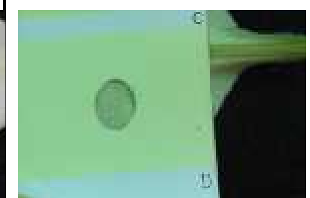
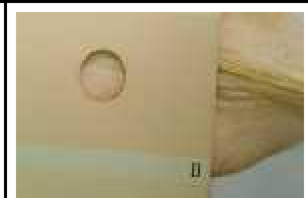
*Stem: distribution of anthocyanin colouration

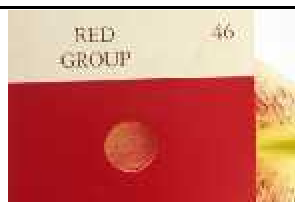
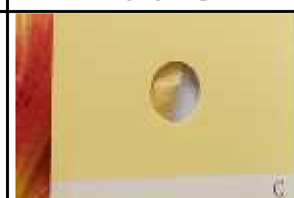
Genotypes	Morphological characterization						
	*Stem	Flower: attitude of perianth (excluding pedicel)	Anther colour	Pollen: colour	Stigma colour	Stamen: main colour of anther filaments	Style: main colour
Acapulco	 Striped	 Erect	 Reddish brown	Orange	Grey green	 Green	 Green
Lilium tigrinum	 Striped	 Drooping	 Brown	Dark brown	Orange	 Orange	 Orange

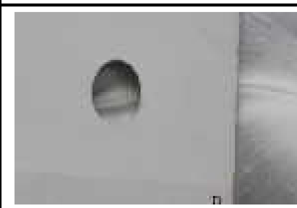
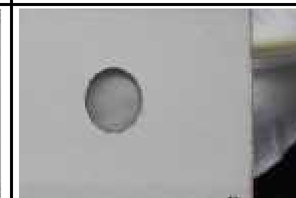
*Stem: distribution of anthocyanin colouration

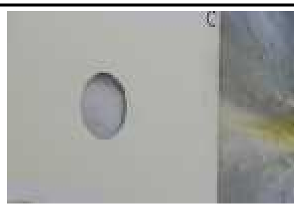
Genotypes	Colour of tepal as per RHS colour chart (indicating reference number)				
	24. Tepal: main colour of central part	25. Tepal: main colour of basal part	27. Tepal: main colour of distal part	28. Tepal: main colour of marginal zone	29. Tepal: main colour of outer side of inner tepal
Navona	 **Yellow group 8C**	 **Yellow group 2D**	 **Yellow group 4D**	 **Yellow group 8D**	 **Yellow group 8D**
Prato	 **Yellow Orange group 22A**	 **Yellow Orange group 24B**	 **Yellow Orange group 22A**	 **Yellow Orange group 24A**	 **Orange group 24C**
Tresor	 **Orange group 28A**	 **Orange group 28B**	 **Orange group 28A**	 **Orange group 28A**	 **Orange group 28B**
Shiraj	 **Red group 55C**	 **Red group 38D**	 **Red group 55C**	 **Red group 51D**	 **Red group 56C**

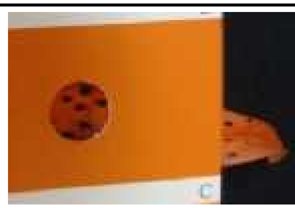
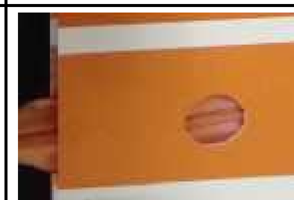
Genotypes	Colour of tepal as per RHS colour chart (indicating reference number)				
	24. Tepal: main colour of central part	25. Tepal: main colour of basal part	27. Tepal: main colour of distal part	28. Tepal: main colour of marginal zone	29. Tepal: main colour of outer side of inner tepal
Brunello	 Orange group 28A	 Orange group 28B	 Orange group 28A	 Orange group 28A	 Orange group 26B
Pollyana	 Yellow Orange group 15B	 Yellow Orange group 14A	 Yellow group 7A	 Yellow group 9B	 Yellow group 8A
Elite	 Orange group 28B	 Orange group 26B	 Orange group 28A	 Orange group 28A	 Orange group 26A
Eyeliner	 Yellow group12A	 Yellow group 8B	 Yellow group12A	 Yellow group12A	 Yellow group 6C

Genotypes	Colour of tepal as per RHS colour chart (indicating reference number)				
	24. Tepal: main colour of central part	25. Tepal: main colour of basal part	27. Tepal: main colour of distal part	28. Tepal: main colour of marginal zone	29. Tepal: main colour of outer side of inner tepal
Ercolano	 Yellow group 4D	 Yellow group 3D	 Yellow group 11D	 Green Yellow group 1D	 Yellow group 4D
Ceb Dazzle	 Yellow group 2D	 Yellow group 9D	 Yellow group 2D	 Yellow group 9D	 Green Yellow group 1D
Best Seller	 Yellow Orange group 19B	 Yellow Orange group 19C	 Yellow Orange group 20C	 Orange group 24D	 Orange group 27B
Pavia	 Yellow group 12A	 Yellow group 7A	 Yellow group 12A	 Yellow group 7A	 Yellow group 10B

Genotypes	Colour of tepal as per RHS colour chart (indicating reference number)				
	24. Tepal: main colour of central part	25. Tepal: main colour of basal part	27. Tepal: main colour of distal part	28. Tepal: main colour of marginal zone	29. Tepal: main colour of outer side of inner tepal
Salmon Classic	 Orange group 26A	 Orange group 26A	 Orange group 26A	 Orange group 25B	 Orange group 26B
Yelloween	 Yellow group 6B	 Yellow group 6A	 Yellow group 6D	 Yellow group 6B	 Yellow group 6D
Cilesta	 Orange group 26B	 Orange group 24C	 Orange group 26B	 Orange group 25C	 Orange group 26C
Montego Bay	 Red group 46A	 Yellow group 8C	 Yellow Orange group 18B	 Yellow group 8C	 Yellow group 11C

Genotypes	Colour of tepal as per RHS colour chart (indicating reference number)				
	24. Tepal: main colour of central part	25. Tepal: main colour of basal part	27. Tepal: main colour of distal part	28. Tepal: main colour of marginal zone	29. Tepal: main colour of outer side of inner tepal
Viviana	 Red Purple group 70A	 Red Purple group 62D	 Red Purple group 70B	 Red Purple group 70B	 Red Purple group 62C
Sapporo	 Yellow group 4D	 Yellow group 4D	 Yellow group 4D	 Yellow group 4D	 Yellow group 4D
Nashville	 Yellow group 7A	 Yellow group 4A	 Yellow group 12A	 Yellow group 7A	 Yellow group 3B
Sorbonne	 Red Purple group 62B	 Red Purple group 62C	 Red Purple group 69A	 Red Purple group 62D	 Red Purple group 62C

Genotypes	Colour of tepal as per RHS colour chart (indicating reference number)				
	24. Tepal: main colour of central part	25. Tepal: main colour of basal part	27. Tepal: main colour of distal part	28. Tepal: main colour of marginal zone	29. Tepal: main colour of outer side of inner tepal
Signum	 White group 155B	 White group 155D	 White group 155B	 White group 155D	 White group 155B
Blackout	 Greyed Purple group 180A	 Greyed Purple group 183B	 Greyed Red group 180A	 Greyed Purple group 183B	 Orange Red group 34B
Crystal Blanca	 White group 155B	 White group 155B	 White group 155D	 White group 155D	 White group 155B
Justina	 Red Purple group 62C	 Red Purple group 69C	 Red Purple group 62B	 Red Purple group 69A	 Red Purple group 69A

Genotypes	Colour of tepal as per RHS colour chart (indicating reference number))				
	24. Tepal: main colour of central part	25. Tepal: main colour of basal part	27. Tepal: main colour of distal part	28. Tepal: main colour of marginal zone	29. Tepal: main colour of outer side of inner tepal
Acapulco	 Red Purple group 62A	 Red Purple group 65A	 Red Purple group 65A	 Red Purple group 65A	 Red Purple group 62C
Lilium tigrinum	 Grayed Orange group 169C	 Grayed Orange group 169C	 Grayed Orange group 171B	 Grayed Orange group 169C	 Grayed Orange group 169D

Chapter-5

SUMMARY AND CONCLUSION

The present investigations on **"Genetic studies and DUS characterization in *Lilium*"** were carried out in 18 diverse *Lilium* genotypes to ascertain the variability, genetic divergence, correlation, path coefficient, stability analysis and morphological DUS characterization. The study conducted at experimental farm of Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan and Indian Council of Agriculture Research-Indian Agricultural Research Institute, Regional Station, Katrain, Kullu (HP) during 2016-2018.

The observations were recorded for two growing years on days taken for bulb sprout emergence, per cent bulb sprouting, plant height (cm), number of leaves/plant, leaf length (cm), leaf width (cm), stem length (cm), days to flower bud formation, bud length (cm), days to first flower, size of the flower (cm), number of flowers per plant, tepal length (cm), tepal width (cm), duration of flowering (days), bulb diameter (cm), weight of bulb (g), number of bulblets per plant, weight of bulblet (g), vase life (days), stem strength (%), grading of cut flowers (%),axillary bulbils/stem and incidence of insect-pest and diseases using the standard methods of cultivation. The results so obtained from present investigations are summarized below:

5.1 VARIABILITY STUDIES

51.1 Varietal evaluation

i) Days taken for bulb sprout emergence

- Genotypes at Nauni conditions during 2017-18 took minimum days (43.89 days) for bulb sprout emergence while maximum days (173.11 days) in genotypes grown at Katrain conditions during 2017-18.
- Among different genotype, 'Best Seller' (95.68 days) took minimum while 'Montego Bay' (130.28 days) took maximum days for bulb sprout emergence.
- Interaction effects of environments and genotypes revealed 'Best Seller' (28.83 days) at Nauni conditions during 2017-18 resulted in early bulb sprouting whereas 'Montego Bay' (193.83 days) at Katrain conditions during 2017-18 took maximum days.

ii) Per cent bulb sprouting

- Most of the genotypes under study recorded 100 % bulb sprouting while minimum in ‘Prato’ (97.50 %), ‘Tresor’ (97.50 %) and ‘Pavia’ (97.50 %)
- Interaction effects of environments and genotypes indicated that most of the genotypes grown during 2017-18 at Nauni conditions and under Katrain conditions during both the years recorded 100 per cent bulb sprouting while ‘Pavia’ (90.00 %) grown at Nauni conditions during 2016-17 recorded minimum bulb sprouting.

iii) Plant height (cm)

- Maximum plant height (73.26 cm) recorded during 2017-18 at Katrain location while minimum (71.51 cm) during 2017-18 at Nauni location.
- Among genotypes, ‘Yelloween’ (97.73 cm) and ‘Best Seller (53.65 cm)’ recorded maximum and minimum plant height, respectively.
- Interaction effects indicated maximum plant height in ‘Yelloween’ (103.07 cm) during 2016-17 at Katrain condition whereas minimum in ‘Best Seller’ (51.34 cm) during 2017-18 at Nauni.

iv) Number of leaves per plant

- As far as number of leaves per plant is concerned, at Katrain location during 2017-18, maximum numbers of leaves per plant (54.04) were produced whereas minimum (47.16) during 2017-18 at Nauni conditions.
- ‘Eyeliner’ (83.62) reported maximum number of leaves/plant while it was minimum in ‘Viviana’ (18.07).
- In case of performance of genotypes over environment revealed Eyeliner’ (89.43) with maximum number of leaves per plant during 2017-18 at Katrain conditions. In contrast minimum observed during 2017-18 at Nauni conditions in ‘Viviana’ (16.01)

v) Leaf length (cm)

- Genotypes at Katrain location during 2016-17 recorded maximum (10.67 cm) leaf length whereas minimum (10.26 cm) during 2017-18 under Nauni conditions.
- In case of genotypes, ‘Prato’ (14.61 cm) recorded maximum leaf length whereas minimum in ‘Sapporo’ (6.59 cm).

- Interaction effect revealed maximum leaf length in ‘Prato’ (15.44 cm) during 2017-18 under Katrain conditions while ‘Sapporo’ (6.34 cm) recorded minimum leaf length during 2017-18 at Katrain location.

vi) Leaf width (cm)

- Among different environments, maximum leaf width (1.74 cm) observed under Katrain condition during 2017-18 while minimum (1.45 cm) during 2017-18 under Nauni conditions.
- Among different genotypes, ‘Viviana’ (3.51 cm) followed by ‘Sapporo’ (3.44 cm) recorded maximum leaf width whereas minimum in ‘Tresor’ (1.42 cm).
- Interaction between environments and genotypes indicted maximum leaf width in ‘Viviana’ (3.76 cm) during 2017-18 under Katrain location while minimum observed in ‘Shiraj’ (1.10 cm) during 2017-18 at Katrain location.

vii) Stem length (cm)

- Stem length (53.26 cm) observed maximum during 2017-18 at Katrain conditions while minimum (51.19 cm) during 2016-17 at Nauni conditions.
- In case of different genotypes, ‘Yelloween’ (77.73 cm) and ‘Best Seller (33.65 cm)’ recorded maximum and minimum stem length, respectively.
- Genotype ‘Yelloween’ (83.07 cm) recorded maximum stem length during 2016-17 at Katrain condition whereas minimum in ‘Best Seller’ (31.34 cm) during 2017-18 at Nauni conditions.

viii) Days to flower bud formation

- Days to flower bud formation noted minimum (44.50 days) at Katrain location during 2016-17 while maximum days (71.96 days) observed under Nauni conditions during 2016-17.
- ‘Best Seller’ (41.60 days) was earliest to flower bud formation while ‘Montego Bay’ (73.48 days) took maximum days.
- Environment and genotypic interaction indicated during 2017-18, ‘Best Seller’ (28.53 days) at Katrain conditions resulted in early flower bud formation whereas, ‘Montego Bay’ (87.67 days) took maximum days for flower bud formation during 2016-17 at Nauni conditions.

ix) Bud length (cm)

- Among different environments, genotypes at Katrain location during 2017-18 observed maximum bud length (9.93 cm) while minimum (8.86 cm) under Nauni conditions during 2017-18.
- 'Yelloween' (12.79 cm) recoded maximum bud length whereas minimum in 'Shiraj' (6.72 cm).
- Interaction between environments and genotypes indicated 'Yelloween' (13.54 cm) with maximum bud length during 2017-18 at Katrain location while minimum in 'Shiraj' (5.46 cm) during 2017-18 at Nauni location.

x) Days to first flower

- Genotypes at Katrain conditions during 2016-17 took minimum (66.58 days) to first flower while genotypes at Nauni conditions during 2016-17 took maximum days (105.33 days) to first flower.
- Among different genotypes, 'Best Seller' (63.73 days) and 'Montego Bay' (101.32 days) took minimum and maximum days to first flower.
- 'Best Seller' (44.42 days) during 2017-18 at Katrain conditions resulted in early flowering whereas 'Montego Bay' (118.22 days) grown at Nauni conditions during 2016-17 took maximum days.

xi) Stem diameter (cm)

- Stem diameters noticed maximum (0.75 cm) under Katrain conditions during 2017-18 while minimum during 2016-17 at Nauni location (0.55 cm).
- In case of different genotypes, 'Pavia' (0.79 cm) recorded maximum stem diameter followed by 'Salmon Classic' (0.77 cm) while minimum in 'Shiraj' (0.44 cm).
- Interaction effect exhibited 'Prato' (0.91 cm) during 2017-18 at Katrain location with maximum stem diameter while minimum in 'Shiraj' (0.36 cm) during 2016-17 at Nauni location.

xii) Size of the flower (cm)

- Character flower size observed maximum (16.81 cm) during 2016-17 at Katrain location whereas minimum during 2017-18 at Nauni location (16.02 cm).

- Among different genotypes, 'Yelloween' (20.39 cm) reported maximum flower size followed by 'Sapporo' (20.20 cm) while minimum in 'Shiraj' (13.23 cm).
- Performance of genotypes over environment revealed maximum flower size in 'Yelloween' (20.81 cm) during 2016-17 at Katrain location whereas, minimum in genotype 'Shiraj' (12.52 cm) during 2017-18 at Nauni location.

xiii) Number of flowers per plant

- Katrain location during 2016-17 recorded maximum numbers of flowers per plant (5.91) while minimum during 2017-18 at Nauni location i.e. 2.86.
- Genotype, 'Eyeliner' (7.97) and 'Viviana' (2.33) produced maximum and minimum number of flowers per plant, respectively.
- Interaction between environments and genotypes revealed 'Eyeliner' (10.69) produced maximum number of flowers per plant during 2016-17 at Katrain location while minimum in 'Sapporo' (1.53) during 2017-18 at Nauni location.

xiv) Tepal length (cm)

- Maximum tepal length (10.10 cm) recorded during 2016-17 at Katrain location whereas minimum during 2017-18 at Nauni condition (8.89 cm).
- In case of genotypes, 'Yelloween' (12.43 cm) and 'Shiraj' (6.95 cm) recorded maximum and minimum tepal length, respectively.
- Interaction between environments and genotypes exhibited maximum tepal length in 'Yelloween' (12.50 cm) during 2016-17 at Nauni conditions. In contrast minimum tepal length observed in 'Shiraj' (6.54 cm) during 2017-18 at Katrain location.

xv) Tepal width (cm)

- Maximum tepal width (3.22 cm) recorded during 2017-18 at Nauni location while minimum (2.73 cm) during 2016-17 at Katrain location
- In case of different genotypes, 'Sapporo' (3.62 cm) recorded maximum tepal width while 'Pollyana' (2.28 cm) recorded minimum.
- Interaction effects recorded 'Salmon Classic' (3.94 cm) during 2017-18 at Nauni location with maximum tepal width. In contrast minimum tepal width recorded during 2017-18 at Katrain location in genotype 'Pollyana' (2.15 cm).

xvi) Duration of flowering (days)

- Genotypes at Katrain location during 2016-17 recorded maximum duration of flowering (19.83 days) while minimum (13.46 days) during 2017-18 at Nauni location.
- In case of different genotypes, 'Eyeliner' (23.81 days) recorded maximum duration of flowering while minimum in 'Ercolano' (12.24 days).
- Interaction between environments and genotypes revealed 'Eyeliner' (27.93 days) during 2016-17 at Katrain location recorded maximum duration of while minimum recorded in 'Montego Bay' (8.13 days) during 2017-18 at Nauni location.

xvii) Bulb diameter (cm)

- Among different environments, at Katrain location, during 2016-17 maximum bulb diameter (5.26 cm) was recorded while minimum bulb diameter (3.59 cm) recorded at Nauni location during 2017-18.
- 'Prato' (5.75 cm) and 'Viviana' (3.33 cm) recorded maximum and minimum bulb diameter, respectively.
- 'Prato' (7.13 cm) during 2016-17 at Katrain location performed better with maximum bulb diameter in whereas minimum bulb diameter observed in 'Shiraj' (2.48 cm) during 2017-18 at Nauni location.

xviii) Weight of bulb (g)

- Katrain location during 2017-18 recorded maximum (64.34 g) bulb weight whereas minimum (27.69 g) at Nauni location during 2017-18.
- Among different genotypes, 'Eyeliner' (64.05 g) recorded maximum bulb weight whereas minimum in 'Sapporo' (22.15 g) followed by 'Viviana' (24.18 g).
- Interaction between environments and genotypes revealed maximum weight of bulb in 'Prato' (95.84 g) during 2017-18 at Katrain location. In contrast minimum bulb weight in 'Sapporo' (18.12 g) during 2017-18 at Nauni location.

xix) Number of bulblets per plant

- Among different environments, maximum bulblets per plant (4.42) recorded during 2016-17 at Katrain location whereas minimum (1.62) during 2016-17 at Nauni location.

- Genotype ‘Eyeliner’ (7.20) recorded maximum number of bulblet per plant while minimum in ‘Sapporo’ (1.40).
- Environmental and genotypic interaction revealed ‘Eyeliner’ (10.87) with maximum number of bulblets per plant during 2016-17 at Katrain location while minimum number of bulblets/plant recorded in ‘Salmon Classic’ (1.10) during 2017-18 at Nauni location.

xx) Weight of bulblets (g)

- Genotypes at Nauni location during 2017-18 observed maximum weight of bulblet (2.17 g) whereas minimum during 2016-17 at Nauni location i.e. 1.40 g.
- Among different genotypes, ‘Eyeliner’ (3.26 g) recorded maximum bulblet weight whereas minimum in ‘Viviana’ (0.67 g).
- Interaction between environments and genotypes revealed during 2017-18 at Nauni location ‘Salmon Classic’ (4.57 g) recorded maximum bulblet weight while minimum in ‘Viviana’ (0.61 g) during 2017-18 at Katrain location.

xxi) Vase life (days)

- Genotypes during 2017-18 at Katrain location exhibited maximum vase life (7.79 days) whereas minimum (5.90 days) during 2016-17 at Nauni location.
- Among different genotypes, ‘Eyeliner’ (10.28 days) recorded maximum vase life whereas minimum in ‘Ercolano’ (6.22 days).
- ‘Eyeliner’ (11.54 days) observed maximum vase life during 2017-18 at Katrain location whereas minimum in ‘Ceb Dazzle’ (4.67 days) during 2016-17 at Nauni location.

xxii) Stem strength (%)

Strength of cut stems was expressed on the basis of grade ‘A’, grade ‘B’ and grade ‘C’. Studies revealed maximum production of ‘A’ grade cut stems in ‘Eyeliner’ (100.00 %) during 2016-17 at Katrain location while minimum in ‘Viviana’ (2.45 %) under Nauni location during 2016-17. On the other hand, ‘Ceb Dazzle’ (50.00 %) produced maximum ‘B’ grade cut stems during 2017-18 at Nauni location whereas minimum in ‘Eyeliner’ (1.43 %) during 2017-18 at Katrain location. With regards to ‘C’ grade cut stems, ‘Viviana’ (56.77 %)

observed maximum production of ‘C’ grade cut stems during 2016-17 at Nauni while minimum in ‘Eyeliner’ (1.07 %) during 2017-18 at Katrain location.

xxiii) Grading of cut flowers (%)

Genotype ‘Yelloween’ (100.00 %) produced maximum grade ‘1’ cut flowers during 2016-17 at Katrain location while minimum in ‘Navona’ (3.00 %) during 2017-18 at Katrain location. ‘Sapporo’ (73.22 %) produced maximum grade ‘2’ cut flowers during 2016-17 at Nauni location while minimum grade ‘2’ cut flowers were produced in ‘Eyeliner’ (1.66 %) during 2017-18 at Nauni location. Genotype, ‘Ceb Dazzle’ (63.34 %) produced maximum grade ‘3’ cut flowers during 2017-18 at Nauni location whereas minimum in ‘Pollyana’ (1.34 %) during 2017-18 at Katrain location.

In case of grade ‘4’ cut stems, ‘Viviana’ (66.67 %) produced maximum cut flowers during 2016-17 at Katrain location while minimum grade ‘4’ cut flowers recorded in ‘Prato’ (1.77 %) during 2017-18 at Katrain location.

‘Best Seller’ (63.34 %) produced maximum grade ‘5’ cut flowers during 2017-18 at Nauni location whereas minimum in ‘Pollyana’ (1.11 %) during 2016-17 at Katrain location .

5.1.2 Parameters of variability

i) Variability studies under Nauni conditions

Under Nauni location, high value of genotypic coefficient of variability (GCV) were obtained for number of bulblet per plant (54.77 %) followed by number of flowers per plant (43.43 %) number of leaves/plant (37.68 %); moderate value for weight of bulblet (29.22 %), weight of bulb (23.52 %), stem length (22.04 %), days to bulb sprout emergence(20.25 %), leaf length (19.90 %), stem diameter (16.83 %), bud length (15.93 %) while rest of all parameters exhibited low genotypic coefficient of variability.

High heritability coupled with moderate genetic advance observed for number of leaves/plant (37.40 %) while it was low for rest of all the parameters.

Moderate heritability with highest genetic gain (100.16 %) recorded for the character number of bulblet/plant while high heritability along with high genetic gain observed for traits like number of leaves per plant (77.35 %), leaf width (59.61 %) and number of flowers per plant (86.51 %).

ii) Variability studies under Katrain conditions

Characters such as number of bulblet per plant (63.55 %) followed by weight of bulblet (52.11 %) number of leaves/plant (36.19 %), weight of bulb (33.41 %) and number of leaves/plant (36.19 %) recorded high value of genotypic coefficient of variability.

High heritability coupled with moderate genetic advance reported for plant height (33.16 %), number of leaves/plant (39.89 %), stem length (33.16 %) and weight of bulb (43.68 %).

High heritability with highest genetic gain (130.63 %) observed for parameters such as number of bulblet/plant followed by weight of bulblet (106.55 %), vase life (106.54 %), number of leaves per plant (74.47 %), leaf width (55.11 %), stem length (65.30 %), number of flowers per plant (50.87 %), duration of flowering (51.48 %) and weight of bulb (68.79 %).

iii) Pooled analysis

On pooling of environments, number of bulblet per plant (50.81 %), number of leaves/plant (33.97 %) and number of flowers/plant (33.96 %) recorded high values of GCV.

High heritability coupled with moderate genetic advance recorded for number of leaves/plant (35.78 %), plant height (25.98 %) and stem length (25.98 %).

Moderate heritability with highest genetic gain (104.08 %) recorded for number of bulblet/plant followed by number of leaves per plant (69.90 %), leaf width (52.19 %), number of flowers/plant (69.54 %) and weight of bulblet (57.12 %).

5.2 CORRELATION STUDIES

The correlation coefficients among different characters were worked out at both phenotypic and genotypic levels.

i) Correlation studies under Nauni conditions

Nauni location exhibited significant positive phenotypic correlation of yield parameter i.e. number of flowers per plant with plant height (0.68), number of leaves/plant (0.87), leaf length (0.70), stem length (0.70), bulb diameter (0.27), weight of bulb (0.44) and number of bulblets/plant (0.30) while at genotypic level, this trait recorded significant positive correlation with plant height (0.74), number of leaves per plant (0.90), leaf length (0.75), stem length (0.72), days to flower bud formation (0.43), bud length (0.89), days to first flower (0.31), bulb diameter (0.36), weight of bulb (0.47), number of bulblets/plant (0.33) and weight of bulblet (0.30).

ii) Correlation studies under Katrain conditions

Katrain location indicated significant positive correlation of yield parameter with plant height (0.69), number of leaves/plant (0.80), leaf length (0.59), stem length (0.69), bud length (0.28), stem diameter (0.52), size of the flower (0.33), duration of flowering (0.51), bulb diameter (0.59), weight of bulb (0.75), number of bulblets/plant (0.39), weight of bulblet (0.50) and vase life (0.70) while on the other hand, parameters such as plant height (0.70), number of leaves per plant (0.80), leaf length (0.60), stem length (0.70), bud length (0.28), stem diameter (0.52), size of the flower (0.33), duration of flowering (0.51), bulb diameter (0.63), weight of bulb (0.74), number of bulblets/plant (0.38), weight of bulblet (0.50) and vase life (0.70) exhibited significant positive correlation at genotypic level.

iii) Pooled analysis

Pooled analysis over four environments illustrated significant positive phenotypic correlation of yield parameter at phenotypic level with plant height (0.59), number of leaves/plant (0.82), leaf length (0.72), stem length (0.59), stem diameter (0.39), duration of flowering (0.83), bulb diameter (0.68), weight of bulb (0.61), number of bulblets/plant (0.55), weight of bulblet (0.55) and vase life (0.70).

Traits such as plant height (0.59), number of leaves per plant (0.82), leaf length (0.73), stem length (0.59), stem diameter (0.40), duration of flowering (0.84), bulb diameter (0.72), weight of bulb (0.62), number of bulblets/plant (0.56), weight of bulblet (0.58) and vase life (0.72) exhibited significant genotypic correlation with yield parameter.

5.3 PATH COEFFICIENT ANALYSIS

i) Path coefficient analysis under Nauni conditions

The pooled data over Nauni location exhibited maximum positive direct effect of days to flower bud formation (5.78) on number of flowers per plant followed by leaf length (4.86), days taken for bulb sprout emergence (2.94) weight of bulb (1.91), size of the flower (1.37), tepal length (1.01), vase life (0.93), plant height (0.45), number of leaves per plant (0.28), weight of bulblet (0.20) and per cent bulb sprouting(0.15) while rest of all the other parameters observed negative direct effect.

ii) Path coefficient analysis under Katrain conditions

On pooling of data at Katrain location, number of leaves per plant (0.67) exhibited maximum positive direct effect on yield parameter followed by days to first flower (0.43), bulb diameter (0.41), leaf width (0.34), bud length (0.27), weight of bulb (0.22), stem diameter (0.17), tepal length (0.14), leaf length (0.13), days to flower bud formation (0.07), weight of bulblet (0.01), duration of flowering (0.001) and per cent bulb sprouting(0.15) while rest of all other exhibited negative direct effect on number of flowers per plant.

iii) Pooled analysis

Pooled analysis over environments observed stem length (24.10) with very high positive direct effect on number of flowers per plant followed by days to first flower (1.03), tepal length (0.99), bulb diameter (0.87), tepal width (0.81), weight of bulblet (0.70), duration of flowering (0.67), leaf length (0.63) and per cent bulb sprouting (0.30) whereas rest of all parameters exhibited negative direct effects on number of flowers per plant.

5.4 GENETIC DIVERGENCE

In present investigation, 18 *Lilium* genotypes were grouped into 4 clusters over different environments.

Clustering pattern under Nauni location revealed maximum numbers of 7 genotypes accommodated in cluster-III, followed by cluster-II with 5 genotypes and cluster-I with 4 genotypes whereas, cluster-IV included only two genotypes. Highest inter cluster distance (78.88) was recorded between cluster-III & cluster-IV followed by cluster-II & cluster-III (62.66) whereas, lowest (41.86) inter cluster distance observed between cluster- II & cluster-IV followed by cluster-I & cluster-III (45.93). Genotypes of cluster-II recorded earliness for days taken for bulb sprout emergence and days to first flower whereas cluster-III recorded maximum cluster means for vegetative parameters like plant height, number of leaves/plant, leaf length and stem length.

At Katrain location, maximum 9 genotypes accommodated in cluster-II, followed by cluster-I with 6 genotypes, cluster-IV with 2 genotypes and cluster III with solitary genotype.

Highest inter cluster distance (103.52) recorded between cluster-II & cluster-IV followed by cluster-I & cluster-IV (90.03) whereas, lowest (52.99) inter cluster distance exhibited by cluster- I & cluster-III followed by cluster-II & cluster-III (63.70). Genotypes of cluster-I exhibited earliness for days taken for bulb sprout emergence (166.27 days), days to flower bud formation (40.52 days), days to first flower (40.52 days) and maximum cluster mean for per cent bulb sprouting (100.00 %) and weight of bulb (69.85 g)

With regards to cluster-II which recorded maximum cluster mean for vegetative parameters such as plant height (87.20 cm), number of leaves per plant (68.01), leaf length (12.46 cm), leaf width (2.18 cm), stem length (67.20 cm) and stem diameter (0.78 cm), flowering parameters like bud length (11.24 cm), size of the flower (17.72 cm), number of flowers/plant (8.35), tepal length (10.56 cm), duration of flowering (23.73 days), vase life (14.86 days) and number of bulblet/plant (5.14).

Pooled analysis of genetic divergence over environments assembled maximum 7 genotypes in cluster-II, followed by cluster-III with 5 genotypes and cluster-I with 4 genotypes. However cluster-IV included minimum of 2 genotypes. Maximum inter cluster distance observed between the genotypes of cluster-I and cluster-IV (85.09) followed by inter cluster distance between cluster-I & cluster-III (83.05) whereas, lowest (47.67) inter cluster distance was exhibited by cluster- II & cluster-III followed by cluster-I & cluster-III (48.02).

Genotypes of cluster-I recorded maximum cluster mean for parameters such as per cent bulb sprouting (99.00 %), plant height (87.24 cm), number of leaves per plant (66.22), leaf length (12.44 cm), leaf width (2.82 cm), stem length (67.24 cm), bud length (10.52 cm), stem diameter (0.68 cm), size of the flower (17.44 cm), number of flowers per plant (6.08), tepal length (10.25 cm), duration of flowering (19.76 days), bulb diameter (4.94 cm), weight of bulb (51.76 g), number of bulblet per plant (3.48), weight of bulblet (2.12 g) and vase life (8.00 days). Cluster-II observed earliness for days to flower bud formation (54.05 days) and maximum cluster means for stem diameter (0.68 cm) and tepal width (3.30 cm).

5.5 STABILITY ANALYSIS

Knowledge of genotype × environment interaction is essential for the development of improved cultivars which shows less sensitivity to environments with respect to desirable economic traits.

In present study, genotype, 'Eyeliner' exhibited stability for most of the parameters like days taken for bulb sprout emergence, bud length (cm), number of flowers/stem, bulb diameter (cm), weight of bulb (g), weight of bulblets (g) and vase life (g) followed by genotype 'Salmon Classic' with stability for total 5 parameters, 'Yelloween', 'Pavia' & 'Brunello' each with 4 parameters, 'Viviana', 'Pollyana', 'Montego Bay' and 'Elite' each with 2 parameters and 'Cilesta', 'Sapporo', 'Best Seller' & 'Navona' each with stability for only one parameter.

5.5 MORPHOLOGICAL CHARACTERIZATION OF GENTOYPES

The nature and magnitude of variation present among 18 *Lilium* genotypes with respect to various vegetative and flowering characteristics were assessed. These genotypes were studied for 40 morphological characters and results were summarized in the form of draft guidelines given under section 4.6 in chapter IV. From the study it can be concluded that morphological DUS descriptor is highly efficient in identification of genotypes and also to group those genotypes into different categories for each character. The variation at the morphological level suggests the diversity among the genotypes which can be further utilized for trait specific breeding programmes through systemic and scientific approaches.

CONCLUSION

From the present investigation, it can be concluded that the existence of wide variations for various vegetative and floral traits among 18 *Lilium* genotypes offered a good scope of selecting the suitable genotypes for all the economic traits.

- Katrain location outperformed Nauni location in terms of all the vegetative, flowering and bulb parameters except days taken for bulb sprout emergence.
- With regards to the performance of genotypes, 'Best Seller' performed well for earliness to flowering while 'Yelloween' with respect to plant height and stem length,
- Genotypes 'Eyeliner' and 'Prato' produced maximum number of flower per plant.
- For good flower quality in terms of stem sturdiness and stem length grades, 'Eyeliner' 'Prato', 'Yelloween', 'Best Seller' and 'Brunello' performed well.
- Characters such as number of bulblet per plant, number of leaves/plant and number of flowers/plant recorded high genotypic coefficient of variability. High heritability coupled with moderate genetic advance recorded for number of leaves/plant, plant height and stem length suggesting selection in the desired directions based on

phenotypic observations might be effective to bring about improvement of desirable traits in *Lilium*.

- Significant positive correlation of yield component with plant height, number of leaves per plant, leaf length, stem length, stem diameter, duration of flowering, bulb diameter, weight of bulb *etc*., is found to be favourable for breeding as it helps in simultaneous improvement of correlated characters.
- Maximum positive direct effect of days to flower bud formation, number of leaves per plant, bulb diameter, weight of bulb, leaf length, leaf width, stem diameter, stem length *etc*., on number of flowers per plant revealed the true relationship between them and direct selection for these traits will be rewarding for the flower yield.
- Highest inter cluster distances recorded between cluster-III & cluster-IV, cluster-II & cluster-IV and cluster-I and cluster-IV under Nauni condition, Katrain condition and pooled analysis, respectively indicating maximum diversification among these clusters.
- In terms of stability performance, 'Eyeliner' exhibited stability for maximum of desirable seven parameters followed by genotype 'Salmon Classic' with stability for total 5 parameters, 'Yelloween', 'Pavia' & 'Brunello' each with 4 parameters, 'Viviana', 'Pollyana', 'Montego Bay' and 'Elite' each with 2 parameters and 'Cilesta', 'Sapporo', 'Best Seller' & 'Navona' each with stability for only one parameter.
- Morphological evaluation of genotypes through DUS testing is not only suitable for varietal characterization but also reliable and reproducible for assessing the genetic purity of varieties and to establish their identity. Further, these identified diverse genotypes with peculiar characteristics may be used as parents in the crop improvement programme for evolving elite genotypes. But morphological traits alone may not be adequate for the DUS criteria, hence, collaboration through biochemical and molecular characters need to be explored for the delineation of *Lilium* varieties for varietal protection.

LITERATURE CITED

*Allard RW. 1960. Principles of plant breeding. John Wiley and Sons Publication, New York, USA. 485p.

*Allard RW and Hansche PE. 1964. Some parameters of population variability and their implication in plant breeding. *Advance Agronomy* 16: 281-324.

Al-Jibouri HW, Miller PA and Robinson HF. 1958. Genotypic and environmental variances and co-variances in an upland cotton cross of inter-specific origin. *Agronomy Journal* 50: 633-636.

Anitha K, Jegadeeswari V and Selvaraj N. 2017. Studies on genetic variability, heritability and genetic advance in lisianthus [*Eustoma grandiflorum* (Raf.) Shinners]. *Agriculture Update* 12(2): 471-474.

Anonymous. 1996. Recommended grades and standards for fresh cut flowers. https://www.flowerscanadagrowers.com/uploads/2016/11/grades%20&%20standards%20for%20fresh%20cut%20flowers.pdf.

Anonymous. 2017. Royal Flora Holland - Annual report. http://annualreport.royalfloraholland.com/?_ga=2.4001779.296685808.1547377011841489915.1547377011#/feiten-en-cijfers?_k=0fe151.

Anonymous. 2016. Growth of horticulture in Haryana. Horticulture Department, Government of Haryana, India.

Anonymous. 2017. Status of floriculture in Himachal Pradesh. Directorate of Horticulture, Shimla, Himachal Pradesh, India.

Arens P, Esselink D, Noordijk Y, Kodde L, Hof L, Wietsma W and Vosman B. 2009. Identification of carnation varieties using microsatellite markers. *Acta Horticulturae* 836: 175-182.

Arora JS and Sharma SC. 1991. Genotype × environment interaction of some quantitative traits in gladiolus. *Indian Journal of Horticulture* 48(1): 83-86.

Asha KM, Sane A and Kumar R. 2016. Characterization of chrysanthemum (*Dendranthema grandiflora* Tzvelev) as per DUS guidelines. *Indian Journal of Agricultural Sciences* 86(1): 103-112.

Barba Gonzalez R, Lim KB and Van Tuyl JM. 2014. Molecular cyto-genetics in *Lilium* breeding. *Acta Horticulturae* 1027: 129-142.

Bhajantri A. 2013. Genetic variability and improvement studies in gladiolus (*Gladiolus hybrida* Hort.). Ph.D Thesis, Department of Horticulture, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad. 117.

Bhajantri A and Patil VS. 2016. Genetic diversity analysis in gladiolus genotypes (*Gladiolus hybrida* Hort.). *Journal of Applied and Natural Science* 8(3): 1416 – 1420.

Bhatia R, Dhiman MR, Chander Parkash and Dey SS. 2017. Genetic variability and character association in tulip (*Tulipa gesneriana* L.) for various quantitative traits. *Indian Journal of Agricultural Sciences* 83(7): 773-780.

Barik D and Mohanty CR. 2015. Evaluation of Asiatic hybrid lily varieties under Bhubaneswar condition. *The Asian Journal of Horticulture* 10(2): 194-200.

Balode A. 2016. Assessment of flowering time and *Botrytis* spp resistance in *Lilium* spp *Miestų zeldynų formavimas* 1(13): 19–24.

Balaram MV and Janakiram T. 2009. Genetic variability in gladiolus genotypes for corm characters. *Journal of Ornamental Horticulture* 12(2): 123–126.

Banerji BK, Batra A and Dwivedi AK. 2012. Morphological and biochemical characterization of chrysanthemum. *Journal of Horticultural Sciences* 7(1): 51-55.

Bhandari NS, Srivastava R and Goshwami V. 2017. Evaluation of *Lilium* hybrids (*Lilium* × *hybrida*) for growth, flowering and bulb attributes in the hilly regions of Uttrakhand. *Journal of Horticultural Sciences* 11: 161-165.

Bhatia R, Dey SS and Kumar R. 2017. Genetic divergence studies in tulip (*Tulipa gesneriana* L.). *Indian Journal of Horticulture* 74(4): 562-567.

Bihari M, Surya Narayan, Singh L, Kumar R, Singh A and Prasad A. 2009. Studies on genetic divergence in gladiolus. *Journal of Ornamental Horticulture* 12(3): 202-205.

Bihari M, Surya N, Singh L, Pandey P, Kumar R and Singh A. 2009. Variability studies in canna genotypes. *Journal of Ornamental Horticulture* 12(3): 217-221.

Burton GW and De Vane EH. 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal* 45: 478-481.

Chandrashekar SY, Naik BH, Kulkarni SB and Jagadeesha RC. 2018. Characterization of Asiatic lily genotypes for flowering and quality parameters under protected conditions. *International Journal of Current Microbiology and Applied Sciences* 7(9): 75-81.

Chauhan P. 2015. Genetic studies on carnation (*Dianthus caryophyllus* L.). Ph.D Thesis, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.), India. 151.

Choudhary M, Moond SK, Kumari A and Beniwal BS. 2012. Genetic variability in quantitative characters of gladiolus (*Gladiolus* × *hybridus* Hort.). *International Journal of Agricultural Sciences* 8(1): 138-141.

Choudhary M, Beniwal BS and Kumari A. 2014. Characterization of marigold genotypes using morphological characters. *Research on Crops* 15(4): 839-845.

Cook JJ, Bredemeijar GMM, Ganal MW, Peeters R, Issac P and Rendell S. 2003. Assessment of the uniformity of wheat and tomato varieties at DNA microsatellite loci. *Euphytica* 132: 331–341.

De Hertogh A and Wilkins HF. 1971. The forcing of NorthWest- grown 'Ace' and 'Nelle White' Easter lilies. *Florists Review* 149:29- 31.

De LC, Rao AN, Rajeevan PK, Dhiman SR, Srivastava M and Chhetri G. 2014a. Morphological characterization in *Paphiopedilum* species. *Electronic Journal of Biosciences* 2(3): 131-145.

De LC, Rao AN, Rajeevan PK, Dhiman SR, Srivastava M and Chhetri G. 2014b. DUS test guidelines in *Oncidium* orchids. *International Journal of Applied Bioresearch* 22:1-8.

De LC, Rao AN, Rajeevan PK, Srivastava M and Chhetri G. 2015b. Morphological characterization in *Vanda* species. *International Journal of Scientific Research* 4(1): 26-32.

De LC, Rao AN, Rajeevan PK, Srivastava M and Chhetri G. 2015a. Morphological characterization in *Dendrobium* species. *Journal of Global Biosciences* 4(1): 1198-1215.

Deka, Kumar R, Bidyut C and Patel VV. 2010. Evaluation of Asiatic *Lilium* under sub-tropical mid hills of Meghalaya. *Journal of Ornamental Horticulture* 13(4): 257-260.

Dewey DR and Lu KH. 1959. A correlation and path co-efficient analysis of components of crested wheat grass seed production. *Agronomy Journal* 51: 515-518.

Desh Raj and Misra RL. 1998a. Stability analysis in gladiolus I. Vegetative characters. *Annals of Agriculture Research* 19(4): 423-428.

Desh Raj and Misra RL. 1998b. Stability analysis in gladiolus II. Floral characters. *Journal of Ornamental Horticulture* 1(2): 61-65.

Desh Raj and Misra RL. 2000. Genetic divergence for economic characters in gladiolus under different environments. *Journal of Ornamental Horticulture* 3(1): 37-42.

Dhiman MR. 2003. Evaluation of hybrid lily under Kullu conditions. *Journal of Ornamental Horticulture* 6(2): 154-155.

Dhiman MR, Suman RS, Kumar R, Prakash C and Guleria M. 2014. Influence of different sites on *Lilium* flower and bulb production in cold desert of Himachal Pradesh, India. *International Journal of Agriculture Innovations and Research* 2(6): 1126-1130.

Dhiman MR, Kumar S, Parkash C, Kumar R, Moudgil S and Sunita. 2015. Studies on genetic variability, heritability, genetic advance and correlation in *Alstroemeria* spp. *Journal of Ornamental Horticulture* 18(3 & 4): 118-125.

Dhiman MR, Chander Prakash, Kumar R, Guleria MS and Dhiman M. 2015. Studies on genetic variability and heritability in Asiatic hybrid lily (*Lilium* × *elegans* L). *Molecular Plant Breeding* 6(2): 1-8.

Eberhart SA and Russell WL. 1966. Stability parameters for comparing varieties. *Crop Sciences* 6: 36-40.

Feng LJ, Yuan ZH, Yin YL and Zhao XQ. 2012. Studies on the genetic diversity of phenotype characteristics for different dahlia population. *Acta Horticulturae* 937: 411-418.

Finlay KW and Wilkinson GM. 1963. Analysis of adaptation in plant breeding programme. *Australian Journal of Agriculture Research* 14: 742-757.

*Fisher RA and Yates F. 1963. Statistical tables for biological, agricultural and medical research. 6th edition. Oliver and Boyd Ltd, London, UK.146p.

*Fisher RA. 1918. The correlation between relatives on the supposition of Mendelian inheritance. *Trans Royal Society Edinburgh* 52: 399-433.

Freeman GH and Perkins JM. 1971. Environmental and genotype-environmental components of variability. *Heredity* 27:15-23.

Gantait SS, Mahato SK and Majumder J. 2016. Genetic variability, character association and path coefficient analysis in gladiolus for various quantitative traits. *Indian Journal of Horticulture* 73(4): 564-569.

Gantait SS, Pal P and Ghosdastdar KK. 2012. Phenotypic stability for flower yield and its components of some selected spray chrysanthemum cultivars. *Acta Horticulturae* 937: 313-320.

Grassotti A and Gimelli F. 2011. Bulb and cut flower production in the genus *Lilium*: current status and the future. *Acta Horticulturae* 900: 21-36.

Gomez KA and Gomez AA. 1984. Statistical procedures for agricultural research. John Wiley and Sons Publication, NewYork, USA. 680p.

Goulden CH. 1959. Method of statistical analysis. John Wiley and Sons Publications, New York, USA. 134p.

*Gupta R. 2002. Evaluation of *Lilium* under Bajaura conditions. *National Symposium on Indian Floriculture in the New Millennium*. pp. 52. (Abstract).

*Gupta R. 2003. Performance of various Asiatic and Oriental hybrid cultivars of *Lilium* under mid-hill zone of Himachal Pradesh. *National Symposium on Recent Advances in Indian Floriculture*. 87p. (Abstract).

*Hegde MV. 1994. Studies of variability, correlation, path analysis and performance of gladiolus hybrids. M.Sc Thesis, University of Agricultural Sciences, Dharwad. India. 97.

*Horner TW and Frey KJ. 1957. Method for determining natural areas for oat varietal recommendations. *Agronomy Journal 49:* 315-317.

Jhon AQ, Khan FU and Rather ZA. 2006. Genetic variability studies in tulip. *Applied Biological Research* 8: 37-39.

Johanson HW, Robinson HF and Comstock RE. 1955. Estimates of genetic and environmental variability in soyabean. *Agronomy Journal* 47: 314-318.

Jones H, Jarman RJ, Austin L, White J and Cooke RJ. 2003. The management of variety reference collection in distinctness, uniformity and stability testing of wheat. *Euphytica* 132: 175–184.

Kadam GB, Kumar G, Saha TN, Tiwari AK and Kumar R. 2014. Varietal evaluation and genetic variability studies on gladiolus. *Indian Journal of Horticulture* 71(3): 379-384.

*Kispotta LM, Jha KK, Horo P, Tirkey SK, Misra S and Sengupta S. 2017. Genetic variability and heritability in gladiolus (*Gladiolus hybrida* L.). *International Journal of Science, Environment and Technology* 6(1): 519 – 528.

*Krishnappa KS. Shivreddy N and Anjanappa 2000. Effect of floral preservatives on the vase life of carnation cut flower cultivars. *Karnataka Journal of Agricultural Sciences* 13(2): 395-400.

Kumar J, Kumar R and Pal K. 2011. Variability and character association in gladiolus (*Gladiolus grandiflorus* L.). *Agricultural Science Digest* 31(4): 280-284.

Kumar R, Kumar S and Yadav Y C. 2012. Genetic variability, heritability, genetic advance, correlation coefficient and path analysis in gladiolus. *Indian Journal of Horticulture* 69(3): 369-373.

Kumar CMP, Dorajeerao AVD, Suseela T, Salma Z and Krishna UK. 2018. Genotype × environment interactions yields stability of chrysanthemum (*Dendranthema grandiflora* Tzvelev) genotypes. *International Journal of Current Microbiology and Applied Sciences* 7(8): 4396-4404.

Kumar R, Verma VP, Bidyut CD, Singh JP and Sindhu SS. 2011. Evaluation of Asiatic *Lilium* under sub-tropical mid hills of Meghalaya. *Advance Research Journal of Crop Improvement* 2(2): 257-259.

Kumar M, Kumar V and Kumar MS. 2010. Genetic variability and character association in gladiolus (*Gladiolus grandiflorus* L.). *Environment & Ecology* 28(1): 622–628.

Kumar R. 2013. Genetic variability, heritability, correlation analysis for quantitative traits in Asiatic *Lilium*. *Indian Journal of Horticulture* 70(4): 555-559.

Kumar R. 2015. Genetic variability and character association among quantitative traits in gerbera. *Indian Journal of Horticulture* 72**(**1): 88-91.

Kumar PS, Kumar R, Choudhary VK and Kanwat M. 2015. Genetic variability and character association in gladiolus (*Gladiolus hybrida*). *Indian Journal of Agricultural Sciences* 85(6): 101-105.

Kumar S, Malik A, Dahiya DS and Kaur M. 2018. Appraisal of Asiatic hybrid *Lilium* cultivars under polyhouse growing condition in semi-arid Haryana, India. *International Journal of Current Microbiology and Applied Sciences* 7(6): 3389-3394.

*Lal SD, Shah A and Seth JN. 1985. Genetic variability in gladiolus. I. Phenotypic variability and its heritable components in some important quantitative characters contributing towards spike weight. *Progressive Horticulture* 17: 28-30.

*Law JR, Cooke RJ, Reeves JC, Donini P and Smith JSC. 1999. Most similar variety comparisons as a grouping tool. *Plant Varieties and Seeds* 12: 181–190.

Lim KB, Chung JD, Van Krononburg BCE, Ramanna MS, De Jong JH and Van Tuyl JM. 2000. Introgression of *Lilium rubellum* Baker. chromosomes into *Lilium longiflorum* Thunb. - a genome painting study of the F_1 hybrid, BC_1 and BC_2 progenies. *Chromosome Research* 8: 119-125.

*Le Nard M. 1983. Physiology and storage of bulbs: concepts and nature of dormancy in bulbs. In: Post harvest physiology and crop preservation Lieberman M ed). Plenum Press, New York, USA. pp. 191–230.

*Mahesh K. 1996. Variability studies in carnation (*Dianthus caryophyllus* L.). M.Sc Thesis, Department of Horticulture, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad. India 109.

Mahalanobis PC. 1936. On the generalized distance in statistics. *Proceedings of National Institute of Science of India* 11(2): 49-55.

Malik KM. 2014. Studies on flower regulation in Asiatic *Lilium* (*Lilium* × *elegans* Thunb). Ph.D Thesis, Department of Floriculture and Landscape Architecture, Sher-e-Kashmir University of Agricultural Sciences & Technology, Kashmir, India. 198.

Malik K and Pal K. 2015. The genetic divergence among 22 *gladiolus* genotypes using D^2 analysis. *African Journal of Basic & Applied Sciences* 7(3): 153-159.

Manoj A. 2016. Genetic variability studies in gladiolus (*Gladiolus hybridus* Hort.). *Acta Horticulturae* 1165: 83-86.

*Misra RL and Saini HC. 1997. Genetic divergence in gladiolus. *Indian Journal of Plant Genetic Resources* 10(2): 249-254.

Misra S. 2002. Variability and stability estimates in carnation. Ph.D Thesis, Department of Floriculture and Landscape Architecture, College of Horticulture, Dr YSP, University of Horticulture and Forestry, Nauni, Solan, (H.P.) 97.

Mishra M and Mohanty CR. 2003. Comparative estimates of genetic divergence in dahlia. *Indian Journal of Horticulture* 60(3): 296-302.

Merel MLG, Miller WB, Croes AF and Geert JDK. 2003. Effect of low temperature on dormancy breaking and growth after planting in lily bulblets regenerated. *Plant Growth Regulation* 40(3): 267-275.

Naik BH. 2003. Stability analysis and standardization of production technology for flower and xanthophylls yield in marigold (*Tagetes* spp). Ph.D Thesis, Department of Horticulture, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad. India 329.

Nair SA and Shiva KN. 2003. Genetic variability, correlation and path coefficient analysis in gerbera. *Journal of Ornamental Horticulture* 6(3): 180-187.

*Naresh S, Dorajee AVDR, Vijaya VB, Paratpara PR and Krishna KU. 2015. Genetic variability, heritability and genetic advance in *Gladiolus hybrida*. *Plant Archives* 15(1): 377-381.

Nazir M, Dwivedi VK and Bhatt K L. 2004. Genetic variability in gladiolus. *Journal of Ornamental Horticulture* 7(3-4): 75-80.

Negi R, Jarial K, Jarial RS, Kumar S and Dhiman SR. 2016. Evaluation of *Lilium* cultivars for suitability under low hill conditions of Himachal Pradesh. *Journal of Hill Agriculture* 7(2): 201-203.

Negi SS, Sharma TVRS, Raghava SPS and Srinivasan VR. 1982. Variability studies in gladiolus. *Indian Journal of Horticulture* 39: 269- 272.

Nimbalkar CA, Dhane AV and Bajaj VH. 2006. Divergence studies in dahlia. *Journal of Ornamental Horticulture* 9(2): 122-125.

*Pant CC and Lal SD. 1998. Heterosis in gladiolus. II [*Gladiolus primulinus* (*Gladiolus dalenii)* Baker]. *Progressive Horticulture* 25(1-2): 1-4.

Panwar S, Singh K P and Namita. 2012. Assessment of variability, heritability components and grouping of Indian rose (*Rosa hybrida*) genotypes based on DUS guidelines. *Indian Journal of Agricultural Sciences* 82(10): 875-880.

Patra SK and Mohanty CR. 2015. Path coefficient analysis in gladiolus. *IOSR Journal of Agriculture and Veterinary Sciences* 8: 28-32.

Priyanka BM. 2012. Genotypic stability analysis in chrysanthemum (*Dendranthema grandiflora* Tzevlev). M.Sc Thesis, Department of Floriculture and Landscape Architecture, Kittur Rani Channama College of Horticulture, University of Horticultural Sciences, Bagalkot.124.

Pal SL, Prasad A and Singh RA. 2006. Analysis of genetic divergence in gladiolus. *Indian Journal of Horticulture* 63(1): 70-72.

Patil AA, Manjula B and Naik H. 2004. Coefficient of variation, heritability and genetic advance in gladiolus hybrids. *Journal of Ornamental Horticulture* 7(3-4): 71-74.

Patil KV, Kulkarni BS, Reddy BS and Jagadeesha RC. 2011. Stability analysis in marigold (*Tagetes erecta* L.) for flower yield and quality parameters. *Research Journal of Agriculture Sciences* 2(2): 237-240.

Perkins JM and Jinks JL. 1968. Environmental and genotype × environmental components of variability: multiple lines and crosses. *Heredity.* 23: 339-356.

PPV and FR Authority [Protection of Plant Varieties and Farmers' right Authority]. 2010. DUS test guidelines for chrysanthemum. *Plant Variety Journal of India* 4(1): 41-73.

PPV and FR Authority [Protection of Plant Varieties and Farmers' right Authority]. 2011a. DUS test guidelines for damask rose. *Plant Variety Journal of India* 5(2 & 3): 13-19.

PPV and FR Authority [Protection of Plant Varieties and Farmers' right Authority]. 2011b. DUS test guidelines for orchids. *Plant Variety Journal of India* 5(10): 6-83.

Pratap M and Rao AM. 2006. Assessment and variability studies in gladiolus. *Journal of Ornamental Horticulture* 9(2): 145-147.

Radhakrishna KN, Janakiram T and Srinivas M. 2004. Correlation studies in tuberose (*Polianthes tuberosa* L.). *Journal of Ornamental Horticulture* 7(3): 110-116.

Ranchana P, Kannan M and Jawaharlal M. 2013. Evaluation of tuberose *(Polianthes tuberosa* L.) genotypes (double) for yield and genetic variability. *Journal of Ornamental Horticulture* 16 (1 & 2): 10-14.

Rao R. 1952. Advanced statistical methods in biometrical research. John Wiley and Sons Publications, New York. USA. pp. 357-363.

*Sandison A and Bartlett BO. 1958. Comparison of varieties for yield. *Journal of National Institute of Agricultural Botany* 8: 351-57.

Sarvade SA, Ranpise SA and Thorat AR. 2015. Evaluation of different varieties of *Lilium* (*Lilium* spp) for flowering and flower quality under shade net conditions. *International Journal of Tropical Agriculture* 33(2): 499-501.

Sharma S, Dastagiri MB and Reddy MN. 2017. Morphological variation and evaluation of gladiolus (*Gladiolus hybrida* Hort.) cultivars. *Journal of Horticulture* 4: 212-217.

Sharma R, Kumar R and Dahiya DS. 2018. Studies on the performance of *Lilium* varieties under polyhouse. *Journal of Pharmacognosy and Phytochemistry* 7(4): 2711-2713.

Sheela VL, Nair CSJ, Rakhi R and Lekshmi PRG. 2006. Correlation studies in heliconia. *Journal of Ornamental Horticulture* 9(1): 29-32.

Sheikh MQ. 2004. Genetic divergence and stability performance for some economic traits in gladiolus (Gladiolus hybrida L.). Ph.D Thesis, Division of Floriculture, Medicinal and Aromatic Plants, Sher-e-Kashmir, University of Agricultural Sciences and Technology, Shalimar, Kashmir, J&K, India. 249.

Sindhu SS and Singh JP. 2012. Evaluation of *Lilium* cultivars under Northern plains. *International Journal of Agriculture Sciences* 8(2): 460-461.

Singh B and Singh M. 1983. Correlation and path coefficient in gladiolus. In: *International Congress on Genetics*, IARI, New Delhi, India. 616p.

Singh P, Santhy V, Vijyakumari PR and Deshmukh RK. 2005. Guidelines for DUS testing in cotton. In: Training manual on DUS test in cotton with reference to PPV & FR Legislation (K Rathinavel, S Manickram and M Sabesh, eds.), Coimbatore, Karnataka, India. pp. 60-64.

Singh RK and Choudhary BD. 1979. Biometrical methods in quantitative genetic analysis. Kalyani Publishers, New Delhi, India. 318p.

Sloan RC and Harkness SS. 2005. Hybrid lily cut flower research in Mississippi. In: Floriculture (Stephen Carver, ed). *SNA Research Conference* 51: 666-670.

Sloan RC and Harkness SS. 2006. Hybrid lily cultivar evaluation. *Mississippi Agriculture & Forestry Experiment Station Information Bulletin* 419: 267-275.

Smulders MJM, Bredemeijer G, Rus-Kortekaas W, Arens P and Vosman B. 1997. Use of short microsatellites from database sequences to generate polymorphisms among *Lycopersicon esculentum* cultivars and accessions of other *Lycopersicon* species. *Theoretical and Applied Genetics* 97: 264-272.

Syamal MM and Kumar A. 2002. Genetic variability and correlation studies in dahlia. *Journal of Ornamental Horticulture* 5(1): 40-42.

Swaroop K and Janakiram T. 2010. Divergence studies in gladiolus. *Indian Journal of Horticulture* 67: 352-355.

*Tamberg TG and Chirva ZF. 1978. Effect of climatic conditions on gladiolus growth and development. *Genetike Selektsii* 62(3): 115-121.

Tejaswini P, Madhavilatha S, Dhananjaya MV and Sudhagar S. 2012. Microsatellite markers in comparison with morphological characters for protection of plant cultivars in carnation. *Acta Horticulturae* 929: 453-458.

UPOV [International Union for the Protection of New Plant Varieties]. 2010. Guidelines for the conduct of tests for distinctness, uniformity and stability in *Lilium* (*Lilium* spp). Document TG/59/7. UPOV, Geneva.

Vijaylaxami M, Rao AM, Padmavatamma AS and Shanker AS. 2010. Evaluation and variability studies in tuberose (*Polianthes tuberosa* L.) single cultivars. *Journal of Ornamental Horticulture* 13(4): 251-256.

Vaidya P. 2006. Evaluation, selection and stability analysis of elite lines of chrysanthemum *(Dendranthema grandiflora* Tzvelev). Ph.D Thesis, Department of Floriculture and Landscape Architecture, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, (H.P.). 122.

Vanlalruati V, Mandal T and Pradhan T. 2016. Genetic variability, character association and path coefficient analysis in orchids (*Orchid* spp) of Mizoram, Sikkim & Darjeeling District of West Bengal for various quantitative traits. *Indian Journal of Agricultural Sciences* 85(3): 105-110.

*Vavilov NI. 1951. The origin, variation, immunity and breeding of cultivated plants. *Chronica Botanica* 1(6): 364.

Verty P, Prasad VM, Collis JP and Nazir M. 2017. Genetic variability for some quantitative characters in gladiolus (*Gladiolus grandiflorus* L.). *International Journal of Current Microbiology and Applied Sciences* 6(9): 750-754.

Wang JM, Ma SLY, Li WQ, Wang Q, Cao HY, Gu JH and Lu YM. 2016. Genetic variability and diversity of the main resources of lily assessed via phenotypic characters, pollen morphology and ISSR markers. *Genetics Molecular Research* 15(2): 1-14.

*Wouters TCAE and Booy G. 2000. Stability of esterases and total proteins during seed storage of perennial ryegrass (*Lolium perenne* L.) and their use for cultivar discrimination. *Euphytica* 111: 161–168.

*Yates F and Cochran WG. 1938. Analysis of groups of experiments. *Journal of Agriculture Research.* 28: 556-558.

Zahor AR. 2015. Analysis of genetic diversity among gladiolus genotypes. Ph.D Thesis, Department of Floriculture and landscaping, Punjab Agricultural University, Punjab, India. 144.

* Original not seen

APPENDIX-I

Mean monthly meteorological data of the study area at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) for the year 2016-18 with effect from September, 2016 to July, 2018

Month	Temperature (°C)			Relative Humidity (%)
	Maximum	Minimum	Mean	
September 2016	28.60	17.40	23.00	74.00
October 2016	27.40	11.60	19.50	55.00
November 2016	25.20	6.40	15.80	41.00
December 2016	21.90	4.20	13.10	47.00
January 2017	16.40	3.10	9.75	60.00
February 2017	21.30	6.10	13.70	49.00
March 2017	22.90	7.80	15.35	45.00
April 2017	29.30	13.20	21.25	44.00
May 2017	30.50	15.80	23.150	53.00
June 2017	28.70	17.90	23.30	68.00
July 2017	27.60	20.40	24.0	81.00
August 2017	26.70	20.10	23.4	82.00
September 2017	26.50	11.50	19.00	60.00
October 2017	27.30	10.8	19.05	60.00
November 2017	22.20	5.90	14.05	69.00
December 2017	20.40	4.50	12.45	60.00
January 2018	19.10	2.10	10.60	39.00
February 2018	20.20	5.30	12.75	38.00
March 2018	24.30	8.80	16.55	47.00
April 2018	27.10	12.60	19.85	51.00
May 2018	30.70	16.10	23.40	41.50
June 2018	29.70	18.90	24.30	62.37
July 2018	28.50	17.20	22.85	65.50

Source: Meteorological Observatory, Department of Environmental Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP) 173230

APPENDIX-II

Mean monthly meteorological data of the ICAR- Indian Agricultural Research Institute, Regional Station, Katrain, Kullu- Valley (HP)-175129 for the year 2016-18 with effect from October, 2016 to November, 2018

Months	Temperature °C			Relative Humidity (%)
	Maximum	Minimum	Mean	
October 2016	24.70	13.50	19.10	58.03
November 2016	20.50	10.50	15.50	53.43
December 2016	16.00	7.70	11.85	57.55
January 2017	13.90	3.40	8.65	83.65
February 2017	14.80	7.70	11.25	67.96
March 2017	15.23	8.03	11.63	74.71
April 2017	20.10	12.10	16.10	71.27
May 2017	25.16	14.61	19.89	62.55
June 2017	25.33	17.17	21.25	69.27
July 2017	27.13	20.93	24.03	80.45
August 2017	25.71	19.81	22.76	82.42
September 2017	25.19	18.52	21.86	81.36
October 2017	22.71	12.52	17.62	66.71
November 2017	18.07	9.50	13.79	68.53
December 2017	13.90	4.55	9.23	72.03
January 2018	13.65	3.90	8.78	64.77
February 2018	15.54	6.64	11.09	64.25
March 2018	20.39	9.77	15.08	63.32
April 2018	21.70	12.63	17.17	62.70
May 2018	25.55	14.81	20.18	58.42
June 2018	28.10	19.03	23.57	65.83
July 2018	26.23	20.61	23.42	84.10

Source: Meteorological Observatory, ICAR- Indian Agricultural Research Institute, Regional Station, Katrain, Kullu- Valley (HP)-175129

APPENDIX-III

Mean monthly meteorological data of the ICAR- Indian Agricultural Research Institute, Regional Station, Katrain, Kullu- Valley (HP)-175129 for the year 2015-16 with effect from September, 2015 to September, 2016

Month	Rainfall (mm)	Temperature (°C)			Relative Humidity (%)	Total Sunshine hours (Hours/min.)
		Maximum	Minimum	Mean		
September 2015	89.20	25.30	16.27	20.79	70.50	6.89
October 2015	26.00	22.71	12.52	17.62	66.71	7.28
November 2015	39.80	18.07	9.50	13.79	68.53	6.14
December 2015	6.30	13.90	4.55	9.23	72.03	5.50
January 2016	33.00	12.74	4.32	8.53	74.55	6.04
February 2016	70.20	15.69	6.10	10.90	72.58	7.08
March 2016	233.40	16.8	9.3	13.05	71.71	5.07
April 2016	71.60	21.7	12.4	17.05	64.30	6.38
May 2016	53.60	25.4	16.3	20.85	60.68	7.42
June 2016	45.80	27.7	19.6	23.65	69.90	6.87
July 2016	168.20	27.7	21.2	24.45	31.94	5.02
August 2016	270.40	25.4	20.3	22.85	89.00	4.00
September 2016	44.00	27.4	20.1	23.75	74.43	7.32

Source: Meteorological Observatory, ICAR- Indian Agricultural Research Institute, Regional Station, Katrain, Kullu- Valley (HP)-175129

APPENDIX – IV

A. Year wise analysis of variance for various parameters of *Lilium* genotypes at Nauni location

Sources of variance	df	Days taken for bulb sprout emergence		Per cent bulb sprouting (%)		Plant height (cm)		Number of leaves/plant		Leaf length (cm)		Leaf width (cm)		Stem length (cm)	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Genotypes	17	280.94	298.07	0.09	0.005	543.62	363.94	1101.09	983.10	13.92	13.41	0.89	1.75	543.62	363.94
Replications	2	1.51	0.68	0.06	0.005	2.32	0.80	2.77	10.51	0.01	0.17	0.01	0.08	2.31	0.80
Error	34	2.12	0.98	0.05	0.005	1.68	3.19	3.71	4.32	0.19	0.12	0.04	0.03	1.68	3.19

Sources of variance	df	Days to flower bud formation		Bud length (cm)		Days to first flower		Stem diameter (cm)		Size of the flower (cm)		Number of flowers/plant		Tepal length (cm)	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Genotypes	17	209.07	206.97	6.49	8.57	333.46	240.48	0.031	0.05	8.83	11.29	35.49	2.01	6.06	6.63
Replications	2	0.17	0.51	0.35	0.22	0.31	0.82	0.004	0.01	0.77	0.30	0.05	0.14	0.31	0.05
Error	34	0.43	0.22	0.23	0.12	0.36	0.79	0.002	0.002	0.50	0.38	0.80	0.15	0.39	0.10

Sources of variance	df	Tepal width (cm)		Duration of flowering (days)		Bulb diameter (cm)		Weight of bulb (g)		Number of bulblet/plant		Weight of bulblet (g)		Vase life (days)	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Genotypes	17	0.57	1.08	8.97	16.03	1.31	0.74	192.32	104.66	0.23	2.78	1.71	3.82	4.82	2.25
Replications	2	0.01	0.01	0.30	0.56	0.16	0.57	1.08	4.70	0.34	0.66	0.06	6.75	0.88	0.12
Error	34	0.05	0.02	1.31	1.51	0.22	0.14	1.82	3.14	0.03	0.27	0.07	0.59	0.32	0.83

Sources of variance	df	Stem strength (%)						Grading of cut flowers (%)									
		'A' grade		'B' grade		'C' grade		Grade '1'		Grade '2'		Grade '3'		Grade '4'		Grade '5'	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Genotype	17	378.90	300.61	491.50	611.28	119.05	23.91	744.24	986.36	1003.74	874.86	267.09	669.14	1029.03	681.80	5.56	1237.18
Replications	2	8.80	0.02	0.23	0.51	0.07	0.47	7.45	6.56	22.43	0.03	22.20	0.06	1.86	0.004	326.57	0.03
Error	34	8.74	0.47	0.57	0.21	0.26	10.06	12.13	13.76	26.16	0.09	14.38	0.07	11.66	0.13	3.59	0.10

APPENDIX – V

B. Year wise analysis of variance for various parameters of *Lilium* genotypes under Katrain location

Sources of variance	df	Mean sum of square													
		Days taken for bulb sprout emergence		Per cent bulb sprouting (%)		Plant height (cm)		Number of leaves/plant		Leaf length (cm)		Leaf width (cm)		Stem length (cm)	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Genotypes		429.10	393.72	0.005	0.005	835.60	757.77	1053.98	1222.32	24.41	22.12	1.00	1.42	835.60	757.77
Replications		0.97	1.64	0.005	0.005	3.27	0.71	7.11	1.09	0.03	0.02	0.004	0.00	3.29	0.73
Error		0.79	0.45	0.005	0.005	2.59	0.50	2.78	0.72	0.04	0.06	0.005	0.002	2.59	0.50

Sources of variance	df	Mean sum of square													
		Days to flower bud formation		Bud length (cm)		Days to first flower		Stem diameter (cm)		Size of the flower (cm)		Number of flowers/plant		Tepal length (cm)	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Genotypes		193.26	180.19	7.01	138.32	289.66	331.84	0.00	0.04	8.63	10.33	18.87	16.89	6.39	7.28
Replications		-0.00	1.63	0.002	0.05	0.07	2.09	0.04	0.00	0.00	0.11	0.002	0.02	0.002	0.07
Error		1.25	0.93	0.002	0.001	0.78	0.58	0.00	0.001	0.04	0.06	0.04	0.01	0.005	0.01

Sources of variance	df	Mean sum of square													
		Tepal width (cm)		Duration of flowering (days)		Bulb diameter (cm)		Weight of bulb (g)		Number of bulblet/plant		Weight of bulblet (g)		Vase life (days)	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Genotypes		0.50	10.31	74.07	76.63	3.25	2.10	1387.67	1365.52	25.61	19.47	107.65	185.25	3.14	5.49
Replications		0.01	0.001	0.17	0.04	0.13	0.30	0.97	0.29	0.004	0.14	1.64	1.02	0.004	0.08
Error		0.01	0.006	0.22	0.36	0.23	0.11	0.92	0.35	0.04	0.10	2.15	0.29	0.04	0.01

Sources of variance	df	Mean sum of square															
		Stem strength (%)						Grading of cut flowers (%)									
		'A' grade		'B' grade		'C' grade		Grade '1'		Grade '2'		Grade '3'		Grade '4'		Grade '5'	
		2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Genotype		457.47	817.63	469.63	635.95	268.56	566.72	457.47	817.63	381.18	471.13	485.84	215.14	1186.47	440.944	1220.06	1237.18
Replications		0.38	0.24	0.28	0.36	1.63	2.55	0.38	0.24	46.29	2.11	1.85	0.34	22.67	0.56	90.68	0.03
Error		0.85	0.22	0.28	0.74	0.64	1.29	0.85	0.22	26.69	1.43	1.83	0.28	17.78	0.23	490.95	0.10

APPENDIX – VI

C. Pooled analysis of variance for various parameters of *Lilium* genotypes

Sources of variance	df	Mean sum of square											
		Days taken for bulb sprout emergence	Per cent bulb sprouting (%)	Plant height (cm)	Number of leaves/plant	Leaf length (cm)	Leaf width (cm)	Stem length (cm)	Days to flower bud formation	Bud length (cm)	Days to first flower	Stem diameter (cm)	Size of the flower (cm)
Replications	2	4.21	0.03	1.73	5.10	0.06	0.04	1.51	0.48	0.04	0.72	0.01	0.28
Environments (E)	3	280,008.75	0.21	44.56	514.370	2.06	0.76	48.91	11,950.88	14.97	26,286.90	0.61	6.74
Genotypes (G)	17	1104.66	0.03	1,915.39	3,631.52	63.16	3.61	1,915.37	720.01	23.26	995.36	0.11	38.14
E ×G	51	91.49	0.02	36.16	192.87	3.57	0.28	35.91	23.17	2.45	66.70	0.02	1.70
Error	142	1.01	0.02	1.64	3.00	0.10	0.02	1.64	0.70	0.07	0.64	0.001	0.18

Sources of variance	df	Mean sum of square											
		Number of flowers/plant	Tepal length (cm)	Tepal width (cm)	Duration of flowering (days)	Bulb diameter (cm)	Weight of bulb (g)	Number of bulblets/plant	Weight of bulblet (g)	Vase life (days)	Stem strength (%)		
											'A'grade	'B'grade	'C'grade
Replications	2	0.01	0.01	0.02	1.70	0.48	1.70	0.003	0.20	0.23	2.61	11.41	2.17
Environments (E)	3	121.99	21.11	3.63	483.90	31.10	20,894.81	119.90	6.45	43.80	1,588.92	1,742.00	1,973.72
Genotypes (G)	17	29.20	20.84	1.65	120.17	4.67	1,559.80	27.49	3.78	10.70	1,005.30	1,125.14	345.56
E ×G	51	5.42	2.11	0.27	32.64	0.93	413.94	6.70	1.53	1.67	316.44	469.68	184.66
Error	142	0.13	0.12	0.02	0.75	0.17	1.43	0.10	0.11	0.30	2.56	26.29	2.83

Sources of variance	df	Mean sum of square				
		Grading of cut flowers (%)				
		Grade '1'	Grade '2'	Grade '3'	Grade '4'	Grade '5'
Replications	2	3.36	26.33	19.68	7.82	27.26
Environments (E)	3	180.05	162.94	15.37	484.31	1,097.13
Genotypes (G)	17	2,863.17	1,672.38	874.86	2,363.18	1,674.68
E ×G	51	474.88	467.00	166.78	428.20	336.80
Error	142	3.07	13.58	7.12	7.36	241.65

APPENDIX - VII

Analysis of variance for stability parameters in 18 *Lilium* genotypes

Sources of variance	df	Mean sum of square											
		Days taken for bulb sprout emergence	Per cent bulb sprouting (%)	Plant height (cm)	Number of leaves/plant	Leaf length (cm)	Leaf width (cm)	Stem length (cm)	Days to flower bud formation	Bud length (cm)	Days to first flower	Stem diameter (cm)	Size of the flower (cm)
Environments (E)	3	93,336.33	26.08	7.98	194.80	0.69	0.16	7.98	3,983.62	5.41	8,762.22	0.20	1.21
Genotypes (G)	17	368.23	4.08	691.99	1,211.14	20.93	1.34	691.99	239.99	7.76	331.77	0.04	8.93
G × E	51	30.49	2.99	47.22	80.79	1.23	0.12	47.22	7.72	0.77	22.24	0.01	1.36
E + (G × E)	54	5,214.15	4.27	45.04	87.12	1.20	0.12	45.04	228.61	1.03	507.79	0.02	1.36
E (Linear)	1	280,008.99	78.24	23.94	584.41	2.06	0.48	23.94	11,950.84	16.24	26,286.67	0.61	3.63
E × G (Linear)	17	88.90	8.09	28.96	173.83	2.41	0.11	28.96	19.54	1.11	59.62	0.01	2.15
Pooled deviation	36	1.22	0.41	53.22	32.36	0.61	0.11	53.22	1.72	0.57	3.35	0.003	0.92
Pooled error	136	1.05	5.94	1.99	2.88	0.10	0.02	1.99	0.71	0.09	0.63	0.001	0.24

Sources of variance	df	Mean sum of square											
		Number of flowers/plant	Tepal length (cm)	Tepal width (cm)	Duration of flowering (days)	Bulb diameter (cm)	Weight of bulb (g)	Number of bulblets/plant	Weight of bulblet (g)	Vase life (days)	Stem strength (%)		
											‘A’grade	‘B’grade	‘C’grade
Environments (E)	3	66.85	8.61	1.52	251.34	12.15	15,392.12	65.85	701.01	14.60	2,024.00	580.67	657.91
Genotypes (G)	17	16.87	6.80	0.63	26.51	1.27	513.25	8.55	47.90	2.39	647.61	375.05	115.19
G × E	51	2.52	0.66	0.10	10.69	0.40	156.27	2.49	17.19	0.95	278.26	156.56	61.55
E + (G × E)	54	6.09	1.11	0.17	24.06	1.05	1,002.70	6.01	55.18	1.71	375.25	180.12	94.69
E (Linear)	1	200.54	25.84	4.55	754.02	36.44	46,176.37	197.56	2,103.03	43.80	6,072.00	1,742.01	1,973.72
E × G (Linear)	17	6.16	1.17	0.15	20.85	0.58	383.83	6.68	42.01	1.54	433.23	215.11	83.36
Pooled deviation	36	0.66	0.39	0.06	5.29	0.29	40.12	0.38	4.51	0.62	189.63	120.21	47.84
Pooled error	136	0.25	0.13	0.02	0.85	0.18	0.80	0.11	0.78	0.30	28.46	27.09	2.93

Sources of variance	df	Mean sum of square			
		Grading of cut flowers (%)			
		Grade ‘1’	Grade ‘2’	Grade ‘3’	Grade ‘4’
Environments (E)	3	137.87	54.31	25.26	161.44
Genotypes (G)	17	2,222.67	557.46	337.01	787.73
G × E	51	355.16	155.67	73.63	142.73
E + (G × E)	54	343.09	150.04	70.95	143.77
E (Linear)	1	413.61	162.94	75.79	484.31
E × G (Linear)	17	268.85	130.21	76.23	99.77
Pooled deviation	36	376.18	159.04	68.32	155.09
Pooled error	136	8.27	13.53	4.14	7.44

Dr Y S Parmar University of Horticulture and Forestry
Nauni, Solan (HP) 173 230
Department of Floriculture and Landscape Architecture

Title of Thesis	:	**"Genetic studies and DUS characterization in *Lilium*"**
Name of the student	:	Sangeeta Kumari
Admission number	:	H-2015-05-D
Major advisor	:	Dr S R Dhiman
Major field	:	Floriculture and Landscape Architecture
Minor field	:	Genetics and Plant Breeding
Degree awarded	:	PhD in Floriculture and Landscape Architecture
Year of award of degree	:	2019
No. of pages in thesis	:	241+vii
No. of words in abstract	:	405

ABSTRACT

The present investigation entitled "Genetic studies and DUS characterization in *Lilium*" was carried out at experimental farm of Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) and ICAR-IARI, RS, Katrain, Kullu during 2016 to 2018. The experiment was laid out in a RBD with three replications. Eighteen diverse genotypes of *Lilium* were evaluated for various growth and flowering parameters to assess the extent of variability, heritability, genetic divergence, stability for various traits and the morphological characterization of these genotypes. Wide and significant variations for all the parameters were observed among the different *Lilium* genotypes. Katrain location outperformed Nauni location in performance of almost all the vegetative, flowering and bulb parameters except days taken for bulb sprout emergence. With regards to the performance of genotypes, 'Best Seller' performed well in case of earliness to flowering, 'Yelloween' with respect to plant height and stem length, 'Eyeliner' and 'Prato' produced maximum number of flower per plant. For good flower quality in terms of stem sturdiness and stem length grades, 'Eyeliner' 'Prato', 'Yelloween', 'Best Seller' and 'Brunello' performed well. Characters such as number of bulblet per plant, number of leaves/plant and number of flowers/plant recorded high GCV. High heritability coupled with moderate genetic advance recorded for number of leaves/plant, plant height and stem length. Moderate heritability with highest genetic gain recorded for number of bulblet/plant followed by traits such as number of leaves per plant, leaf width, number of flowers/plant and weight of bulblet *etc.* Significant positive correlation of yield parameter recorded with plant height, number of leaves per plant, leaf length, stem length, stem diameter, duration of flowering, bulb diameter and weight of bulb *etc.* Maximum positive direct effect of days to flower bud formation, number of leaves per plant, bulb diameter, weight of bulb, leaf length, stem length *etc.*, on number of flowers per plant revealed the true relationship between them. Highest inter cluster distances recorded between cluster-III & cluster-IV, cluster-II & cluster-IV and cluster-I and cluster-IV under Nauni condition, Katrain condition and their pooled analysis, respectively indicating maximum diversification among these clusters. In terms of stability for different parameters among different genotypes, 'Eyeliner' exhibited stability for most of the desirable parameters followed by 'Salmon Classic', 'Yelloween', 'Pavia' and 'Brunello' Morphological characterization of these genotypes was done for 40 characters and the genotypes were then categorized accordingly and the results were summarized in the form of draft guidelines.

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

Countersigned

Professor and Head
Department of Floriculture and Landscape Architecture
Dr YS Parmar UHF, Nauni, Solan (HP)-173 230

BRIEF BIO-DATA

Name : Sangeeta Kumari

Father's Name : Sh. Shiv Kumar

Date of Birth : 17.03.1991

Sex : Female

Marital Status : Unmarried

Nationality : Indian

Education Qualifications:

Certificate/Degree	Class/Grade	Board/University	Year
10	First	HP Board, Dharmshala	2006
10+2	First	HP Board, Dharmshala	2009
B.Sc. Horticulture	First	Dr. Y.S.Parmar UHF, Nauni, Solan (173 230) H.P.	2013
M.Sc. Floriculture and Landscape Architecture	First	Dr. Y.S.Parmar UHF, Nauni, Solan (173 230) H.P.	2015

Whether sponsored by some state/ Central Govt / Univ / SAARC : No

Scholarship/ Stipend/ Fellowship any other assistance received during study period **:** Ph.D Merit scholarship

(Sangeeta Kumari)