STUDIES ON CHARACTER ASSOCIATION AND PATH ANALYSIS FOR YIELD AND QUALITY PARAMETERS IN STOCK (*Matthiola incana* L.) GENOTYPES

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SHIVAMOGGA

2023

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Thesis submitted to the

KELADI SHIVAPPA NAYAKA
UNIVERSITY OF AGRICULTURAL AND HORTICULTURAL SCIENCES
SHIVAMOGGA

In partial fulfillment of the requirements
for the award of the degree of

Master of Science (Horticulture)

in

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE

Mudigere **October, 2023**

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE
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CERTIFICATE

This is to certify that the thesis entitled **'STUDIES ON CHARACTER ASSOCIATION AND PATH ANALYSIS FOR YIELD AND QUALITY PARAMETERS IN STOCK (*Matthiola incana* L.) GENOTYPES'** submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE) in FLORICULTURE AND LANDSCAPE ARCHITECTURE** to the College of Horticulture, Mudigere, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga is a bonafide record of research work carried out by **Mr. Sanketh, M. R., ID NO. MH2TBA0282** (sankethmr999@gmail.com) during the period of study in this university under my guidance and supervision and no part of this thesis has previously formed the basis for the award of any other degree, diploma, associateship, fellowship or any other similar titles.

Mudigere
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ACKNOWLEDGEMENT

Words cannot express the love and gratitude that is in my heart, but this is my humble attempt...

This thesis is the culmination of my journey of M.Sc. which was just like climbing a high peak step by step accompanied with encouragement, hardship, trust and frustration. When I found myself at the top experiencing the feeling of fulfilment, I realized though only my name appears on the cover of this dissertation a great many people including my teachers, family members, friends and well-wishers have contributed to accomplish this huge task.

Let me first express my solemn reverence to the Supreme power of the universe "Almighty God" for bestowing me with patience, courage and faith to reach this important milestone of my academic career.

With an overwhelming sense of legitimate pride and genuine obligation, I seize this rare opportunity to express my deep sense of gratitude, indebtedness and personal regards to respected and acuminous teacher and chairman of my advisory committee ***Dr. Hemla Naik, B.*** *Professor (Higher Administrative Grade) cum Director of Education, KSN University of Agricultural and Horticultural Sciences, Shivamogga for his sensible and freehearted guidance, keen interest, discreet approach and perpetual encouragement during the entire course of investigation.*

Further wish to express my bountiful appreciation and thanks for the pains he has taken for critically going through the manuscripts and for the assistance rendered during the preparation of the thesis.

I deem it my privilege in expressing my fidelity to the members of my advisory committee, ***Dr. Chandrahekhar, S. Y.*** *Professor (Horticulture) and Station Head, Agricultural and Horticultural Research Station, Madikeri,* ***Dr. Kantharaj, Y.*** *Assistant professor, Department of Post Harvest Technology and* ***Dr. Ganapathi, M.*** *Assistant professor, Department of Crop Physiology, College of Agriculture, Shivamogga for their transcendent suggestions, valuable comments during the course of investigation and affectionate counselling that positively inspired me to embellish the study.*

I owe my flow of thanks to ***Dr. Narayan S Mavarkar,*** *the Dean (Hort.) and* ***Dr. Srinivasa, V.*** *Professor and Head, Department of FLA,* ***Dr. Nataraj, S. K.*** *and* ***Dr. Hemanth Kumar,*** *Assistant professor, Department of FLA,* ***Dr. Suchitra Kumari, M. H.*** *and* ***Dr. Hanumantharaya, L.*** *Professors of Entomology department for their worthful suggestions and timely help during the study.*

I am equally thankful to ***Dr. Subashini*** *and* ***Dr. Chandana, B. C.*** *for helping me in carrying out analysis with their support and encouragement.*

I would like to express my heart-felt gratitude to my parents ***Mr. Raju, M. S., Mrs. Lakshmidevi****, my brother* ***Mr. Indudhara, M. R****. and my friends* ***Sushma, Rajashree and Madhu*** *for their moral support.*

I extend my gratitude to my friend ***Abhishek, J. K.*** *who helped me in every step of my research journey.*

I am also thankful to my beloved seniors ***Pushpa, Kavya, Puneeth, Arpitha, Indhumathi, Namratha, Praveen, Lakshmikanth, Halesh, Sharath, Nikhil, Raghavendra, Arkesh and others*** *and lab assistant* ***Rukmini*** *for timely support and co-operation helped throughout the study.*

My sincere thanks to library staffs ***Praveen anna, Manu anna, Arpitha akka*** *for their constant help and support during my M. Sc. programme.*

I would like to thank zerox shop ***Ganan anna*** *for his huge patience and help during my research program.*

I value and treasure the company and support of my beloved floricos ***Kamalashree, Yashaswini, Jyothi Vyshnavi, Abhishek, Shivani and Ayesha*** *and friends* ***Vaishnavi, Yogi, Omkar, Anand, Yoshitha, Lekhana, Rakshitha, Rajeshwari, Lekhana, Chandana, Pradeep, Vinay, Sourab, Lathamani, Supriya, Rajyalakshmi, Manjushree, Rashmi, Yeshwanth, Prajwal and other.*** *I also thank my juniors* ***Shashank, Rohith, Madhu, Muruli, Manja. Pavithra, Vismitha, Mandhira, Bhumika and others.***

I avail this opportunity to express my heartfelt thanks to ***Vishala akka, Giriyappanna, Vinay, Gavi, Ratan, Kamalamma*** *for their needful help during the research programme.*

Finally, I extend my sincere thanks to the Department of Floriculture and Landscape Architecture, College of Horticulture Mudigere, for giving me an opportunity to complete my higher education M. Sc. (Horticulture) in Floriculture and Landscape Architecture. I would also like to thank the teaching and non-teaching staffs of College of Horticulture, Mudigere, under KSN UAHS Shivamogga, who helped me to accomplish my research work.

Mudigere
October, 2023

(Sanketh, M. R.)

Studies on Character Association and Path Analysis for Yield and Quality Parameters in Stock (*Matthiola incana* L.) Genotypes

(Sanketh, M. R.)

ABSTRACT

The investigation entitled "Studies on character association and path analysis for yield and quality parameters in stock (*Matthiola incana* L.) genotypes" was conducted at the College of Horticulture, Mudigere under KSNUAHS, Shivamogga, 2022-23. The experiment consisted of 11 genotypes, which were replicated thrice in a Randomized Complete Block Design (RCBD). The result revealed that the genotype Stock Katz Blue recorded the maximum plant height (72.00 cm) and internodal length (2.99 cm). The maximum number of leaves and leaf area was observed in the genotype Stock Katz Ruby (70.73 and 3199.94 cm^2/plant, respectively). The minimum days taken to flower stalk emergence, first visible flower and harvest (43.60, 55.40 and 74.40, respectively) were recorded in Stock Katz Ruby. The maximum stalk length (93.93 cm), florets per stalk (32.07) and vase life (13.47 days) were recorded in Stock Katz Blue. The genotype Arrow White recorded the maximum number of cut flowers per sq. m (25.00) and number of cut flowers per 1000 sq. m (20000). Correlation studies revealed that plant height, leaf area and number of florets per stalk with stalk length; stalk girth with days taken for stalk emergence showed a significant positive correlation, whereas plant height, leaf area, intermodal length and stalk length showed significant negative correlation with days taken for stalk emergence. The number of cut flowers per sq. m exhibited highly positive direct effect of path coefficient analysis with the plant height, leaf area, number of florets per stalk and stalk girth. This suggests that these are the potential traits in improving the stalk quality and marketable flower yield.

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ಸ್ಟಾಕ್ (ಮ್ಯಾಥಿಯೋಲಾ ಇಂಕಾನಾ ಎಲ್.) ತಳಿಗಳಲ್ಲಿ ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ನಿಯತಾಂಕಗಳ ಲಕ್ಷಣ ಜೊತೆಗಾರಿಕೆ ಮತ್ತು ಮಾರ್ಗ ಗಣಾಂಕದ ಅಧ್ಯಯನ

(ಸಂಕೇತ್, ಎಂ. ಆರ್.)

ಸಾರಾಂಶ

ಸ್ಟಾಕ್ (*ಮ್ಯಾಥಿಯೋಲಾ ಇಂಕಾನಾ* ಎಲ್.) ತಳಿಗಳಲ್ಲಿ ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ನಿಯತಾಂಕಗಳ ಲಕ್ಷಣ ಜೊತೆಗಾರಿಕೆ ಮತ್ತು ಮಾರ್ಗ ಗಣಾಂಕದ ಅಧ್ಯಯನ ಎಂಬ ಶೀರ್ಷಿಕೆಯುಳ್ಳ ತನಿಖೆಯನ್ನು ೨೦೨೨-೨೩ ರಲ್ಲಿ ಕೆಳದಿ ಶಿವಪ್ಪ ನಾಯಕ ಕೃಷಿ ಮತ್ತು ತೋಟಗಾರಿಕೆ ವಿಜ್ಞಾನಗಳ ವಿಶ್ವವಿದ್ಯಾನಿಲಯದ ಅಡಿಯಲ್ಲಿ ಮೂಡಿಗೆರೆಯ ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯದಲ್ಲಿ ನಡೆಸಲಾಯಿತು. ಪ್ರಯೋಗವು ೧೧ ತಳಿಗಳನ್ನು ಒಳಗೊಂಡಿದ್ದು, ಯಾದೃಚ್ಛಿಕ ಸಂಪೂರ್ಣ ಖಂಡ ವಿನ್ಯಾಸದಲ್ಲಿ ಮೂರು ಬಾರಿ ಪುನರಾವರ್ತಿಸಲಾಯಿತು. ಸ್ಟಾಕ್ ಕಟ್ಜ್ ಬ್ಲೂ ತಳಿಯು ಗರಿಷ್ಠ ಸಸ್ಯ ಎತ್ತರ (೭೨.೦೦ ಸೆಂ. ಮೀ.) ಗೆಣ್ಣು ನಡುವಣ ಉದ್ದ (೨.೯೯ ಸೆಂ. ಮೀ.)ವನ್ನು ದಾಖಲಿಸಿದೆ ಎಂಬ ಫಲಿತಾಂಶವು ಬಹಿರಂಗವಾಗಿದೆ. ಸ್ಟಾಕ್ ಕಾಟ್ಜ್ ರೂಬಿ ತಳಿಯಲ್ಲಿ ಪ್ರತಿ ಸಸ್ಯಕ್ಕೆ ಎಲೆಗಳ ಸಂಖ್ಯೆ ಮತ್ತು ಎಲೆಯ ವಿಸ್ತೀರ್ಣವು (ಕ್ರಮವಾಗಿ ೭೦.೭೩ ಮತ್ತು ೩೮೯.೩೪ ಚದರ ಸೆಂ. ಮೀ) ಗರಿಷ್ಠವಾಗಿ ಗಮನಿಸಲಾಗಿದೆ. ಹೂವಿನ ಕಾಂಡ ಹೊರಹೊಮ್ಮಿಕೆಗೆ, ಮೊದಲ ಹೂವು ಹರಡುವಿಕೆ ಮತ್ತು ಹೂ ಕಾಂಡದ ಕೊಯ್ಲಿಗೆ (ಕ್ರಮವಾಗಿ ೪೩.೬೦, ೫೫.೪೦ ಮತ್ತು ೭೪.೪೦) ಸ್ಟಾಕ್ ಕಟ್ಜ್ ರೂಬಿ ತಳಿಯಲ್ಲಿ ಕನಿಷ್ಟ ದಿನಗಳು ದಾಖಲಾಗಿದೆ. ಸ್ಟಾಕ್ ಕಟ್ಜ್ ಬ್ಲೂ ತಳಿಯಲ್ಲಿ ಗರಿಷ್ಠ ಹೂ ಕಾಂಡದ ಉದ್ದ (೯೩.೯೩ ಸೆಂ. ಮೀ), ಪ್ರತಿಕಾಂಡಕ್ಕೆ ಹೂಗಳ ಸಂಖ್ಯೆ (೩೨.೦೭) ಮತ್ತು ಹ್ಯೂದಾನಿಯಲ್ಲಿ ಜೀವಿತಾವಧಿ (೧೩.೪೭ ದಿನಗಳು) ದಾಖಲಾಗಿವೆ. ಆರೋ ವೈಟ್ ತಳಿಯು ಪ್ರತಿ ಚದರ ಮೀ. ಗೆ (೨೫.೦೦) ಮತ್ತು ೧೦೦೦ ಚದರ ಮೀ. ಗೆ (೨೦೦೦೦) ಗರಿಷ್ಠ ಕತ್ತರಿಸಿದ ಹೂಗಳನ್ನು ದಾಖಲಿಸಿದೆ. ಸಹಯೋಗದ ಅಧ್ಯಯನದಲ್ಲಿ ಬಹಿರಂಗವಾಗಿರುವುದು ಏನೆಂದರೆ ಸಸ್ಯದ ಉದ್ದ, ಪ್ರತಿ ಸಸ್ಯಕ್ಕೆ ಎಲೆಯ ವಿಸ್ತೀರ್ಣ ಮತ್ತು ಪ್ರತಿ ಕಾಂಡಕ್ಕೆ ಹೂಗಳ ಸಂಖ್ಯೆಯು ಸಸ್ಯದ ಎತ್ತರದೊಂದಿಗೆ; ಹೂ ಕಾಂಡದ ಸುತ್ತಳತೆಯು ಹೂ ಕಾಂಡವು ಹೊರಹೊಮ್ಮಲು ತೆಗೆದುಕೊಂಡ ದಿನಗಳ ಸಂಖ್ಯೆಯೊಂದಿಗೆ ಗಮನಾರ್ಹ ಧನಾತ್ಮಕ ಸಹಯೋಗವನ್ನು ಹೊಂದಿದ್ದರೆ ಸಸ್ಯದ ಎತ್ತರ, ಪ್ರತಿ ಸಸ್ಯಕ್ಕೆ ಎಲೆಯ ವಿಸ್ತೀರ್ಣ, ಗೆಣ್ಣು ನಡುವಣ ಉದ್ದ ಮತ್ತು ಹೂ ಕಾಂಡ ಉದ್ದವು ಹೂ ಕಾಂಡವು ಹೊರಹೊಮ್ಮಲು ತೆಗೆದುಕೊಂಡ ದಿನಗಳ ಸಂಖ್ಯೆಯೊಂದಿಗೆ ಗಮನಾರ್ಹ ಋಣಾತ್ಮಕ ಸಹಯೋಗವನ್ನು ಹೊಂದಿದೆ. ಸಸ್ಯದ ಎತ್ತರ, ಪ್ರತಿ ಸಸ್ಯಕ್ಕೆ ಎಲೆಯ ವಿಸ್ತೀರ್ಣ, ಪ್ರತಿ ಕಾಂಡಕ್ಕೆ ಹೂಗಳ ಸಂಖ್ಯೆ ಮತ್ತು ಹೂ ಕಾಂಡದ ಸುತ್ತಳತೆಯು ಪ್ರತಿ ಚದರ ಮೀ. ಗೆ ಹೂ ಕಾಂಡದ ಇಳುವರಿಯೊಂದಿಗೆ ನೇರ ಸಕಾರಾತ್ಮಕ ಪರಿಣಾಮ ಬೀರಿರುವುದು ಕಂಡುಬರುತ್ತದೆ. ಕಾಂಡದ ಗುಣಮಟ್ಟ ಮತ್ತು ಇಳುವರಿಯನ್ನು ಉತ್ತಮಗೊಳಿಸುವಲ್ಲಿ ಇವು ಸಂಭಾವ್ಯ ಲಕ್ಷಣಗಳಾಗಿವೆ ಎಂದು ಇದು ಸೂಚಿಸುತ್ತದೆ.

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ಪುಷ್ಪಕೃಷಿ ಮತ್ತು ಉದ್ಯಾನ ವಿನ್ಯಾಸ

ಕೆಳದಿ ಶಿವಪ್ಪ ನಾಯಕ ಕೃಷಿ ಮತ್ತು ತೋಟಗಾರಿಕೆ

ವಿಜ್ಞಾನಗಳ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ, ಶಿವಮೊಗ್ಗ,

ಅಕ್ಟೋಬರ್, ೨೦೨೩

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INTRODUCTION

I INTRODUCTION

The flowers are meant to symbolize love, purity, beauty as well as peace and prosperity. They provide a visual feast to our eyes. Flowers are intricately connected with social beliefs and no social function is complete without their use, especially in India, where it is a common belief that flowers are aligned with man from birth to death. Flowering plants aim to create a more natural atmosphere by reducing pollution.

Floriculture is increasingly regarded as a viable diversification from the traditional field crops d ue to an increase per in unit returns and the increasing habit of 'saying it with flowers' during all occasions. Flowers and flowering plants have been associated with mankind since immemorial, as they have been used for religious offerings and other social ceremonies. At the same time, commercial floriculture development is associated with urbanization and accelerated income level. Flowers are regarded as symbol of beauty, love and tranquility; they form the soul of the garden and convey the message of nature. Flowers are extensively used to convey the message of love and memorials to departed souls. Besides their aesthetic and religious value, flowers are also crucial important for economic use. One such flower, outvaluing all utilities of the world through its magnificent beauty, varying colours and fragrance is the Gilly flower 'Stock' (Syamel, 2014).

Stock or Gilly flower (*Matthiola incana* L.) is an annual or biennial plant flowering in terminal clusters. It is native to Southern Europe and is naturalized in the western part of the Mediterranean region and belongs to the cabbage family Brassicaceae with the chromosomal number 2n = 14 (Irani *et al.,* 2016). It exists in both single and double forms and is valued for fragrant flowers that can be used as fresh or dried cut flowers. Stocks are a most valuable race of garden plants for they are easy to grow and can be in bloom during the greater part of the year. They are excellent pot plants for the greenhouse in Winter and Spring and provide good cut flowers. Flowers are well arranged on a long column and the colours are variable from white to rose, crimson, purple, yellow, mauve, pink, etc. Seeds of stock are aphrodisiac, bitter, diuretic, expectorant, stimulant and are used as tonic. An infusion has been used in the treatment of cancer and when mixed with wine, it has been used as an antidote to poisonous bites. The highly fragrant flowers are used as a garnish, especially with sweet desserts.

Stock, earlier known as *Leucoium album* or *Viola alba,* was later renamed as *Matthiola* after Peter Andrew Matthioli, an Italian physician and botanist. This was being grown by the ancient Greeks and was liked for its fragrance. In the wild state, stocks are found in the Mediterranean, Egypt, South Europe and in South Africa and two species, *Matthiola incana* and *M. sinuate* are among the rare British natives. This has now been naturalized in many parts of the world particularly the southern parts of

California. Both single and double forms were grown in Europe from the 10th century onwards and became popular garden flowers. Sowing stock seed mixed with radish seeds in order to distract flea beetle was a common practice. British settlers spread stock from Europe to different parts of the world and presently two species are mainly described *Matthiola annua* and *Matthiola incana*.

The different kinds vary in height from 30 to 90 cm and all have narrow, oblong shaped leaves, which are 3 to 8 cm in length and are usually glaucous. But in varieties known as Wallflower-leaved stocks, leaves are green. The varieties usually cultivated are of *Matthiola incana* L.

The single flowers of all stocks are cruciform *i.e.,* four petals in the shape of a cross, but the double-flowered kinds are the most popular ones. These have been evolved through the changing of the stamens into petals. Single flowered stocks have four petals on four stamens and a pistil having 30 to 60 ovules, whereas double flowers have 40 to 70 petals and are male and female sterile. According to the production of single and double flowers, stock plants are of following types (Singh, 2006).

1. Singles which produce only single flowers
2. Singles producing 75 per cent single and 25 per cent double flowers
3. Eversporting singles that produce 54 to 56 per cent double flowers and 44 to 46 per cent single flowers
4. Double flowered stocks that are double and do not have the ability to produce seeds due to complete sterility, *i.e.,* without male and female reproductive organs.

Stock requires full to light shade and is frost tolerant. Temperature plays an important role on growth and flowering of stock. The crop should be grown at the night temperature of 16°C until ten fully developed leaves are produced and then temperature should be maintained at 10°C for at least three weeks and can be raised again to 16°C. Stock will not flower if it is to exposed more than 6 hours/day to 18°C. For obtaining better quality flowers, the night temperature should be 2-4°C. High temperature encouraged formation of more leaves before flower Initiation. Flowering is also influenced by the duration of low temperatures and cultivars. Early cultivars require fewer days than late ones. It is observed that the shortest duration of 10 days is required for 100 per cent flowering by early cultivars, while 20 days are required by medium and 40 days were required for late flowering ones (Singh, 2006).

Stocks are propagated through seeds. Around 18 to 24°C temperature is required for germination. Sowing of seeds is done in well prepared nursery beds or pots from mid-September to mid-October in plain and February to March in hilly areas.

Stock are attacked by diseases like damping off (*Pythium debaryanum*), grey mould (*Botrytis cinerea*), wilt (*Fusarium oxysporium*), leaf spot (*Alternaria raphani*), downy mildew (*Pernospora parascitica*), white rust (*Albigo candida*), mosaic virus, and pests like aphid (*Aphis mathiolae*), diamond back moth (*Plutella maculupennis*), flea beetle, springtails (*Bourletiella hortensis*).

Stock is grown both for bedding purpose and cut flower production. Yield of stock ranges from 80 to 100 quality flower spikes per m² (Singh, 2006).

The performance of any crop or genotype largely depends on the interaction between the genotype and the environment. The phenotypic expression of a character is mainly governed by the genetic make-up of the plant, the environment in which it is grown and the interaction between the genotype and environment. As a result, genotypes which perform well in one region may not perform same in other regions of varying climatic conditions. Genotype environment interactions pose a major problem in developing new genotypes and choosing suitable genotype for specific location, making it difficult to identify the most desirable genotypes. The performance of genotypes depends on climatic conditions under which they are grown. During the introduction of new germplasm from different agroclimatic conditions, it becomes important to carry out evaluation studies in order to identify suitable genotypes for commercial cultivation. Therefore, varietal evaluation becomes necessary to identify the suitable genotype for specific a region.

Flower yield is a complex character controlled by a large number of contributing characters and their interactions. A study of correlation between different quantitative characters provides the association that could be effectively exploited to formulate selection strategies for improving yield components. It is essential to know the degree of mutual association (correlation) prevailing between yield and its component characters, which forms a basis for selecting the desirable genotypes. However, the correlation is between the yield and its component characters themselves. The analysis of inter componential correlation is very essential to expose the direct and indirect contribution of each of the components which is determined by path coefficient analysis (Namratha, 2021).

Keeping the above points in view, the present investigation on “Studies on character association and path analysis for yield and quality parameters in Stock (*Matthiola incana* L.) genotypes” was carried out with the following objectives.

1. To study the correlation and path analysis in Stock genotypes for morphological and yield parameters.
2. To assess the correlation and path analysis in Stock genotypes for quality parameters.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Stock is becoming one of the most highly ranked cut flowers in the international market due to its rose like flowers, fragrance and excellent post-harvest life. It gained importance on account of a variety of cultivars developed with respect to many traits like uniform flowering throughout the year, lack of resetting, heat tolerance, flower colour, fragrance, flower size and form including double flower. But their performances with respect to marketable flower yield, flower quality have differed greatly in different regions. It is because of the fact that, a variety performing well in a particular region may not perform well in other regions because of differences in agro-climatic conditions.

Information on association among the morphological, flower quality and yield characters and magnitude of variability existing in the plant material and are prerequisite for improvement of yield. The information on genetic variability, heritability, correlation and path analysis in Stock is very useful for crop improvement. Therefore, in this chapter attempt has been made to review the information available in the literature pertaining to the study in Brassicaceae and other family crops are presented under the following heads.

2.1 Performance of genotypes

2.1.1 Morphological parameters

2.1.2. Flowering and quality parameters

2.1.3. Yield parameters

2.2 Genetic variability, heritability and genetic advance

2.3 Correlation coefficient analysis and Path analysis

2.1 Performance of genotypes

2.1.1 Morphological parameters

Other related crops

2.1.1.1 Lisianthus

Harbaugh *et al.* (2000) evaluated 47 cultivars of lisianthus for resetting, plug performance, vegetative characters at Southwest Forestry University, Kunming, China. Significant differences among the cultivars were found for all attributes evaluated. Heidi Wine Red cultivar had the highest percentage rosetted plants (35%) followed by Flamenco Wine Red (29%) Alice Pink (1%) and Avila Rose (3%) had the lowest. Plant height ranged from 94 cm for Heidi Pastel Blue Imp and Ventura Purple to 129 cm. Malibu Purple, Catalina Blue Blush and Alice Pink were selected as best performer in seedling stage since they had less than five per cent rosette, large leaves and vigorous root system.

Uddin *et al.* (2013) investigated eight lisianthus genotypes for growth related characters at Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka. The result showed that the cv. Pink Rose found to be the highest plant height (58.9 cm), number of stems per plant (7.4) and number of leaves per plant (22) and the lowest plant height (40.1 cm), number of stems per plant (2.9) found in *cv*. Pink Picotee. Cultivar Chandra recorded the highest stem diameter (5 mm) and least recorded in Blue Bell (1.7 mm). The higher chlorophyll content in leaf was found from Chandra variety (77.2%) and lower (51.2%) from in cv. Blue Bell. The highest leaf area (42.4 cm^2) was obtained with Chandra and the lowest (20.6 cm^2) was from Blue Bell at harvesting stage.

Anitha *et al.* (2013a) evaluated lisianthus cultivars for morphological traits at TNAU, Coimbatore. The result concluded that the cultivar 'Echo Pink' was found to be the best for the traits plant height (93.43 cm), number of leaves (45.33), stem length (91.68 cm), internodal length (8.49 cm) and shoot yield $plant^{-1}$ (5.27).

Wazir (2014) evaluated 16 genotypes of lisianthus cultivars for assessing their suitability as prominent new cut flower crop under hill station of Himachal Pradesh. The result concluded that cv. Flamenco Blue recorded the maximum plant height of 94.50 cm.

Ahmad *et al.* (2017) evaluated eight lisianthus lines for commercial production at Sher-e-Bangla Agricultural University, Bangladesh. The cv. Nandini Royal showed the maximum for plant height (68.8 cm), number of leaves (51.7), chlorophyll content of 58.40 per cent. Cultivar Nandini Violet recorded the maximum number of stems per plant (5.7).

Bhargav *et al.* (2020) evaluated six genotypes of lisianthus under naturally ventilated polyhouse for assessing morphological traits at Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj. The result concluded that the highest plant height (73.55 cm) and a greater number of leaves (42.00) was observed in Arena champagne, the widest plant spread was recorded in Rosita Red (176.22 cm).

Onozaki *et al.* (2020) conducted experiment on 29 lisianthus cultivars and one inbred line of *Eustoma exaltatum* for resistance to two isolates of *Fusarium solani* at Institute of Vegetable and Floriculture Science, Japan. The result found large differences in resistance among 29 cultivars and the one inbred line tested. The cv. Papillon Pink Flash was highly resistant to both isolates and showed no disease symptoms in a total four tests. Furthermore, *E. exaltatum* Ohkawa No1 was highly resistant to two isolates, MAFF712388 and MAFF712411 showing no disease symptoms. Varieties Mink, Nagisa A, Nagisa B and Vulcan Marine were stably susceptible with 70 per cent to 100 per cent of plants of these four cultivars wilting in all tests. MAFF712411 had greater pathogenicity than MAFF712388.

Namratha (2021) evaluates 15 genotypes of lisianthus for morphological traits at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere. The results revealed that Echo Purple recorded the maximum plant height (94.02 cm) and internodal length (8.05 cm), Echo Lavender recorded the maximum number of leaves (44.48), leaf area (41.05 cm2) and leaf area index (4.56).

2.1.1.2 Carnation

Verma *et al.* (2012) conducted an experiment on evaluation of Carnation varieties in Chattisgarh for morphological parameters. The result revealed that the maximum plant height at bud emergence was noted for cv. Sissagree (67.5 cm) followed by Cherry Solar (65.0 cm). The maximum number of leaves were observed in cv. Neva (25.3) whereas, the minimum number of leaves were recorded in *cv.* Madras (12.50).

Tarannum and Naik (2012) conducted experiment on evaluation of Carnation under hill zone of Karnataka. The results confirmed that the most of the morphological parameters *viz*., plant height, plant spread, number of branches, internodes and leaves; leaf length and width, leaf area, dry matter production, chlorophyll content was found superior in cv. Soto.

Maitra and Roychowdhary (2013) evaluated the carnation genotypes for morphological parameters in West Bengal. The result showed that the cv. Dark Red recorded the maximum plant height (78.36 cm), leaf length (12.24 cm), leaf width (0.79 cm) and number of shoots (27.46).

Singh *et al.* (2013) evaluated carnation varieties for growth parameters in mid hills of Kumaon Himalayan region. The result concluded the cv. Red king recorded the maximum number of branches per plant (8.00), cv. Tuaerg recorded the maximum leaf pairs per stem (11.00).

Jose *et al.* (2017) evaluated nine Carnation varieties for vegetative characters in Naini Agricultural Institute, Allahabad. The result concluded that the cv. Irene was recorded the maximum plant height (109.49 cm), internodal length (8.12 cm). number of shoots (8.46). Cultivar Eskimo recorded the maximum number of leaves (169.00); cv. Manuela recorded the maximum number of internodes (15.46).

Medeo *et al.* (2019) evaluated eight Carnation varieties in Prayagraj with respect to vegetative parameters. The result confirmed that the variety Davinci recorded the maximum plant height (73.59 cm), number of shoots per plant (7.44), number of internodes (15.44) and internodal length (6.153cm).

2.1.1.3 Lily

Kannan *et al.* (2013) opined that, among Asiatic hybrids cv. Cannes has got the maximum plant height (95.00 cm). Whereas, cultivars. like London (75.00 cm), Loreto (75.00 cm) and the cv. Monet Negro (75.00 cm) recorded the minimum plant height.

Nataraj *et al.* (2014) observed significant differences among the hybrids for their growth. The maximum plant height was recorded in the hybrid Tresor (67.11cm) followed by Pavia (62.78 cm) and the lowest plant height was recorded in Levi (48.00 cm). The number of leaves per plant was the maximum in the hybrid Tresor (157.89) followed by Pollyanna (141.89). The leaf length was the maximum in the hybrid Tresor (8.61 cm) which was followed by Pavia (8.38 cm) while, the hybrid Gironde recorded least leaf length (5.45 cm).

Thakur *et al.* (2015) evaluated the nine cultivars of Asiatic lily, among these cv. 'Brunello' was the tallest (73.27 cm), whereas, cv. 'Harmony' recorded the maximum number of leaves per plant (46.07).

Bhat *et al.* (2016) reported that, the cv. Munich produced the tallest plans with the maximum stem diameter, whereas cv. Belgrade recorded the maximum leaf width and leaf area and the cv. Monger Bay had the maximum number of leaves per plant

Negi *et al.* (2016) reported that among the Lilium cultivars the plant height was the maximum in cv. Pollyana (71.66 cm) while, the minimum plant height was recorded in the cv. Grand Paradiso (56.11 cm). Whereas the higher number of leaves per plant was recorded in cv. Pollyana (49) and the minimum recorded in the cv. Alliana (29).

Kumar *et al.* (2018) opined that among Asiatic Hybrids Lilium Cultivars grown under Polyhouse, the maximum plant height (123.73 cm) was recorded in Nashville and followed by the cv. Eyeliner (112.87 cm). Cultivar Nashville recorded that the maximum (99.60 cm) stem length which was followed by Eyeliner (87.40).

Kumari *et al.* (2018) stated that among the Lilium cultivars the minimum days taken for emergence of sprouts (38.17 days) were recorded in cv. Best Seller and the cv. Yelloween recorded the maximum plant height (99.23 cm) and number of leaves per plant (86.97). While, cv. Prato recorded the maximum leaf length (14.80 cm).

Rupali *et al.* (2018) evaluated nine varieties of Lilium, among these the *cv.* Indian Diamond has recorded the maximum plant height (108.20 cm) and number of leaves per plant was the maximum (89.80) in cv. Sulpice.

Sandesh (2019) evaluated seven Lilium cultivars, result revealed that the cv. Yelloween recorded the maximum plant height (56.93 cm), number of leaves (69.24), leaf area (681.99 cm^2) and leaf area index (1.51).

2.1.1.4 Chrysanthemum

Roopa (2018) evaluates 20 genotypes of Chrysanthemum for morphological traits at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere. The result disclosed that genotype ACC 1 recorded the maximum plant height (56.26 cm). The genotype Chandini recorded the maximum plant spread E-W and N- S (21.32 cm and 14.09 cm, respectively), number of leaves per plant (511.41), number of primary and secondary branches per plant (12.39 and 24.24, respectively), leaf area (9913.82 cm^2) and leaf area index (11.02) and genotype Star Pink recorded the maximum stem girth (5.50 mm).

2.1.1.5 Marigold

Shivakumar *et al.* (2015) evaluates 15 genotypes of African marigold for growth parameters at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under KSNUAHS, Shivamogga. The result showed that the genotype Nilakkotai local orange recorded the maximum plant height (104.20 cm), number of secondary branches per plant (29.27), number of leaves per plant (392.47), stem girth (17.43) and internodal length (7.53).

2.1.2 Flowering and quality parameters

Other related crops

2.1.2.1 Lisianthus

Harbaugh *et al.* (2000) evaluated 47 cultivars of lisianthus for cut flower characteristics. Heidi Cherry Blossom, Ventura Purple, Flamenco Pink Rim and Echo Lilac Rose had earliest harvest dates of 138 to 143 days from sowing while, Bridal Ocean, Mariachi White and Mariachi Lime Green were the last cultivars to be harvested at 162 days from sowing. Mariachi Misty Blue had the greatest weight at 87 g and Echo Lilac Rose the least at 43 g. Royal Rose Lavender had the thickest stem (7.8 mm), while, 'Balboa Blue Blush' had the thinnest (5.4 mm). Flower diameter was smallest with Alice Purple (7.4 cm) and largest for Malibu Purple (11.8 cm). Petal number varied from 9 per flower for Catalina Blue Blush and Echo Lilac Rose to 28 for Avila Rose. Vase life recorded the highest in the cultivar Alice white (31 days) and the lowest recorded in Catalina yellow (10 days).

Uddin *et al.* (2013) investigated eight lisianthus genotypes for flowering parameters. The result showed that Pink rose required the maximum days to first flower (113 days), whereas the minimum days required for cv. Bell Neela and Mickey Rose (78 days, respectively). The highest flower length and flower head diameter recorded in White Pink (6.3 cm and 7.1 cm, respectively) and the lowest recorded in Pink White (3.6 cm and 3.4 cm, respectively). The highest petal number (11.3) was obtained from Pink rose and the lowest in cv. *C*handra (5). All the cultivars in this experiment showed very good shelf life (12-25.0days) in normal condition.

Anitha *et al.* (2013a) evaluated lisianthus cultivars for flower and flower quality traits. The result concluded that the cv. Bolero White was better with shorter duration for bud initiation (107.33 days), first flowering (142.67 days) and longer vase life (22 days). With respect to flowering traits, Minuet Dark Purple recorded bud diameter (5.75 cm) which bestowed a mass effect. Art Marine recorded the highest bud length (4.50 cm), flower diameter (8.30 cm) and flower length (6.67 cm).

Wazir, (2014) evaluated 16 genotypes of lisianthus cultivars for assessing their suitability as prominent new cut flower crop under hill station of Himachal Pradesh. The result showed that the minimum days to visible flower bud and flowering were reported in cv. Echo Double Lavender (142.5 days) and (170.4 days) whereas the cultivar Art Marine took the maximum time to form visible flower buds (159.4 days) and also was the latest to flower (187.6 days). Flamenco Blue produced the tallest stems (85.5 cm) in the maximum flower size (9.2 and 9.0 cm, respectively) whereas cv. Flamenco Blue had the smallest flower size (5.7 cm). The maximum vase life of 18.5 days and 18.2 days was recorded with cv. Art Marine and Bolero white, respectively.

Ahmad *et al.* (2017) evaluated eight lisianthus lines for commercial production. The cv. Nandini Royal showed the maximum for flower head diameter (7.3 cm), stem length (53.5 cm) and vase life (20.7 days). cv. Nandini Chandra recorded the maximum number of petals (14.00).

Bhargav *et al.* (2020) evaluated six genotypes of lisianthus under naturally ventilated polyhouse for flowering traits. The minimum number of days taken to flower bud emergence was observed in Arena Pink (108.440 days), Arena champagne took the minimum days to full bloom (13.11 days), the maximum vase life recorded in Echo Purple (13.88 days).

Namratha (2021) evaluates 15 genotypes of lisianthus for flowering and quality traits at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under KSNUAHS, Shivamogga. The result revealed that the minimum days taken for bud initiation and flower opening was observed in the genotype Echo Pure White (62.29 and 12.95, respectively). The maximum flower diameter, number of petals per flower and individual weight of flower were recorded in Robella 2 Pure White (6.76 cm, 18.00 and 11.16 g. respectively).

2.1.2.2 Carnation

Tarannum and Naik (2012) conducted experiment on evaluation of Carnation varieties. The results confirmed that the cv. Soto produced the longest stalk length, bigger sized flowers with the maximum number of petals, stalk girth.

Verma *et al.* (2012) conducted the experiment on evaluation of Carnation varieties in for flowering parameters. The result revealed that the number of days taken for flower bud emergence was found to be the minimum (57 days) in cv. Madras while, cv. White Wedding took the maximum days (144.5), the maximum flower stalk length (50.5 cm) was observed in cv. New Tempo. The superior flower size was noted in cv. Sunrise (5.40 cm).

Maitra and Roychowdhary (2013) evaluated the Carnation genotypes for flowering and quality parameters. The result showed that the earliest flower bud initiation was recorded with Lilac Tarres (69.66 days). Bright Red recorded the lowest time period for flower bud development (18.94 days) and Orange Isac recorded the highest time period (24.98 days). Bud length and bud diameter was found the highest with Tashman Pink (3.81 cm). The longest stalks recorded with Dark Red (71.62 cm). Bright Red was found to produce flowers of the highest diameter (7.21 cm) and in-situ longevity of flowers (11.78 days).

Singh *et al.* (2013) evaluated carnation varieties for flowering and quality parameters. The result concluded the cv. Red king recorded the maximum stem length (75.46 cm), fresh weight of flower (8.76 g), flower diameter (7.8 cm), vase life (29.30 days).

Jose *et al.* (2017) evaluated nine Carnation varieties for flowering and quality parameters. The result concluded that the days taken for bud initiation (79.53), days to bud opening (93.53) was recorded the minimum in Irene. The maximum number of leaves (169.46) and days to bud opening (123.33) were recorded in Eskimo. Flower stalk girth (8.49 mm) was recorded the maximum in Farida. The maximum bud length (4.10 cm), flower diameter was recorded in Manuela (8.22 cm).

Medeo *et al.* (2019) evaluated eight Carnation varieties in Prayagraj with respect to flower quality parameters. The result confirmed that the variety Hillary (174.99) was recorded the maximum flower length (5.4cm) and the maximum flower diameter (6.27cm). The maximum bud length (3.17cm), the maximum bud diameter (2.23cm), flower stalk girth (21.33 mm) and the maximum vase life (10.67) were recorded in the variety Cinderella. The minimum days taken to bud opening was recorded in the variety Kino (15.67).

2.1.2.3 Lily

Kannan *et al.* (2013) opined that, among Asiatic hybrids cv. Toronto recorded the maximum number of buds per spike (7.01), whereas the minimum was recorded in *cvs.* like Orpressa and Vermeer.

Nataraj *et al.* (2014) revealed that, significant differences among the hybrids for flowering. Flowering parameters differed significantly among the hybrids. The maximum number of buds per plant was in the hybrid Gironde (6.08) while, the bud length and bud diameter were the maximum in Pavia (9.30 cm and 9.41 cm, respectively) and on the other hand the maximum bud girth (23.56 mm) was recorded in Turrondot and the maximum bud weight (40.29 g) was noticed in the hybrid Levi. The performance of Asiatic hybrid Tresor was significantly better over other hybrids under evaluation.

Thakur *et al.* (2015) evaluated the nine cultivars of Asiatic lily Among these, the maximum number of buds/plants were recorded in *cv*. Toscana' (3.93) and the *cv,* 'Apeldoom' took less number days to flowering (56,80). While, the longest bud length and the maximum flower size was recorded in cv. 'Prato' (8.45 cm and 17.81 cm, respectively).

Bhat *et al.* (2016) reported that cv. Fuziana taken less number days for flower bud emergence and recorded the maximum bud length (45.30 and 6.4cm, respectively) and cv. Monger has the maximum number buds per shoot (6.30).

Negi *et al.* (2016) reported that Pollyana taken the smaller number of days for flower bud emergence (88.00) followed by Grand Paradiso (94.00). Whereas the minimum number of days taken for flower opening was recorded in cv. Pollyana (119.22) followed by Grand Paradiso (121.60).

Chandrashekhar *et al.* (2018) studied characterization of Asiatic lily genotypes for flowering parameters under protected conditions at hill zone of Karnataka, College of Horticulture, Mudigere. The result revealed that genotype Telisker was the earliest to show colour by taking (35.00 days) whereas, Ercolania (48.67 days) was late for expressing colour in its flower. The genotype Pirandeu was the earliest to show colour by taking the minimum number of days followed by Telisker. The genotype Merluza (19.51 cm) followed by Courier (19.34 cm) produced significantly bigger sized flowers than any other genotypes. The genotype Pirandeu extended its vase life maximum up to 12.37 days and found significantly superior over other genotypes and it was found to be on par with Pavia (12.17 days) whereas, the minimum number of days was recorded in Navona (7.73).

Kumar *et al.* (2018) reported that the cv. Hyde Park taken a smaller number of days for emergence of bud and days to colour change of first bud (33.40 and 73.07, respectively). Cultivar Nashville recorded the maximum flower diameter and flower bud diameter (20.81 cm and 34.20 mm, respectively) followed by Eyeliner (19.48 cm and 31.97mm, respectively).

Kumari *et al.* (2018) noticed that among the Lilium cultivars, cv. Best Seller took the minimum number of days for bud formation (98.77 days) and the minimum number of days taken for harvesting (124.37) While, cv. Yelloween recorded the maximum bud length (12.65 cm).

Rupali *et al.* (2018) stated that, cv. Pavia produced the maximum number of flower buds per shoot (5.70). While, cv. Yellow Diamond taken less number days to flower bud opening (69.20) and cv. Indian Summerset recorded the maximum flower diameter (19.30 cm).

Sandesh (2019) noticed that cv. Meria Zanlorva recorded the maximum bud length (15.27 cm), bud diameter (20.31 mm). While, cv. Yelloween recorded the maximum stalk length (56.50 cm), stalk girth (7.19 mm).

2.1.2.4 Chrysanthemum

Roopa (2018) evaluates twenty genotypes of Chrysanthemum for flowering and quality traits at Department of Floriculture and Landscape Architecture, College of Horticulture. The result revealed that genotype Kolar Local recorded the minimum days for appearance of first flower and 50 per cent of flowering (90.59 and 99.66, respectively.) and the maximum flowering duration (149.33 days).

2.1.3 Yield parameters

Other related crops

2.1.3.1 Lisianthus

Harbaugh *et al.* (2000) evaluated 47 cultivars of lisianthus for yield parameters. Significant differences among the cultivars were found for all attributes evaluated.
The number of flowers per plant recorded the highest in Catalina yellow (15.00) followed by Mariachi White and Heidi Lime Green (14.00), whereas least recorded by Alice Pink and Tyrol White (10.00). Cultivars Echo Pink, Alice White, Avila Blue Rim, Flamenco Rose Rim, Malibu Blue Blush, Alice Purple and Mariachi White selected as best in all attributes.

Uddin *et al.* (2013) investigated eight lisianthus genotypes for yield parameters. The result obtained that the maximum number of buds (20.3) was found in Chandra and the minimum (8.3) was in Bell Neela. The highest numbers of flowers were 20.1 per plant produced in Chandra but the lowest of 7.3 per plant was in Bell Neela. The maximum number of seeds (717.3) were recorded from Pink Rose and was minimum (267) in Pink Picotee. All the seven cultivars performed satisfactorily as ideal cut flowers and therefore could be popularized as commercial cultivars of lisianthus.

Anitha *et al.* (2013a) evaluated lisianthus cultivars for yield traits. The result concluded that the cv. Minuet Dark Purple recorded the maximum number of buds per stem (60.31), number of flowers per stem (17.09).

Wazir, (2014) evaluated sixteen genotypes of lisianthus cultivars for assessing their suitability as prominent new cut flower crop under hill station of Himachal

Pradesh. The result showed that the maximum number of flower buds per plant were obtained in cv. Luna Rose (18.6) and Shallot Green (18.5).

Ahmad *et al.* (2017) evaluated eight lisianthus lines for commercial production. The cv. Nandini Royal showed the maximum for cv. Nandini Purple showed the maximum number of buds per stem (6.7), number of flowers per stem (7.7), number of flowers per plant (47.00).

Bhargav *et al.* (2020) evaluated six genotypes of lisianthus under naturally ventilated polyhouse for yield parameters. The maximum flower was harvested from the Echo purple (17.663) and also the maximum Cost: Benefit ratio.

Namratha (2021) evaluates 15 genotypes of lisianthus for yield traits at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under KSNUAHS, Shivamogga. The result showed that the maximum number of buds per plant (16.59), number of stalks per plant (2.62), number of stalks per sq. m (41.92) and number of stalks per 560 sq. m (20,960) recorded in Echo Lavender.

2.1.3.2 Carnation

Verma *et al.* (2012) conducted an experiment on evaluation of Carnation varieties in for yield parameters. The result revealed that the maximum number of flowers per plant was observed in *cv*. Tikar (6.50).

Tarannum and Naik (2012) conducted an experiment on evaluation in Carnation varieties. The results confirmed that the cv. Soto realized the maximum net return (Rs. 3,50,483) and B:C ratio (2.50) in 560 sq. m.

Maitra and Roychowdhary (2013) evaluated the Carnation genotypes for yield parameters. The result showed that the variety Dark Red produced the highest number of flowers per plant (4.54) and Bright Red produced the lowest number of flowers per plant (2.65).

Singh *et al.* (2013) evaluated carnation varieties for yield parameters. The result concluded the cv. Red king recorded the maximum number of flowers per plant (35.60).

Jose *et al.* (2017) evaluated nine Carnation varieties for yield parameters. The result concluded that the cv. Irene recorded the highest number of cut flower stalks (8.06) number of cut flower stalk per square meter (193.44), vase life (13.93), the highest benefit to cost ratio (4.91).

Medeo *et al.* (2019) evaluated eight Carnation varieties in Prayagraj with respect to yield parameters. The result confirmed that the variety Davinci number of cut flower stalks per plant (7.55), number of cut flower stalks per square meter (181.2) and benefit cost ratio of 3.73.

2.1.3.3 Chrysanthemum

Roopa (2018) evaluated twenty genotypes of Chrysanthemum for yield traits at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere. The result revealed that genotype Kolar Local recorded significantly the maximum flower yield per plant (250.78 g) and per hectare (25.72 t).

2.1.3.4 Lily

Rajiv *et al.* (2011) reported that, among the Asiatic hybrids the bulb weight (28.26 g) and number of scales per bulb (18.46) was recorded the maximum in the cv. Botticelli, whereas the maximum bulb weight (56.66 cm) was recorded in the cv. Detroit.

Barik and Mohanty. (2015) revealed that, cv. Nov Cento recorded the maximum circumference and the maximum weight of bulb (16.04 cm and 64.58 g, respectively). While, the maximum number of bulblets per bulb (3.79) was recorded in the cv. Orange Matrix.

Bhandari *et al.* (2017) tested the 18 Lilium hybrids Ceb Dazzle recorded the maximum number of bulblets (6.66) per plant followed by Pollyana (6.33). Whereas Brindisi recorded the minimum number of daughters bulblets (3.33) per plant.

Chandrashekhar *et al.* (2018) characterized asiatic lily genotypes for yield parameters under protected conditions at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under KSNUAHS, Shivamogga. The genotypes *viz.,* Pirandeu, CEB Dazzle, Dazzle, Courier, Pavia and Tresor recorded the maximum number of spikes per square meter (24.00) while, the genotype Batistero recorded the minimum number (16.67).

Sandesh (2019) noticed that the cv. Yelloween recorded the highest number of florets per spike, number of spikes per sq. m (23.00) and number of spikes per 560 sq. m (12839.00).

2.1.3.5 Marigold

Shivakumar *et al.* (2015)) evaluated 15 genotypes of African marigold for yield traits at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under KSNUAHS, Shivamogga. The result showed that the genotype Nilakkotai local orange recorded the maximum number of flowers per plant (59.40), flower yield (529.33 g/plant), flower yield (19.60 t/ha) and petal meal yield (122.00 g/kg).

2.2 Genetic variability, heritability and genetic advance

Genetic variability studies help the plant breeder to make an effective and efficient selection of genotypes from the available material which can be utilized for further crop improvement. The success of any breeding programme mainly depends on the extent of genetic variability available in the population. Genotypic coefficient of variation indicates the relative magnitude of genetic diversity present in the material and helps to compare the genetic variability of different characters.

Phenotype of any plant is influenced by the genotype, environment and the interaction between the two. Further, the variation in a segregating population is attributed by both heritable and non heritable components and the variation in a pureline by only environmental factors (Johansen, 1909). Heritability and genetic advance are important selection parameters. Heritability estimates provides information on degree of inheritance of characters from parent to progeny. Knowledge on the heritability of different characters in relation to their contribution towards yield is a pre-requisite for an efficient breeding programme.

Genetic advance is another important genetic parameter for determining the amount of expected change that could occur due to selection. Heritability values alone may not provide clear predictability of breeding values. Heritability along with genetic gain is more useful in predicting the resultant effects for selecting the best individual (Johanson *et al.,* 1955).

Cruciferae crops

2.2.1 Cauliflower

Sutanij *et al.* (2013) studied genetic variability in sixteen genotypes of cauliflower and showed that both PCV and GCV were higher for most of the characters, representing that characters were much influenced by environmental agents. The genotypes Pusa Snowball K-1 recorded high GCV for vitamin C followed by Pusa Sharad and Pusa Hybrid2, whereas the genotype K-1 recorded low GCV and PCV for number of leaves per plant.

Singh and Dogra (2013) observed a significant difference among all the cultivars of cauliflower with respect to all the traits *viz*., plant height, number of leaves, stem diameter, leave length, leave width, total weight of the plant, fresh weight of leave, days taken to curd initiation, days taken to curd maturity, diameter of the curd, average weight of curd with guard leaves, vitamin C, curd weight without guard leaves and yield of curd with guard leaves.

Yadav *et al.* (2013) investigated 15 cauliflower hybrids and observation was noted on various traits *viz*., plant height, leaves, spread curd, size and yield. Amongst all the cauliflower hybrids, ‘Poornima’ was considered superior and had the highest plant height, number of leaves per plant, plant spread, diameter of curd, weight of untrimmed curd, weight of trimmed curd, curd yield, vitamin C and moisture-dry matter ratio.

Chittora and Singh (2015) evaluated genetic variability in 45 cultivars of early group of cauliflower and recorded observation for eighteen quantitative characters and five qualitative characters. They estimated broad sense heritability and genetic advance as per cent of mean for traits like net curd weight, marketable curd weight, curd yield per hectare, gross plant weight and harvest index. However, the lowest heritability and genetic advance were recorded in two traits *viz*., days to curd initiation and days to curd maturity.

Ansari (2017) evaluated ten genotypes of mid- group cauliflower for genetic variability, correlation and path coefficients. The field experiment was laid out in randomized block design with three replications at Horticultural Research cum Institutional Farm, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh during the year 2016-17. The PCV and GCV were recorded high for traits *viz*., marketable curd weight, gross plant weight, net curd weight and marketable curd yield. The genotype 2016/CAUMHYB10 was found to be superior for marketable yield per plant and other component traits *viz*., gross weight per plant and curd size index. He suggested that amongst studied traits, curd yield per plot, curd size index and gross weight per plant should be given priority for developing high yielding and horticultural superior genotypes of mid - group cauliflower.

Kumar *et al.* (2017) recorded high genetic advance for gross curd weight and net curd weight and low genetic advance was observed by stalk length and days to maturity. The high genetic advance as per cent of mean was recorded for stalk length whereas moderate for net curd weight and gross curd weight. Plant spread and days to curd maturity estimated the higher heritability along with low genetic advance representing non–additive gene effects while, plant spread and curd breadth estimated low genetic advance.

Sharma *et al.* (2018) evaluated twenty-five genotypes along with one standard check, Madhuri for variability, heritability and genetic advance in late maturing group of cauliflower. The experiment was undertaken in randomized block design with three replications at the Department of Vegetable Science and Floriculture, CSK HPKV Palampur during Rabi season of 2014-2015. Analysis of variance revealed significant variability for most of the traits. The PCV and GCV were observed high for curd solidity indicated that there is substantial variability ensuring ample scope for improvement of this trait through selection and moderate for ascorbic acid content, stalk length, marketable yield per plant, curd size index, dry matter content, harvest index and gross weight per plant which could be due to differences in genetic material and growing conditions.

2.2.2 Lisianthus

Anitha *et al.* (2013b) conducted an experiment on genetic variability, heritability and genetic advance in lisianthus. The result showed that the co-efficient of variation was found to be higher in number of buds per plant [GCV= 43.24% and PCV= 43.60%] and the minimum for bud diameter [GCV = 6.62% and PCV = 8.27%]. The highest heritability was noticed for number of buds per plant (h^2 = 98.35%). The high genetic advance as per cent mean was exhibited by number of buds per plant (88.35%) while, the minimum (10.43%) was noticed in bud diameter. The high heritability coupled with high genetic advance was noted for traits namely days taken for bud initiation [h^2 = 98.20% and GA = 39.86] and number of buds per plant (h^2 = 98.35% and GA = 25.03] indicating the possible role of additive gene action which suggested that improvement of these traits would be effective for further selection of superior genotypes.

Namratha (2021) studied genetic variability in 15 genotypes of lisianthus at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under KSNUAHS, Shivamogga. The result revealed that high (>20%) PCV and GCV were recorded by number of branches per plant, leaf area, chlorophyll b, number of buds per plant, flower bud diameter, individual weight of flower, number of stalks per sq. m and number of stalks per 560 sq. m. The estimates of high heritability (> 60%) coupled with high genetic advance as per cent over mean (> 20%) was observed in all growth and flowering traits.

2.2.3 China aster

Kumar *et al.* (2003) evaluated eleven genotypes of China aster for fourteen quantitative characters and revealed that genotypic coefficient of variation was high for plant spread, leaf area per plant, average weight of fresh flower and flower yield per plant. The high heritability and high genetic advance as per cent of mean were observed for plant spread [99.09 and 75.19% respectively), flower yield per plant [99.06% and 73.25%, respectively], average weight of fresh flower [97.34% and 58.78%, respectively] indicating additive gene action. While, time taken for first flower bud initiation showed high heritability with low genetic advance [77.89% and 21.63%, respectively] indicating non additive gene action.

Khangjarakpam *et al.* (2014) estimated genetic variability, heritability and genetic advance in 20 genotypes of China aster for 15 traits and revealed that high GCV and PCV were recorded for plant height, number of branches, leaves per plant, flower diameter, number of disc florets, stalk length, number and weight of flowers per plant. Heritability estimates ranged from (28.30%) for flowering duration to flower diameter (99.54%). The high heritability (>60%) was observed for all the traits except flowering duration. The maximum heritability, coupled with high genetic advance as per cent mean recorded for flower diameter, stalk-length, number of branches per plant, weight of flowers per plant, days to first flower opening, days to 50 per cent flowering, plant height, number of leaves per plant, number of rays, disc florets per flower head and number of flowers per plant indicating a possible role of additive gene action.

The genetic variability was studied by Rajiv *et al.* (2014) in twenty genotypes of China aster for 15 traits and revealed that PCV was higher than the GCV for all the traits. The high (>20%) GCV and PCV were recorded for plant height, number of branches, leaves per plant, flower diameter, number of rays, disc florets per flower head, stalk length, number and weight of flowers per plant. The high heritability (>60%) was observed for all the traits except for duration of flowering. The high heritability coupled with high genetic advance as per cent mean was recorded for flower diameter, flower stalk length, number of branches per plant, weight of flowers per plant, days to first flower opening, days to 50 per cent flowering, plant height, number of leaves per plant, number of ray and disc florets per flower head and number of flowers per plant, indicating the possible role of additive gene action.

Rachappa (2014) estimated genetic variability in 17 genotypes of China aster and revealed that moderate phenotypic co-efficient of variation and genotypic coefficient of variation for ray floret length and disk floret length. The high heritability (>60%) and genetic advance (>20%) were reported for ray floret length and disc floret length.

Harishkumar *et al.* (2017) studied genetic variability, heritability and genetic advance in F_2 segregating population of China aster and reported that AAC-1 × Arka Poornima and Arka Kamini × P G Purple crosses showed high phenotypic and genotypic coefficient of variation for number of flowers per plant, individual flower weight and flower yield per plant. The crosses AAC-1 × Arka Poornima and Arka Kamini × PG Purple showed almost high heritability for all the traits except for days taken for flower bud initiation in AAC-1 × Arka Poornima. The high heritability along with high genetic advance existed in both the crosses for plant height, number of branches, number of leaves, flower stalk length, flower diameter, disc diameter, number of flowers per plant, individual flower weight and flower yield per plant.

Eight genotypes of China aster were evaluated by Kumari *et al.* (2017) to determine genetic variability, heritability for 13 growth, flowering and post-harvest traits. Significant differences among genotypes for all the traits were observed through the analysis of variance. The higher genotypic and phenotypic coefficient of variation was recorded for number of leaves per plant and number of ray florets per flower head. High heritability (>60%) was recorded for all traits. The genetic advance ranged from 0.97 (flower head diameter) to 143.01 (number of leaves/plant). The high genetic gain was recorded for number of leaves per plant and number of ray floret per flower head.

Rai *et al.* (2017) evaluated ten genotypes of China aster for 12 quantitative traits and revealed that the high PCV and GCV was recorded for plant height and plant spread. The high heritability was observed for all the traits, except for number of harvests of loose flower. The genetic advance ranged from 1.36 (individual flower weight) to 57.15 (weight of flowers per plant) and the high genetic gain were recorded for plant height (69.81%), followed by weight of flowers per plant.

Ramya *et al.* (2018) conducted an experiment to evaluate genetic variability in F_2 population of cross Arka Archana × AAC-1 in China aster, the result revealed that there was a wide range of variability existed in cross Arka Archana × AAC-1 for different growth, flowering, quality and yield parameters. Plants which exhibited different characters with the high heritability coupled with high genetic advance would be effective for selection and utilized for breeding of high yielding China aster cultivars.

Studies on genetic variability, heritability and genetic advance in F_4 population of China Aster was conducted by Anitha *et al.* (2019). The result observed that high heritability along with high genetic advance existed in cross *viz.,* AAC-1 × Arka Poornima and Arka Kamini × P G Purple for number of flowers per plant, individual flower weight and flower yield per plant. Thus, these characters could be improved through simple selection procedure due to the presence of additive type of gene action.

2.2.4 Chrysanthemum

A study on variability was conducted by Shirohi and Behera (2000) in 57 genotypes of chrysanthemum and revealed the higher GCV and PCV values were found for number of flowers per plant followed by number of branches per plant, plant spread and diameter of disc. The high heritability values with high genetic advance were observed for number of branches per plant, plant spread, diameter of discs, number of petals per flower, vase life and yield per plant.

Talukdar *et al.* (2003) studied the genetic variability in chrysanthemum and revealed that cv. Purple Decorative was found to be superior for most of the growth characters like plant height (73.12 cm), plant spread (41.36 cm), number of primary branches (12.07), internodal length (2.60 cm) and the highest stem thickness (1.29 cm). The high heritability with high genetic advance over per cent mean was observed for the characters number of flowers per plant [99.74 and 185.38%, respectively] leaf number [99.97 and 160.66%, respectively] and number of ray florets [99.54 and 156.63%, respectively] indicating additive gene effects.

Seven chrysanthemum genotypes for vegetative and floral characters were studied by Reddy *et al.* (2008) and revealed that phenotypic and genotypic coefficient of variation was high for suckers per plant [67.76 and 67.08%, respectively], yield for plant [49.05% and 48.09%, respectively] and number of flowers per plant [47.05% and 46.72%, respectively]. The high heritability with high genetic advance was observed for traits like suckers per plant [136.78 and 97.99%, respectively], yield per plant [100.18% and 98.89%, respectively], number of flowers per plant [95.56 and 96.71%, respectively], number of branches per plant [67.48% and 96.71%, respectively] and duration of flowering [51.86% and 98.02%, respectively] showing additive gene effect.

An investigation on genetic variability, heritability and genetic advance were carried out by Bhaskaran *et al.* (2009) among ten genotypes of chrysanthemum and revealed that high phenotypic and genotypic co-efficient of variation was observed for number of suckers per plant [GCV=90.13% and PCV=95.67%] and flower disc diameter [GCV=63.19% and PCV=66.76%]. The high heritability coupled with high genetic advance as per cent of mean was observed for number of suckers per plant, flower disc diameter and number of flowers per plant.

Prakash *et al.* (2017) studied the genetic variability, heritability and genetic advance of twenty genotypes of chrysanthemum and revealed that high phenotypic and genotypic co-efficient of variation was observed for number of flowers per plant [GCV = 49.33% and PCV = 49.34%] and flower size [GCV = 37.40% and PCV = 37.43%]. The high heritability values were obtained for all the characters. The high heritability estimate coupled with high genetic advance as per cent of mean was observed for number of flowers per plant, flower size and number of primary branches per plant.

An investigation was carried out by Telem *et al.* (2017) on sixty chrysanthemum genotypes and found that high phenotypic and genotypic coefficient of variation was found for the character such as number of flowers per plant, number of branches per plant, number of primary branches, number of secondary branches, plant spread and plant height. The high heritability coupled with high expected genetic advance was observed for number of flowers per plant and number of secondary branches per plant.

Hebbal *et al.* (2018) assessed variability, heritability and genetic advance in 10 chrysanthemum genotypes and concluded that Phenotypic coefficient of variation was higher than Genotypic Coefficient of Variation for all the traits, indicating genotype and environment interaction. The high (>20%) PCV and GCV was observed for number of secondary branches, number of leaves, leaf area, stem girth, days to flower bud initiation and days to first flowering. Heritability estimates ranged from a moderate (55.10%) for number of secondary branches/plants to high as (99.74%) for days to flower bud initiation. The high heritability (>60%) was observed for all traits except number of secondary branches per plant. Estimates of high heritability coupled with high genetic advance as per cent of mean (GAM) were observed for all the growth, flowering, yield and quality parameters studied indicating the possible role of additive gene action.

An investigation was carried out for 15 genotypes of chrysanthemum to evaluate Variability, Heritability and Genetic Advance by Sushma *et al.* (2019) and the result showed that high PCV and GCV was recorded in fresh flower weight [GCV= 69.92% PCV= 70.25%] indicate the existence of wide range of genetic variability. The high heritability with high genetic advance as per cent mean was recorded for number of leaves per plant, leaf area, number of cut flowers per plant indicating the additive gene action of these characters. The high heritability with moderate genetic advance as per cent of mean recorded in plant height (90.72%), flower diameter and days to flower bud appearance indicating the non-additive component of variance for the character.

Negi *et al.* (2020) studied genetic variability, heritability and genetic advance among nineteen genotypes of newly evolved genotypes of chrysanthemum, observed that phenotypic coefficient of variation was higher than genetic coefficient of variance exhibiting that genotype and environment interaction. The high (> 98.09%) PCV and GCV was observed for plant height, plant spread, number of stems per plant, flower diameter, days taken to flowering, duration of flowering, stem length, weight of cut stem, number of flowers per stem. Heritability estimates range from moderate to high i.e. (46.02%) days taken to bud formation to plant height (98.09%). Estimates of high heritability along with high genetic advance as percent GAM recorded for all vegetative and flowering parameters exhibiting the additive gene effect.

Gaikwad *et al.* (2020) investigated genetic variability in annual chrysanthemum for yield and it's contributing characters for eighteen genotypes and revealed that genotypic coefficient of variation was lower than phenotypic coefficient of variation for all the traits under study. The highest value of genotypic and phenotypic coefficient of variation was recorded for the character number of ray florets [57.21% and 57.57%, respectively]. The high estimate of heritability (98.80%) was recorded for number of ray florets. The character, yield of flowers per hectare exhibited the highest genetic advance (12067.69%), followed by yield of flowers per plant (203.40%), followed by yield of flowers per plot (150.69%). The lowest value of genetic advance was reported for character disc diameter (0.38).

2.2.5 Marigold

Genetic variability in 31 accessions of African marigold was studied by Mathod *et al.* (2003) for yield parameters and revealed that phenotypic and genotypic coefficient of variations were recorded high for the traits like flower yield per plant, flower yield per plot and flower yield per hectare indicating existence of wide range of genetic variability in the germplasm. The high heritability estimates coupled with high genetic advance over per cent mean were observed for traits like number of days for the first flower bud initiation, flower weight, flower yield per plant, flower yield per hectare, shelf life of flowers and xanthophylls content indicating the predominance of additive gene component.

Reena *et al.* (2005) studied the variability and heritability in 15 genotypes of African marigold and revealed that genotypic and phenotypic coefficients of variation were the maximum for seed yield, dry weight of flowers, flower yield, seed vigour and fresh weight of flowers. The high heritability along with high genetic advance were recorded for number of buds per plant, number of flowers per plant, flower yield and seed vigour.

Singh and Kumar (2008) studied the 11 selections of French marigold and depicted significant differences in all characteristics studied. The coefficient of variation was the maximum for number of flowers per plant [GCV=40.23% and PCV=42.66%] and the minimum for number of seeds per head [GCV=12.15% and PCV=13.66%]. The high heritability along with high genetic advance was observed for flower yield (h^2=81.49% and GA=117.87) and number of flowers per plant (h^2=88.75% GA=75.42). The high genetic advance as per cent mean was observed for number of flowers per plant (78.08%). However, low genetic advance as per cent mean was observed for 1000 seed weight (18.37%).

An investigation on genetic variability was conducted by Karuppiah and Senthil (2011) in 34 genotypes of African marigold and revealed that high GCV was observed for number of flower heads per plant followed by number of branches per plant, flower yield per plant, flower head size and flower head weight, while, moderate PCV and GCV observed for plant height. The high heritability were observed for plant height, number of branches per plant, flower head diameter, flower head size, number of flowers per plant and flower yield per plant.

Anuja and Jahnavi (2012) studied the variability and heritability in 30 genotypes of French marigold and found high genotypic co-efficient of variation for stem girth, flower head weight and flower yield per plant. Moderate PCV and GCV for plant height. Heritability estimate in general were high for most of the characters studied. The high heritability coupled with high genetic advance as per cent of mean for number of flowers per plant, flower yield per plant, stem girth and plant height. Hence, these characters need to be given more importance in selection as these are expected to be controlled additive genes.

Gobade *et al.* (2017) assessed variability studies for various quantitative traits of twelve local selections of Marigold, resulted that the coefficient of variation both at genotypic and phenotypic levels were the maximum for disc diameter, yield of flowers ha^{-1}, weight of flower, diameter of fully opened flower, shelf life, number of flower $plant^{-1}$ and length of pedicel. The high heritability along with high genetic advance as per cent of mean was observed for disc diameter, yield of flowers ha^{-1}, weight of flower, diameter of fully opened flower, number of flowers $plant^{-1}$, shelf life and length of pedicel which were due to additive gene effect. Based on these seven traits, genotypes NAM-2, NAM-6 and NAM-12 were found significantly superior.

Latha and Dharmatti (2018) estimated the genetic variability in marigold using twenty-six genotypes. The result revealed that the maximum value of GCV and PCV were recorded for number of petals per flower and plant height. The highest broad sense heritability was recorded for flower yield (t/ha), flower yield (g/plant), number of flowers per plant, flower diameter and number of petals per flower. The highest genetic advance over mean was recorded for plant height, flower yield (t/ha), flower yield (g/plant), flower diameter and internodal length. The high heritability and genetic advance as percent mean are due to additive type of gene action.

Kumar *et al.* (2019) evaluated variability, heritability and genetic advance studies in ten genotypes of French marigold and recorded that phenotypic coefficient of variation were found to be higher than their corresponding genotypic coefficient of variation.
The high broad sense heritability coupled with high genetic advance was reported for number of flowers per plant (h^2=99.62%, GA=59.78) and flower yield per plant (h^2=99.53%, GA=133.82), showing additive gene effects and shows the effectiveness of selection of these characters.

Tamut and Singh (2019) investigate on genetic variability, heritability and genetic advance in French marigold. The highest heritability was observed for fresh weight per flower (99.34%) followed by flower yield per plant (99.24%). The high genetic advance and genetic advance as per cent of mean was observed the highest in flower yield per plant (464.27%) followed by number of flowers per plant (93.66). The estimates of genotypic and phenotypic coefficient of variations were ranged from 12.32 per cent to 63.15 per cent and 12.65 per cent to 63.39 per cent, respectively.

2.2.6 Gaillardia

Genetic variability and heritability studies involving eight genotypes of gaillardia were studied by Arulmani *et al.* (2016). The analysis of variance revealed that highly significant differences among genotypes for all the characters studied. The high PCV and GCV estimates were found for number of branches per plant, number of leaves per plant, flower yield per hectare and seed yield per plant. Estimates of high heritability with high genetic advance over per cent mean were observed for plant height, number of branches per plant, number of leaves per plant, leaf area, chlorophyll content, duration of flowering and days taken for seed set, indicating the possible role of additive gene action.

Studies to assess the genetic variability present in seven genotypes in gaillardia for various quantitative traits by Giranje *et al.* (2017). The results indicated that there were highly significant differences between the genotypes for yield of flower per hectare and 15 other characters. The coefficient of variation both at genotypic and phenotypic levels were the maximum for disc diameter, dry weight of flower, weight of flower, shelf life and leaf area. The high heritability along with high genetic advance as per cent of mean was observed for dry weight of plant, yield of flowers per hectare, diameter of flower, plant height and plant spread which were due to additive gene effects.

Byadwal *et al.* (2018) experimented on variability studies using twelve genotypes of gaillardia, observed that high PCV and GCV was recorded in number of ray floret per flower, weight of flowers per plant, weight of flowers per plot, number of whorls of ray floret, fresh flower weight, plant dry weight, number of disc florets per flower, plant fresh weight, number of flowers per plant, indicate the existence of wide range of genetic variability.

<u>*2.2.7 Gladiolus*</u>

Bhujbal *et al.* (2013) studied the variability, heritability and genetic advances of 31 gladiolus genotypes. Days for 50 per cent flowering showed low PCV (9.05%) and GCV (8.87%) along with high heritability (98.00%) and moderate genetic advance (17.89%). The presence of high amount of variability for all characters except sprout per corm and number of side spikes. Very high heritability coupled with high genetic advance for spike length, days to 50 per cent flowering, plant height advocated high genetic progress for them.

Naresh *et al.* (2015) studied the genetic variability, heritability, genetic advance in eight gladiolus hybrids and revealed that phenotypic coefficient of variation was higher than genotypic coefficient of variation. Days taken for spike initiation has shown low PCV and GCV with high heritability and moderate genetic advance and vase life has shown moderate PCV and GCV with heritability and high genetic advance and PCV and GCV were found high for leaf area along with high heritability and high genetic advance.

Ramzan *et al.* (2016) studied the estimates of genetic variability and genetic parameters in three gladiolus cultivars and revealed that the highest genotypic coefficient variation and phenotypic coefficient variation magnitude was observed for spike length, number of florets per spike and number of leaves. Among the traits studied the highest heritability estimates was recorded in spike length (99.50%) and the lowest in plant height (98.20%). The genetic advance as per cent of mean was ranged (2.80% to 24.75%). The high heritability combined with high genetic advance was noticed for number of florets per spike, spike length and floret breadth.

Swetha *et al.* (2020) assess the genetic variability of forty gladiolus genotypes, observed that characters like days to corm sprouting, number of shoots per plant, leaf area per plant, leaf area index, number of spikes per plant, spike weight, weight of corm before planting, number of daughter corms per plant, average weight of daughter corm, number of cormels per plant and average weight of cormels which are showing high GCV, PCV, heritability and genetic advance.

2.3 Correlation and path analysis studies

Knowledge of correlation that exists among different characters or the association between yield and its components will facilitate in interpretation of results already obtained and provide a basis for more efficient breeding programme.

The idea of correlation was presented by Galton (1889) and later elaborated by Fisher (1918) and Wright (1921). The direct observation of phenotypic correlations does not indicate the magnitude or direction of genetic correlation, where as it presents a true genetic picture of relationship between the genes controlling the characters.

The correlation of characters may be due to either genetic linkage or pleiotropy (Harland, 1939). Probably the main cause of genetic correlation is due to pleiotropic effects of genes, *i.e.,* some of genes which affect one trait also affect the other. If the correlation is high, then probably pleiotropy is important and if the correlation is low then we might say that the two traits are inherited independently as they are under the control of different sets of genes (Jain, 1982).

The concept of path analysis was developed by Wright (1921), as a means of separating direct and indirect contribution of various factors. Path coefficient analysis is a standardized partial regression coefficient analysis and as it measures the direct influence of one variable upon the other and permits the separation of correlation coefficients into components of direct and indirect effects.

Use of this technique requires a cause-and-effect situation among the variables. It is a technique used to find the relative contribution of component characters directly on the main characters and indirectly through other characters to increase the efficiency in selection programmes. The correlation between dependent and independent characters is due to the direct effect of the characters, it reflects a true relationship between them and selection can be practiced for such characters in order to improve dependent variable. Otherwise, broadly speaking a breeder has to select for the later through which the indirect effect is exerted.

2.3.1. Stock

Cordea *et al.* (2008) recorded that, at phenotypic level flower diameter showed positive correlation with plant height, number of inflorescences per plant, number of flowers per inflorescences and persistence of flowering with number of flowers in inflorescence, plant height and start of blooming.

Mousavi *et al.* (2008) evaluated the correlation among some traits of nineteen different genotypes of *Matthiola incana* L. They found significant positive correlation among plant height, inflorescence length, number of leaves, number of florets, stem diameter and stem height. The number of leaves per plant was significantly and positively correlated with number of florets, stem diameter and stem height

Cruciferae crops

2.3.2 Cauliflower

Singh *et al.* (2014) recorded correlation and path coefficient analysis on different genotypes of cauliflower and estimated that yield is positively correlated with leaf count, curd weight, curd depth and plant height. Whereas, plant spread, leaf area and curd diameter showed direct negative effects.

Singh *et al.* (2014) studied about inter correlation and revealed that plant height had significant positive correlation with plant girth, weight of plant, curd weight, curd diameter and curd depth. Whereas, plant girth was positively correlated with weight of plant, curd weight, curd diameter and curd depth. Plant weight also exhibited positive correlation with curd weight, curd diameter and curd depth, while, curd diameter was positively correlated with curd depth.

Ansari (2017) investigated that the correlation coefficient of yield per plot was positive and significant with curd yield per plot, leaf length, marketable curd yield, harvest index, leaf width, marketable curd weight and gross plant weight at genotypic and phenotypic levels whereas, leaves attached to curd was recorded to be positively and significantly correlated with curd yield per plot at genotypic level. The path coefficient analysis estimated that gross plant weight showed the highest positive direct effect followed by marketable curd yield, harvest index, days to first harvest for earliness, net curd weight, curd yield per plot, stalk length, duration of crop, leaf width, leaves attached to curd and number of leaves. Whereas, curd index indicated the highest positive direct effect on curd yield (q/ha) and direct selection for these characters would be effective to select the promising genotypes.

Sharma *et al.* (2017) estimated that curd size index, gross weight per plant, days to marketable curd maturity from date of transplanting, curd solidity, stalk length, curd diameter, per cent marketable curds and harvest index had high positive direct effects on marketable yield per plant at phenotypic level. Whereas, traits such as days to marketable curd maturity from date of transplanting, curd diameter, curd size index, dry matter content, per cent marketable curds and number of leaves per plant also had appreciable positive direct contribution to the total association with marketable yield per plant at genotypic level.

Vanlalneihi *et al.* (2017) investigated that a positive and significant association was recorded for characters *viz.,* curd polar diameter, curd equatorial diameter, plant height, marketable curd weight and net curd weight with curd yield. Curd polar and equatorial diameter had positive significant association with marketable curd weight and net curd weight at both genotypic and phenotypic levels. Net curd weight had the maximum direct positive effect on curd yield.

Other related crops

2.3.3 Carnation

Sanyat and Gupta (2003) conducted correlation and path analysis of twenty genotypes in carnation, observed that number of flowering stems per plant showed significant positive correlation with number of buds per plant and was also positively associated with plant height, stem length and days to flowers bud opening. The maximum positive direct effect on number of flowering stems per plant shown by number flower buds per plant while, number flower buds per plant showed indirect positive effect.

Correlation studies was carried out by Patil *et al.* (2004) using ten genotypes. Result indicated that, number of flowers per plant was positively and significantly correlated with number of branches (0.378). Plant height was positively and significantly correlated with stalk length (0.917), number of leaves (0.779), number of branches (0.672), leaf area (0.486), total chlorophyll content (0.466), stem girth (0.437) and leaf length (0.426), vase life was positively and significantly correlated with plant height (0.614), stem girth (0.610), number of leaves (0.488) and number of branches (0.472).

Mukund *et al.* (2004) estimated correlation in carnation for different traits and found that stalk length was positively and significantly correlated with plant height, days for bud appearance, leaf area, bud diameter and flower diameter.

Path coefficient analysis was studied by Sharma *et al.* (2012) in sixteen carnation genotypes and revealed that flower diameter, flower duration, leaf pair per stem, incidence of diseases, incidence of pest damages had the maximum positive direct effect on yield of flowers. Hence, these traits deserve greater weightage than other traits while, formulating selection indices in carnation.

Tarannum and Naik (2012) evaluate eight genotypes of carnation for correlation studies. The result revealed that genotypic correlation coefficients were higher than phenotypic correlation coefficients for most of the characters studied. Flower yield per square meter showed highly significant association with number of branches, nodes per stalk and nodes per plant; stem girth, number of leaves, leaf area, total dry matter and duration of flowering. Whereas the number of nodes per plant and duration of flowering exhibited positive and highly significant correlation with yield, only significant correlation was found with plant spread, number of branches, nodes per stalk; stem girth, number of leaves and vase life, at the phenotypic level.

Sharma and Srivastava (2014) studied correlation in carnation for sixteen genotypes, result revealed that number of flowers per square meter had highly significant and positive correlation with flower diameter (cm), flower duration and leaf pair/stem while, flower yield/m^2 had negative and significant correlation with per cent incidence of disease and incidence of insect pests damage at both genotypic as well as phenotypic levels.

Dalwai and Naik (2017) studied correlation in carnation, showed that flower yield per sq. m showed highly significant association with plant height, number of branches, plant spread, leaf area, dry matter production and total chlorophyll content. Correlation between nitrogen were highly significant for all characters studied. Potassium was found highly significant with all flowering parameters. Negative correlation was seen between flower bud initiation and all flowering parameters with nitrogen and phosphorus. Whereas, the nutrient status of soil with biofertilizers exhibited positive and highly significant correlation with yield and vase life of flowers.

<u>*2.3.4 China aster*</u>

Naik *et al.* (2004) evaluated fourteen quantitative characters in 11 genotypes of China aster and revealed that flower yield was positively and significantly correlated with diameter of flower and number of flowers per plant.

Poornima *et al.* (2006) studied the correlation for 10 characters and revealed that highly significant varietal differences were noticed with respect to all characters. Flower yield per plant was significantly and positively associated with plant spread, number of branches and number of leaves per plant.

Sreenivasulu *et al.* (2007) studied the correlation and revealed that number of flowers per plant was positively and significantly associated with plant height, primary and secondary branches, days taken for 50 per cent flowering, diameter of flower, fresh weight of flower and dry weight of plant. The fresh weight of flower was positively and significantly associated with dry weight ofplant.

Khangjarakpam *et al.* (2015) evaluate correlation and path analysis in twenty genotypes of China aster for 12 quantitative traits and number and weight of flowers per plant were significant and positively correlated with plant height, number of branches per plant, number of leaves per plant and flower stalk length. Days to 50 per cent flowering showed the highest positive indirect effect on yield of flowers followed by flower stalk length, plant height, flowering duration, number of branches and flowers per plant. There was a direct positive influence on weight of flowers per plant from duration of flowering, days taken to 50 per cent flowering, flower diameter and number of ray florets per flower**.**

Tirakannanavar *et al.* (2015) studied correlation in ten genotypes, Phule Ganesh White and Phule Ganesh Purple recorded the maximum flower and seed yield per plant. Phule Ganesh Purple recorded the higher germination percentage whereas Phule Ganesh Pink recorded the maximum root and shoot length and seedling vigour index. Flower yield per hectare was positively and significantly correlated with plant height, plant spread number of secondary branches and leaf area at genotypic level.

Eight genotypes of China aster were evaluated by Kumari *et al.* (2017) to determine path coefficient analysis for 13 growth, flowering and post-harvest traits and revealed that 100 flowers weight contributed the highest positive direct effect on weight of flowers per plant followed by number of leaves per plant and number of flowers per plant. This study suggests that effective selection for desirable traits can be achieved in China aster.

Rai *et al.* (2017) studied the correlation in ten genotypes of China aster for 12 quantitative traits and revealed that weight of flowers per plant is significantly and positively correlated both at genotypic and phenotypic level to plant height, plant spread, flower head diameter, number of flowers per plant and individual flower weight.

Harishkumar *et al.* (2018) studied the correlation and path analysis for F_2 segregating population of AAC-1×Arka Poornima in China aster for 19 characters and revealed that number of branches, number of leaves per plant, leaf area, plant spread, number of flowers per plant, individual flower weight, weight of 10 flowers, flower diameter, ray florets length and disc diameter were found to positively correlated with flower yield. All the flower parameters had the maximum positive direct effect on yield of flowers. Hence, these traits deserve greater weight age than other traits while, formulating selection in F_2 segregating population of AAC-1× Arka Poornima in China aster.

Naikwad *et al.* (2018) studied correlation and path analysis among the different characters influencing the flower yield of twelve different genotypes of China aster, the number of leaves, number of secondary branches per plant and plant spread showed significant positive correlation with yield both at phenotypic and genotypic level. The test weight (10 flower weight), number of secondary branches plant and number of flowers plant directly influenced the flower yield and had the maximum direct effect. This result suggests that these traits can be directly used to improve the yield of China aster.

2.3.5 Chrysanthemum

Shirohi and Behera (2000) reported that positive and significant phenotypic association of yield was observed for flowers per plant (0.650), plant spread (0.597) and number of branches per plant (0.372) and flower diameter had positive and significant correlation with length of ray floret and flower weight.

Correlation and path analysis was conducted by Deka and Paswan (2002) in nine quantitative characters of ten chrysanthemum genotypes and revealed that there was positive and significant correlation of flower yield with number of branches and number of leaves. Size of flowers showed the greatest direct positive effect on flower yield followed by number of flowers, plant height and duration of flowering.

Correlation and path analysis were carried out by Bhaskaran *et al.* (2004) among ten genotypes of chrysanthemum. Positive and significant association was observed for number of flowers per plant with respect to number of branches per plant (0.892) and number of suckers per plant (0.845), thus selection based on these characters helps in further crop improvement programme.

Mishra *et al.* (2006) studied the correlation in 25 germplasm of spray chrysanthemum and revealed that number of primary branches per plant had the highest positively significant correlation (0.998) followed by number of secondary branches per plant (0.997) and number of leaves per plant (0.997). Path coefficient analysis revealed that number of primary branches per plant had the highest direct effect on flower yield (0.6010) followed by number of secondary branches per plant (0.2452) and number of leaves per plant.

Misra *et al.* (2013) evaluated twenty-five germplasm of spray chrysanthemum to determine path coefficient among seven different parameters to differentiate the contribution made by each parameter in the final flower yield and revealed that number of primary branches per plant had the highest direct effect on flower yield (0.601) followed by number of secondary branches per plant (0.245) and number of leaves per plant (0.163).

Beeralingappa *et al.* (2016) studied correlation and path coefficient in Chrysanthemum for sixteen genotypes and revealed that the genotypic correlations were higher than the phenotypic correlations for the characters studied. The genotypic correlation of flower yield per plant was showed highly significant and positive correlation with leaf area (0.885), number of leaves per plant (0.714), number of flowers per plant (0.677), duration of flowering (0.640), plant height (0.609), number of primary branches per plant (0.575), stem girth (0.531), flower weight (0.542) and number of secondary branches per plant (0.441). Path coefficient result revealed that the number of flowers per plant (1.831), flower weight (0.701), internodal length (0.296), number of secondary branches per plant (0.168), flower diameter (0.162), duration of flowering (0.155) and leaf area (0.088) exhibited the maximum positively direct effect on flower yield per plant.

Study on character association and path analysis was carried out by Telem *et al.* (2017) in sixty chrysanthemum genotypes and revealed that genotypic correlation coefficients were found to be higher than the phenotypic correlations for most of the characters. Number of flowers per plant showed highly positive significant correlation at both genotypic and phenotypic level with plant spread (0.977 and 0.974 respectively), number of primary branches (0.952 and 0.828 respectively), number of branches per plant (0.956 and 0.950), number of flowers per plant (0.932 and 0.821) and number of secondary branches (0.770 and 0.744). Plant spread, number of primary branches, number of flowers per spray and number of branches per plant had the highest positive and direct effects on number of flowers per plant at genotypic and phenotypic levels.

Hebbal *et al.* (2018) assessed ten genotypes of chrysanthemum to study the path analysis of different parameters. Genotypic path coefficient analysis revealed that flower yield per plant was directly and positively influenced by number of flowers per plant, individual flower weight, days to flower bud initiation and shelf life of flowers. Phenotypic path coefficient analysis revealed that flower yield per plant had positive direct effect from number of flowers per plant, individual flower weight, days taken for flower bud initiation, flower diameter and shelf life of flowers. Hence, selection for these traits would be effective for flower yield improvement in chrysanthemum.

Correlation and path analysis were carried out in 20 genotypes of chrysanthemum. The results indicated that the primary branches per plant, plant height after full bloom and days to flower bud initiation showed positive significant correlation with number of flowers per plant at both genotypic and phenotypic level. The path coefficient analysis at genotypic level revealed that primary branches per plant, plant height after full bloom and days to flower bud initiation had the highest direct positive effect on number of flowers per plant. At phenotypic level primary branches per plant, plant height after full bloom and days to flower bud initiation showed the highest direct positive effect on number of flowers per plant. (Prakash *et al.*, 2017).

Roopa (2018) recorded correlation and path coefficient analysis for 15 genotypes of lisianthus at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under KSNUAHS, Shivamogga. Flower yield per plant was significantly correlated in positive associations with leaf area, flower weight, number of primary and secondary branches per plant, flower diameter, number of leaves per plant, duration of flowering, number of flowers per plant, stem girth and plant height at both genotypic and phenotypic level. The flower yield per plant exhibited high positive direct effect with number of primary branches per plant, internodal length and flower weight at genotypic and phenotypic level.

2.3.6 Gerbera

Anuradha and Narayanagowda (2000) studied the path analysis in gerbera and revealed that flower yield was directly and positively influenced by number of leaves per plant, diameter of disc, plant height and weight of ray florets per head, whereas, number of leaves was influenced by yield indirectly and positively through days taken to bud initiation and fresh weight of stalks had direct and indirect negative effect on yield.

Nair and Shiva (2003) studied the correlation and path analysis for twenty five genotypes of gerbera. Positive and direct correlation of amount of leaves/ plant with cut flower yield revealed that flower production can be increased by direct selecting for increased number of leaves. Number of ray florets had high correlation with flower yield.

Magar *et al.* (2010) estimated the correlation and path analysis for twenty eight diverse genotypes of gerbera and revealed that genotypic correlations were higher than corresponding phenotypic correlations. The number of leaves per plant showed significant positive correlation with plant spread, leaf area, number of suckers per plant and number of flowers per plant at phenotypic level. Leaf area (0.536) had the highest direct effect on number of flowers per plant, followed by plant spread (0.227) and number of leaves per plant (0.207) and direct selection could be made for these characters for improving the yield.

Kumar (2015) studied correlation in nine varieties of gerbera and revealed that magnitude of genotypic correlation was higher than their corresponding phenotypic correlation for most of the traits, indicating a strong inherent linkage between various traits. At genotypic level, number of leaves per plant exhibited positive significant correlation with diameter of flower and number of flowers per sq. m per year but highly significant and positive correlation with number of flowers per sq. m per year at phenotypic level.

Narayan *et al.* (2016) estimate variability studies for sixty-three genotypes and Correlation Studies of Gerbera using sixty-three genotypes, it could be inferred that there is sufficient variability, high heritability and genetic gain in most of the traits of study were present, besides significant strong positive association among all the traits of study were also exhibited in present germplasm.

2.3.7 Marigold

Mathod *et al.* (2005) studied correlation and path co-efficient analysis in African marigold and revealed significantly positive correlation with plant height, number of branches, plant spread, duration of crop, number of flowers/ plants, flower weight, flower diameter, seed yield per plant. The maximum positive direct effect on flower yield was shown by flower weight, seed yield per plant and plant height.

Correlation and path analysis in marigold studied by Mathew *et al.* (2005) and revealed that the plant spread, number of buds and fresh weight of the flower showed the highest positive direct effect while, number of branches showed the lowest positive direct effect on flower yield. Similarly number of flowers per plant showed the highest positive direct effect on flower yield.

The correlation study was conducted by Reena *et al.* (2005) to assess the relative contribution of different yield attributing characters on flower and seed yield and revealed that seed yield per plant, buds per plant and number of flowers per plant showed highly significant correlation with flower yield, while, the number of flowers, number of buds and flower yield per plant showed highly significant correlation to seed yield.

Singh and Kumar (2008) evaluated fourty four germplasm of marigold for correlation and revealed that significant positive correlation was found between number of primary branches per plant and number of flowers per plant, days taken to bud initiation and flower diameter, days taken to flowering and weight of seeds per peduncle, average fresh weight of flower and weight of seeds per peduncle. Significant but negative correlation was observed between number of primary branches per plant and plant height, plant spread and days taken to flowering, duration of flower and number of flowers per plant and between duration of flower and flower diameter.

Kavitha and Anburani (2010) conducted a field experiment to find out the association between various quantitative traits and found that flower yield per plant exhibited highly significant and positive correlation with number of flowers per plant, number of laterals per plant, flower head size, stem girth, plant height, xanthophyll content and dry matter production.

Karuppaiah and Kumar (2011) studied the correlation and to asses direct and indirect effects on flower yield in 34 genotypes of African marigold and revealed that the flower yield per plant was found to be significant and positive correlation with number of branches per plant, flower size, stem girth, flower diameter, flower weight, number of flowers per plant and xanthophyll content. Path analysis revealed that number of flowers per plant and xanthophyll content had high positive direct effects.

Medium level of direct effect was recorded by flower diameter and other characters recorded low or very low direct effects.

Correlation and path analysis was studied by Anuja and Jahnavi (2012) in French marigold for seven characters and revealed that stem girth, flower head diameter and number of flowers per plant were found to be positively correlated with flower yield. The flower head diameter, days to first flowering and number of flowers per plant had the maximum positive direct effect on yield of flowers. Hence, these traits deserve greater weightage than other traits while, formulating selection indices in French marigold.

Shivakumar *et al.* (2014) studied the correlation and revealed that plant height, number of branches per plant and plant spread had a positive and significant correlation with number of flowers, individual flower weight and flower yield per plant. Days to first flower bud initiation had positive and significant correlation with days to fifty per cent flowering and duration of flowering. Also found that flower weight had a positive significant correlation with flower weight and flower diameter and flower yield.

Usha *et al.* (2014) studied the correlation in 28 genotypes of African marigold and revealed that positive and significant correlation was recorded for flower yield per plant with plant height (0.641), stem girth (0.600), number of flowers per plant (0.531), flower size (0.700), single flower weight (0.692) and number of petals per flower (0.521).

An investigation was carried out by Mahesh *et al.* (2015) to assess association of yield components in marigold and revealed that quantitative traits had a significant correlation with flower yield per plant except stalk length. Plant spread and individual flower weight had significant correlation with number of flowers, flower diameter and flower yield per plant.

Lydia and Ponnuswami (2019) studied correlation in Marigold for thirty-one diverse genotypes. Revealed that plant height had positive significant correlation, whereas positive non-significant correlation was found for characters such as germination percentage, internodal length, days to flowering, bud diameter, buds per plant, number of flowers, flower diameter, flower stalk length, flower stalk girth, shelf life and individual flower weight.

2.3.8 Gladiolus

Path coefficient analysis was studied by Geeta *et al.* (2014) for number of spikes per plant in 15 genotypes of gladiolus and revealed that stem girth, leaf area, days taken for spike initiation, rachis length, number of florets per spike, number of daughter corms per plant, weight of daughter corm had high direct effects on number of spikes per plant which indicated the possibility of increasing spike yield by selecting the genotypes for these characters directly.

Ganitait *et al.* (2016) studied the correlation co-efficient for different traits in 20 gladiolus genotypes. The results showed significant differences for all the traits studied among the genotypes and estimated that genetic correlations in general were higher than phenotypic correlations. The plant height exhibited positive significant correlation at genotypic and phenotypic levels with number of florets per spike, spike length and spike weight. Hence, traits like spike weight, plant height and spike length may be considered for further improvement.

Ramzan *et al.* (2016) estimated character association and path analysis among different flower traits between three gladiolus cultivars *viz*., Sancerre, Fado and Advanced Red and revealed that plant height and number of florets per spike showed highly positive and significant association with spike length, number of leaves, leaf area, floret length and floret breadth while, spike length registered positive and significant correlation with number of leaves and floret breadth. Spike length imparted the maximum positive direct effect on the number of florets per spike. Hence, spike length and number of florets per spike may be considered for further improvement.

Kispotta *et al.* (2017) carried out correlation studies in gladiolus varieties and found that 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, days taken for first floret to open, number of floret open at a time, diameter of the floret and spike length. Days taken for spike emergence was however, negatively and significantly correlated with number of florets per spike, number of shoots per plant and vase life.

2.3.9 Dahlia

Nimbalkar *et al.* (2004) studied the correlation coefficient between number of flowers per plant and the related contributing characters in dahlia. The number of flowers per plant was highly significant and negatively correlated with fresh flower weight (-0.630) followed by days to flowering (-0.548), indicating the dependence of yield on these characters.

Basavaraju (2006) studied correlation and path analysis for twenty accessions of dahlia and revealed that significant and positive association of yield with plant height, number of branches, plant spread, number of leaves, duration of crop and number of tubers per plant. The high direct effect of path analysis for flower yield recorded for plant height, number of branches, number of leaves and days to 50 per cent flowering indicated the possibility of increasing flower yield by selecting the accession considering these characters directly.

Vikas *et al.* (2011) studied the association between fourteen vegetative and floral parameters in twenty five accessions of dahlia and revealed that number of leaves and leaf area had positive and significant correlation with plant height, number of days taken for first flowering, individual flower weight, ray floret length and number of flowers per plant.

Manjula and Nataraj (2016) studied the correlation and path analysis in Dahlia.
The results indicated a significant and desirable correlation between flower yield per hectare with the characters like plant height (0.614), number of branches per plant (0.806), internodal length (0.239), duration of the crop (0.195), flower weight (0.206), flower diameter (0.224), stalk length (0.549), number of tubers per plant (0.537), tuber weight (0.453) and vase life (0.234). Number of flowers per hectare had high positive direct effect with plant height (0.962), number of days taken to first flowering (0.646), flower weight (1.034), stalk length (0.253), number of tubers per plant (0.353), tuber weight (0.194) and vase life (0.285) at genotypic level. Thus, these characters have the maximum contribution towards the number of flowers per hectare.

2.3.10 Lisianthus

Namratha (2021) recorded correlation and path coefficient analysis for 15 genotypes of lisianthus at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under KSNUAHS, Shivamogga. The flower stalk yield revealed high significant positive correlation with plant height, leaf area, number of leaves, number of branches, internodal length, flower bud length. Path analysis for stalk yield per plant revealed that the plant height, number of branches, internodal length, flower length, individual weight of flower, have high positive effect.

MATERIAL AND METHODS

III MATERIAL AND METHODS

The present investigation on "Studies on character association and path analysis for yield and quality parameters in Stock (*Matthiola incana* L.) genotypes" was carried out under naturally ventilated polyhouse at College of Horticulture, Mudigere, under Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga during 2022-2023. The details of the experiment, materials used, methodologies followed and statistical analysis adopted for conducting the experiment and observations recorded during the course of investigation are furnished in this chapter.

3.1 Geographical location of the experimental site

The experiment was carried out in a Naturally ventilated polyhouse in the experimental block of the Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere which is situated in the Western Ghats and represents the typical hill zone (Zone-9 and Region-V) of Karnataka and lies at 13° 25' North latitude and 75° 25' East longitude with an altitude of 980 m above Mean Sea Level (MSL).

3.2 Climatic condition of the experimental site

Mudigere weather during experimental period was cool and pleasant throughout the year. The area received a total annual rainfall of 1150 mm during the experimental year
2022-23, which was mainly distributed six to eight months with the peak period of rainfall from July to August. The average annual maximum temperature was 33.11°C and the minimum temperature was 12.35°C. The average annual maximum relative humidity was 99.57 per cent and the minimum relative humidity was 50.07 per cent. The meteorological data for the period of experimentation was obtained from the meteorological observatory of Krishi Vigyan Kendra (KVK), Mudigere and the same is presented in Appendix-I.

3.3 Details of Naturally Ventilated Polyhouse (NVPH)

The naturally ventilated polyhouse of 1000 m^2 area is oriented in North-South direction. The frame work is made up of galvanized iron pipe (class B) with a central height of 6 meters and covered with UV-stabilized 200 micron LDPE film. Two sides are covered with 40 mesh insect proof net for natural ventilation and protection against entry of insect pests. Besides this insect net, a rollable flap of polyethylene sheet has also been provided outside the insect net to regulate the requirements of temperature and humidity depending on the season and weather conditions. The shade net with 50 per cent shade was laid out at above the headspace inside the polyhouse to manage the light intensity and temperature during summer.

3.4 Experimental details

3.4.1 Collection of genotypes

Eleven genotypes of Stock were collected and evaluated under the experiment. Among them, eight genotypes were collected from Sakata seeds, Doddaballapura and three genotypes from Pan America seed company.

3.4.2 Experimental design and layout

Location	College of Horticulture, Mudigere (NVPH)
Crop	Stock (*Matthiola incana* L.)
Season	*Rabi*
Design	Randomized Complete Block Design (RCBD)
Number of genotypes	11
Number of replications	3
Planting method	Raised bed
Plot size	1.2 m × 1.2 m
Spacing	25 cm × 25 cm

3.4.3 Genotype Details

The eleven Stock genotypes used, were considered as the genotypes in the study.

Genotypes no.	Genotypes
G_1	Early Arrow white
G_2	Arrow White
G_3	Quartet Deep Yellow
G_4	Early Iron White
G_5	Early Iron Yellow
G_6	Early Iron Deep Yellow
G_7	Early Iron Marine
G_8	Early Iron Pink
G_9	Stock Katz Ruby
G_{10}	Stock Katz Blue
G_{11}	Stock Katz Purple

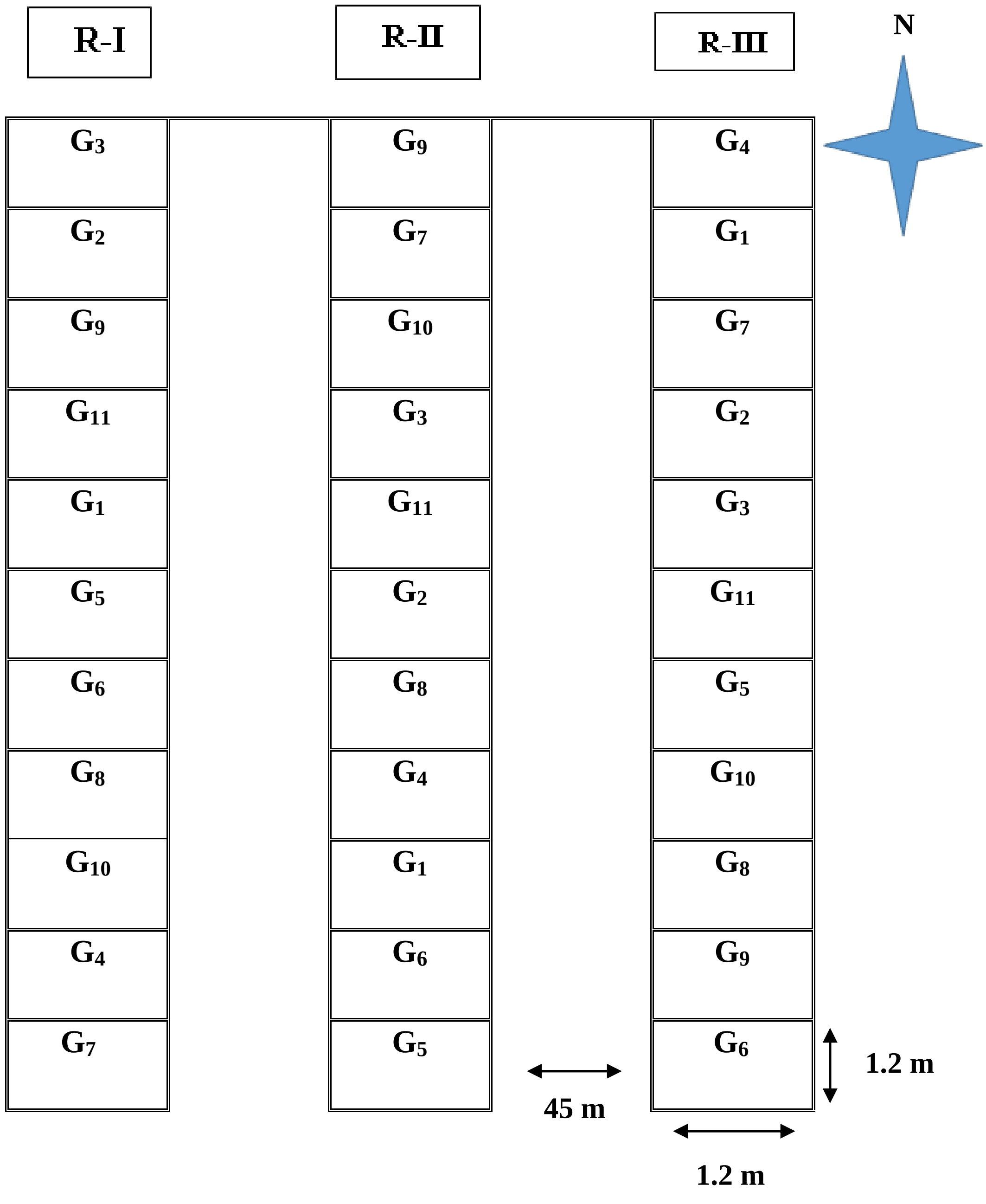

Fig. 1. Plan and layout of the experimental block under protected condition

3.4.4 Experimental material

Eleven genotypes were used in the experiment. The salient features of different varieties are detailed below (Table 1).

3.5 Cultural practices

The details regarding the various cultural operations carried out during the programme of investigation are furnished below.

3.5.1 Bed preparation

The experimental field was prepared well by removing the stones, weeds and other materials and brought into a fine tilth. The raised beds of 20 cm height, 1.2 m wide and 14 m long were prepared by adding FYM and coco peat in the ratio of 2:1:1 and neem cake 500 g/m² was added 30 days before the planting.

3.5.2 Fertilizer application

The recommended fertilizer dose of 250:150:150 g N:P:K per m² was applied in the form of Calcium nitrate, Diammonium phosphate and Muriate of potash. 50 per cent of N and entire dose of P and K were applied at the time of field preparation. Remaining dose of N was applied 30 days after transplanting (Singh, 2006).

3.5.3 Transplanting

Irrigation was given three to four days prior to transplanting to minimize the damage to the roots. sixty days old seedlings (fourth true leaf stage) were transplanted to the experimental plot at 25 cm × 25 cm spacing. In order to avoid stem rot, care was taken not to bury the plants too deep. Light irrigation was given just after transplanting. To ensure a healthy start, high relative humidity for 10 days after transplanting was maintained and the soil was not allowed to dry. Thereafter, drenching was done with Carbendazim (0.1%)

3.5.4 After care

3.4.4.1 Gap filling

After one week of transplanting, gap filling was done whenever the mortality of seedlings was observed in order to maintain the desired plant population.

3.5.4.2 Fertilizer application

Basal dose of fertilizers was applied before transplanting. Thereafter, the application of water-soluble fertilizers was started 30 days after transplanting. NPK was applied in the form of 19:19:19 at 5g L^{-1} and micronutrient at 2g L^{-1} mixture was sprayed twice a week (Singh, 2006).

Table 1. Details of the different Stock (*Matthiola incana* L.) genotypes used in the investigation.

Genotypes no.	Genotype	Features
G_1	Earl Arrow white	Medium inflorescence, standard type with mild fragrance.
G_2	Arrow White	Long inflorescence, standard type with mild fragrance.
G_3	Quartet Deep Yellow	Medium inflorescence, spray type with mild fragrance.
G_4	Early Iron White	Long inflorescence, standard type with mild fragrance.
G_5	Early Iron Yellow	Medium inflorescence, standard type with mild fragrance.
G_6	Early Iron Deep Yellow	Medium inflorescence, standard type with mild fragrance.
G_7	Early Iron Marine	Medium inflorescence, standard type with more fragrance.
G_8	Early Iron Pink	Medium inflorescence, standard type with more fragrance.
G_9	Stock Katz Ruby	Long inflorescence, spray type with mild fragrance.
G_{10}	Stock Katz Blue	Long inflorescence, standard type with more fragrance.
G_{11}	Stock Katz Purple	Long inflorescence, spray type with mild fragrance.

G_1: Early Arrow white

G_2: Arrow White

G_3: Quartet Deep

G_4: Early Iron White

Plate 1a. Stock (*Matthiola incana* L.) genotypes used in the present investigation

G_5: Early Iron Yellow

G_6: Early Iron Deep Yellow

G_7: Early Iron

G_8: Early Iron Pink

Plate 1b. Stock (*Matthiola incana* L.) genotypes used in the present investigation

G_9: Stock Katz Ruby

G_{10}: Stock Katz Blue

G_{11}: Stock Katz Purple

Plate 1c. Stock (*Matthiola incana* L.) genotypes used in the present investigation

Raised bed preparation

Stock seedling at transplanting stage

Plate 2. Raised bed preparation and Stock (*Matthiola incana* L.) seedling at transplanting stage

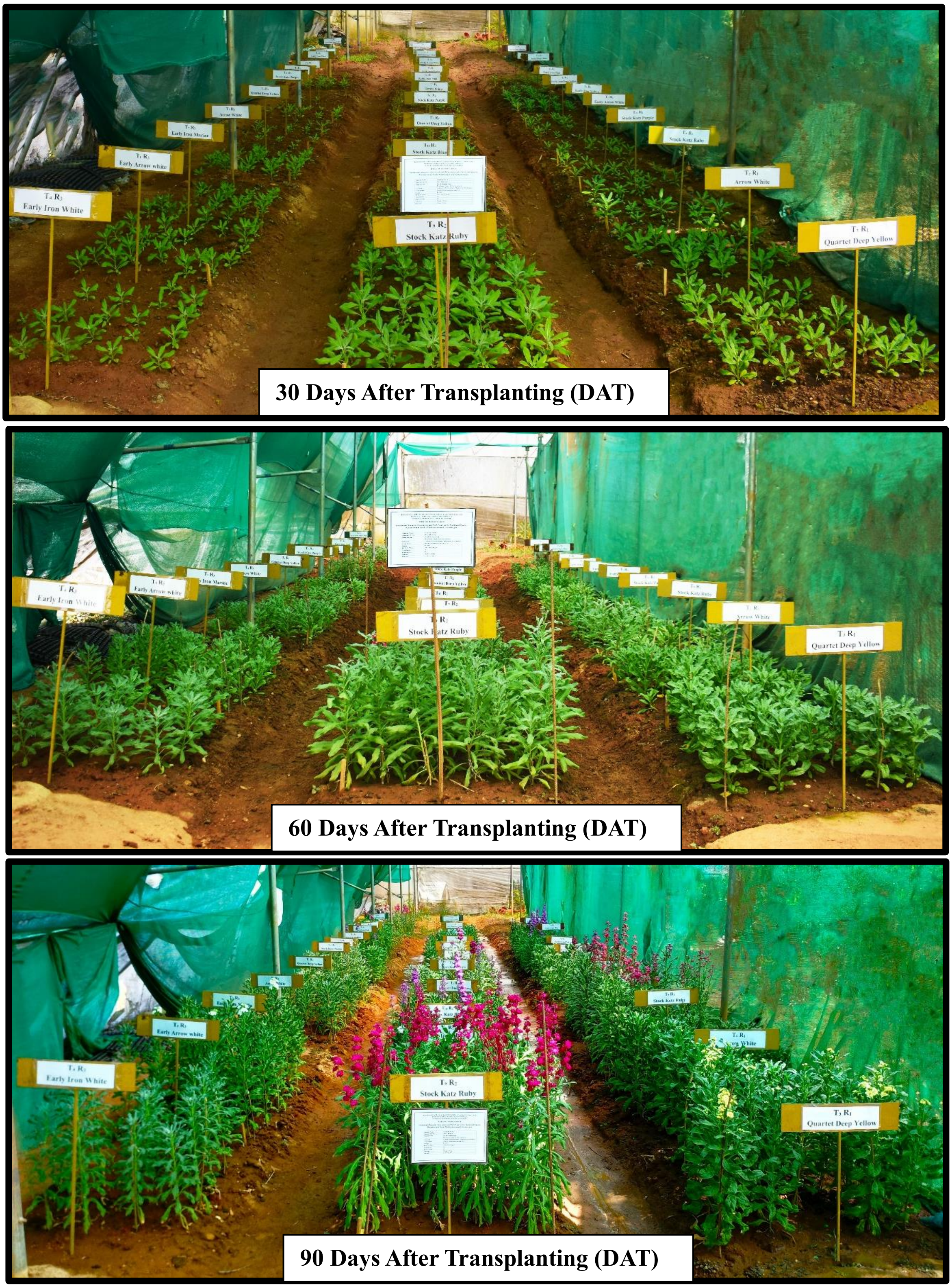

Plate 3. General view of experimental field at different crop growth stages

Plate 4. General view of experimental field at peak flowering stages

3.5.4.3 Irrigation

The overhead irrigation system was followed to maintain the humidity inside the polyhouse. The irrigation was done four times a week for the plants during hot months and twice a week during cool months.

3.5.4.4 Staking

Staking of the plant by wooden sticks or by wire mesh is essential to avoid the breakage of flower stalks and stems.

3.5.4.5 Weeding

Manual weeding was done whenever the weeds appeared to avoid the competition with the main crop.

3.5.4.6 Other intercultural operations

Routine intercultural operations like, earthing up, raking, hoeing and control of insect-pests and diseases, *etc*. were done as per the requirement.

3.5.5 Harvesting of flowers

Stock requires 12 to 15 weeks for flowering. The flowers were cut along with stems above the ground level. The inflorescence was harvested when ten to twenty florets were opened. Harvesting was done in the morning hours when temperature was cool. The stems were placed in cool water with preservatives and brought to the cold room to remove the field heat.

3.6 Collection of experimental data

3.6.1 Vegetative parameters

Five plants were selected randomly and labeled from each plot. The observations were recorded at 30 days intervals after transplanting for the parameters *viz.*, plant height, number of leaves, leaf length, leaf width, internodal length, plant spread whereas, leaf area and chlorophyll content were recorded at grand growth stage.

3.6.1.1 Days taken for germination

Five seeds which were sowed in the portray were selected randomly and recorded the days taken for germination and the average was worked out for each genotype.

3.6.1.2 Plant height (cm)

The plant height was taken from the base to the tip of the plant at different growth stages from the randomly selected five plants and the average was worked out.

3.6.1.3 Number of leaves per plant

Number of leaves produced per plant from five randomly selected plants were recorded and average number of leaves produced was worked out.

3.6.1.4 Leaf length (cm)

The leaf length was recorded by measuring from the base to the longest point and average of these five leaves were worked out.

3.6.1.5 Leaf width (cm)

The leaf width was taken from the widest part of the leaf and average of these five leaves were worked out.

3.6.1.6 Leaf area (cm^2/plant)

The leaf area was estimated by using leaf area meter (Leaf area meter model 211) at peak stage of growth by selecting leaves randomly and equally from top, middle and bottom of the plant. The readings were taken from the tagged plants and average leaf area was multiplied by the number of leaves per plant of individual genotypes to get leaf area per plant.

3.6.1.7 Plant spread (cm)

Plant spread was recorded in East-West and North-South directions from the randomly selected five plants. The average plant spread in each direction was worked out.

3.6.1.8 Internodal length (cm)

Internodal length was recorded between two nodes of stem and average of these five plants were worked out.

3.6.2 Flowering parameters

3.6.2.1 Days taken to flower stalk emergence

This was recorded from the randomly selected plants by counting the days from date of transplanting to the stage at which the flower stalk was initiated in different genotypes.

3.6.2.2 Days taken to first visible flower

This was recorded by counting the number of days from the date of transplanting to the stage at which the first floret bloomed in the inflorescence. This was recorded from the randomly selected plants and average was worked out.

3.6.2.3 Days taken to flower stalk harvest

Number of days taken from the date of transplanting to the opening of 10-20 florets in the inflorescence in each genotype. This was observed in the randomly selected plants.

3.6.2.4 Flower longevity in plants (days)

Total number of days from the date of flower opening to the colour fading of the florets in the inflorescence were measured in the field.

3.6.3 Flower quality parameters

3.6.3.1 Stalk length (cm)

The flower stalk length was measured from scale from five randomly selected plants.

3.6.3.2 Stalk girth (mm)

The flower stalk diameter was taken from Vernier caliper from randomly selected five plants and expressed in millimeter.

3.6.3.3 Weight of flower stalk (g)

The flower stalk of five randomly selected plants was harvested and weighed by using weighing balance and expressed in grams.

3.6.3.4 Number of florets per stalk.

Total number of florets per stalk was recorded from five randomly selected plants of each genotype and average was calculated.

3.6.3.5 Floret diameter (cm)

Diameter of the floret was measured at the point of maximum breadth with scale from randomly selected plants.

3.6.3.6 Vase life (days)

The flower stems were harvested from the selected tagged plants. Soon after harvest, flowers were kept in a bucket containing fresh water to remove field heat. Then the stalks were cut again to uniform stem length. The flower stalks were placed in a conical flask containing 500ml of tap water. The flowers were observed daily up to the senescence of flowers. The vase life was measured from the date of harvest until the senescence of petals.

3.6.3.7 Flower colour

For the assessment of colour characteristics, the Royal Horticulture Society (RHS) – 2015 (6^{th} edition) colour chart was used to record the variations and presented in Table 2.

3.6.3.8 Consumer acceptance

Consumer acceptance of Stock inflorescence was carried out based on various attributes like flower colour, cut flower suitability, fragrance and overall acceptability. (Perk *et al.,* 2009). The score has been given using a 1-5 hedonic scale and the same is presented in Table 16.

Table 2. Flower colour of different Stock (*Matthiola incana* L.) genotypes

Genotypes	Colour Group	Colour	Code
G_1 : Early Arrow white	White	White	NN155 C
G_2 : Arrow White	White	White	NN155 C
G_3 : Quartet Deep Yellow	Yellow	Pale greenish yellow	10 D
G_4 : Early Iron White	White	White	NN155 C
G_5 : Early Iron Yellow	Yellow	Light yellow	10 C
G_6 : Early Iron Deep Yellow	Yellow	Light yellow	10 B
G_7 : Early Iron Marine	Purple	Light purple	76 A
G_8 : Early Iron Pink	Red purple	Deep purple pink	73 A
G_9 : Stock Katz Ruby	Red purple	Vivid reddish purple	N74 A
G_{10}: Stock Katz Blue	purple violet	Light purple	N82 C
G_{11}: Stock Katz Purple	purple violet	Strong purple	N82 A

3.6.4 Biochemical parameters

3.6.4.1 Chlorophyll content

Chlorophyll estimation procedure (Shoaf and Lium., 1976)

The fresh and fully matured leaves from the plant were collected from the research field and brought to a laboratory. The known weight of the leaf sample (100 mg) was cut down into small pieces and incubated in 7 ml of dimethyl sulphoxide at 65°C for 120 minutes. After the incubation period, the supernatant was collected and leaf tissue was discarded.

The volume of the supernatant was made into 10 ml using DMSO. The absorbance of the extract was measured at 645 and 663 nm using DMSO as a blank in a Spectrophotometer (VISISCAN, 167).

The amount of Chlorophyll 'a', 'b' and total chlorophyll content was calculated using the formulae given below and was expressed in milligram per gram fresh weight (mg/g fresh weight):

Chlorophyll- a = $12.70 (A_{663}) - 2.69 (A_{645}) \times V/ (1000 \times W \times a)$ (mg/g fresh weight)

Chlorophyll- b = $22.90 (A_{645}) - 4.68 (A_{663}) \times V/ (1000 \times W \times a)$ (mg/g fresh weight)

Total chlorophyll = $20.20 (A_{645}) + 8.02 (A_{663}) \times V/ (1000 \times W \times a)$ (mg/g fresh weight)

Where A = Absorbance at a specific wavelength (645 nm and 663 nm)

V = Final volume of the extract (10 ml)

W = Fresh weight of the sample (100 mg)

a = path length of light in the cuvette (1 cm)

3.6.5 Incidence of pests and diseases

Pests and diseases incidence were observed during crop growth and flowering stages. Appropriate prophylactic plant protection measures were taken as and when necessary, during the experimentation period.

3.6.6. Yield parameter

3.6.6.1 Number of cut flowers per plant

The total number of cut flower stalks were harvested at peak flowering stage from the five randomly selected tagged plants individually were worked out.

3.6.6.2 Number of cut flowers per m^2

The total number standard cut flower stalks were harvested within the plot at peak flowering stage and were worked out.

3.6.6.3 Number of cut flowers per 1000 m^2

The number of stalks per 1000 m^2 was worked out by converting the total number of stalk yield per square meter to a 1000 m^2

3.7 Economics of cultivation

To assess the effect of each genotype the cost of cultivation (per 1000 m^2) was worked out this includes the cost of planting materials (₹ 67,650), cost of fertilizer (urea, diammonium phosphate, Muriate of potash, 19:19:19, micronutrients and calcium nitrate) (₹ 5,970) and the cost of FYM (300 ₹/tonnes) was taken at the current existing rates. The labour cost (₹ 300/head), including fertilizer application, irrigation, plant protection, weeding *etc*. were taken into account during the cropping period and worked out the cut flower yield obtained for individual genotype taken into consideration and the same is presented in Appendix-II. Based on the total cost obtained, gross return, net return and the benefit-cost ratio were computed.

3.7.1 Cost of cultivation

The prize of all inputs prevailing at the time of their use and the labour cost was used to work out the cost of cultivation and expressed in rupees per 1000 m^2.

3.7.2 Gross return

The gross income was worked out based on the prevailing market rate of Stock flower stems per 1000 m^2.

3.7.3 Net return

The net return was calculated by subtracting cost of cultivation from gross income and expressed in rupees per 1000 m^2.

Net income was calculated by using the formula

Net income = Gross income - Cost of cultivation.

3.7.4 Benefit:Cost Ratio (BCR)

The cost-benefit ratio for different genotypes was worked based on the prize of the inputs used for cultivation and prize of marketable products in the local market by using the formula and expressed in the ratio.

Benefit: cost ratio = (Net return)/(Cost of cultivation)

3.8 Statistical analysis

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

3.8.1 Mean

Mean is the sum of all observations in a sample divided by the number of observations (n).

Mean= ∑ Xi/n

Where, Xi = i^{th} observation of a population

n = Number of observations

3.8.2 Range

Range is the minimum and maximum values of the observations in a sample of the genotype.

3.8.3 Analysis of variance (ANOVA)

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1967) using mean value of random plant in each replication from all genotypes to find out significance of genotype effects. The model of variance was as follows:

Source of variation	**Degree of freedom**	**Sum of square (SS)**	**Mean sum of square (MSS)**	**'F' ratio**	
				Calculated	**Table at 5%**
Replications	(r-1)	SSr	Mr = SSr/ r-1	Mr/ Me	
Genotypes	(t-1)	SSt	Mt = SSt/ t-1	Mt/ Me	
Error	(t-1) (r-1)	SSe	Me = SSe/ (r-1) (t-1)		
Total	(rt-1)				

Where,

r = Number of replications

t = Number of genotypes

SSr = Replication sum of squares

SSt = Treatment sum of squares

SSe = Error sum of squares

Mr = Replication mean sum of squares

Mt = Treatment mean sum of squares

Me = Error mean sum of squares

MSS =Mean sum of square

3.8.4 Standard error

It was the measure of uncontrolled variation present in a sample which was estimated by dividing the standard deviation (SD) by the square root of the number of observations (n) in the sample and was denoted by SE.

$$SE = \frac{SD}{\sqrt{n}}$$

3.8.5 Critical difference

Critical difference (CD) was calculated by multiplying the SE with table't' value at 5 per cent and 1 per cent of probabilities for error degrees of freedom. The critical difference was calculated as,

$$\text{Critical difference (CD)} = \sqrt{2 \times \text{S.Em} \times t(\alpha, \text{Edf})}$$

$$\text{S.Em}\pm = \sqrt{2\ \text{EMS}/r}$$

Where,

S. Em = Standard error of two treatment means

EMS = Error mean of square

r = Number of replications

Where,

α - the level of significance (5 and 1 %)

df - degrees of freedom.

3.8.6 Variance

Variance is defined as the average of the standard deviation of individual observation from the mean. It is expressed as sum of squares of the deviations of all observation of a sample from its mean and divided by (n-1), where 'n' is the number of observations. It is estimated by the following formula.

$$\text{Variance} = \frac{\Sigma \text{Xi}\ 2 - (\Sigma \text{X})2/n}{(n-1)}$$

Where, X_i= i^{th} observation of population

n= Number of observations

3.8.7 Standard deviation (SD)

The standard deviation was calculated as,

$$SD = \sqrt{Variance}$$

3.8.8 Estimation of genetic variability parameters

The variability for different quantitative and qualitative traits in Stock was estimated as detailed below.

3.8.8.1 Phenotypic, genotypic variance and environmental variance

Variance due to genotype, phenotype and environment were computed as follows.

Phenotypic variance (σ^2p) = Genotypic variance + Environment variance

$$\text{Genotypic variance } (\sigma^2 g) = \frac{\text{MSS (genotypes)-MSS (error)}}{\text{Number of replications}}$$

Environment variance (σ^2e) = Error mean sum of squares

3.8.8.2 Phenotypic and genotypic coefficient of variance

Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for all the characters were calculated according to the formula given by Burton and De Vane (1953).

a. Phenotypic coefficient of variation (PCV%) = $\frac{\sigma^2 p}{\bar{X}} \times 100$

b. Genotypic coefficient of variation (GCV%) = $\frac{\sigma^2 g}{\bar{X}} \times 100$

Where,

σ^2p = Phenotypic variance

σ^2g = Genotypic variance

$\bar{X}$ = Mean

PCV and GCV values were classified as shown below following the method suggested by Robinson *et al*. (1949).

0-10% = Low

10-20% = Moderate

Above 20% = High

3.8.8.3 Heritability (h^2 broad sense)

Heritability (broad sense) was estimated for all the characters using the following of Johnson *et al*. (1955).

$$h^2 (\%) = \frac{\sigma^2 g}{\sigma^2 p} \text{ X } 100$$

Where,

h^2_{bs} = Heritability (broad sense) expressed in per cent.

$\sigma^2 g$ = Genotypic variance.

$\sigma^2 p$ = Phenotypic variance.

The heritability percentage was categorized as low, moderate and high as suggested by Robinson *et al.* (1949) and is given below.

0-30% = Low

30-60% = Moderate

Above 60% = High

<u>*3.8.8.4 Genetic advance (GA)*</u>

The extent of genetic advance expected through selection for each character was estimated by using the following formula of Johnson *et al*. (1955).

$GA = h^2 \times K \times \sigma_p$

Where.

h^2 = Heritability estimate

K = Selection differential which is equal to 2.06 at 5 percent intensity of selection.

σ_p = Phenotypic standard deviation

<u>*3.8.8.5 Genetic advance as per cent over mean*</u>

The genetic advance as per cent of mean was computed by using the following formula

$$\text{GA as percent of mean} = \frac{\text{GA}}{\text{Grand mean}} \times 100$$

Genetic advance as per cent of mean was categorized into low, moderate and high as given below following the method of Johnson *et al.* (1955).

0-10% = Low

10-20% = Moderate

Above 20% = High

<u>*3.8.9 Correlation analysis*</u>

To determine the degree of association of flower stalk yield with its attributing traits as well as among the yield attributing traits, the correlation coefficients were calculated using the following formulae of Al-Jibouri *et al.* (1958).

$$r_p\,(xy) = \frac{Cov_p\,(xy)}{\sqrt{\sigma^2 p(x).\ \sigma^2 p(y)}}$$

Where,

r_p (xy) = phenotypic correlation coefficient between characters ‘x’ and ‘y’

Cov_p (xy) = phenotypic variance of character ‘x’

$\sigma^2_p(y)$ = phenotypic variance of character 'y'

The calculated 'r' value was compared with table 'r' value at (n=2) degrees of freedom for significance at 0.05 and 0.01 probability level, where 'n' refers to number of pairs of observations.

3.8.10 Path coefficient analysis

Path coefficient analysis was carried out using the simple correlation coefficient to know the direct and indirect effects of the yield components as suggested by Wright (1921) and illustrated by Dewey and Lu (1959).

Path coefficients were obtained by solving simultaneous equations, which express the basic relationship between correlations and path coefficients as described by Goulden (1959).

The equations were as follows

$P_{01} + P_{02}\, r_{12} + \text{..........................} + Pop\, r_{1p} = r_{01}$

$P_{02}\, r_{12} + P_{02} + \text{..........................} + Pop\, r_{2p} = r_{02}$

$P_{02}\, R_{iop} + P_{02}\, r_{2p} + \text{..........................} + P_{op} = r_{02}$

Where,

P_{01}, P_{02},............Pop = Direct path coefficient of variables 1, 2, ...P on the independent variable 0.

r_{12}, r_{13}, r_{ip}, ...r_p (p-1) = Possible correlation coefficients between independent variables.

r_{01}, r_{02},.......................r_{op} = The correlation between dependent and independent variables.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The present investigation was conducted on "Studies on character association and path analysis for yield and quality parameters in Stock (*Matthiola incana* L.) genotypes" which was carried out in the Naturally ventilated polyhouse at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, in the year 2022-2023. The study involves 11 genotypes of Stock to study the correlation and path coefficient analysis. Further, the variability studies *viz.,* genetic variance (GV), phenotypic variance (PV), genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense), genetic advance (GA) and genetic advance over per cent mean (GAM) were also conducted under protected cultivation for growth, flowering, yield and quality parameters. The experimental data that supports the objectives collected during the study for various parameters have been statistically analyzed and are presented in this chapter with the following headings.

4.1 Growth parameters

4.2 Flowering parameters

4.3 Flower quality parameters

4.4 Yield parameters

4.5 Genetic variability studies

4.6 Correlation coefficient analysis

4.7 Path coefficient analysis

4.8 Incidence of pests and diseases

4.9 Economics

4.1 Growth parameters

Growth parameters *viz.,* days taken for germination, plant height, leaf length, leaf width, internodal length, plant spread, number of leaves per plant were recorded at 30 days interval after transplanting whereas, leaf area and chlorophyll content were recorded at grand growth stage. The results obtained from these characters were analyzed and are presented below.

4.1.1 Days taken for germination

The data pertaining to days taken for germination of different genotypes of Stock is presented in Table 3.

Among different genotypes, the genotype Stock Katz Ruby recorded earlier seed germination (5.33 days) which was on par with Stock Katz Blue and Quartet Deep Yellow (6.33 days) while, the seed germination was delayed in Early Iron Yellow (13.33 days) which was on par Early Iron Marine (12.67 days).

Table 3. Performance of Stock (*Matthiola incana* L.) genotypes with respect to days taken for germination

Genotypes	Days taken for germination
G_1 - Early Arrow white	8.67
G_2 - Arrow White	9.67
G_3 - Quartet Deep Yellow	6.33
G_4 - Early Iron White	10.00
G_5 - Early Iron Yellow	13.33
G_6 - Early Iron Deep Yellow	12.00
G_7 - Early Iron Marine	12.67
G_8 - Early Iron Pink	11.33
G_9 - Stock Katz Ruby	5.33
G_{10} - Stock Katz Blue	6.33
G_{11} - Stock Katz Purple	6.67
S. Em ±	**0.44**
CD @ 5%	**1.30**

4.1.2 Plant height (cm)

The data pertaining to plant height of different genotypes of Stock at various growth stages after transplanting are presented in Table 4.

The height of the plant varied significantly among the different genotypes of Stock at 30 days after transplanting (DAT). Among different genotypes, the genotype Stock Katz Ruby recorded the maximum plant height (13.50 cm) which was on par with Quartet Deep Yellow (13.46 cm), Arrow White (12.89) and Early Arrow white (12.27) while, the minimum plant height was recorded in Early Iron White (7.73 cm).

The height of the plant varied significantly among the different genotypes of Stock at 60 days after transplanting (DAT). Among different genotypes, the genotype Stock Katz Ruby recorded the maximum plant height (53.99 cm) which was followed by Early Iron Marine (45.10 cm) which is on par with Stock Katz Purple (37.71 cm) while, the minimum plant height was recorded in Early Iron Deep Yellow (27.39 cm).

The significant differences were observed with respect to plant height in different genotypes of Stock at 90 days after transplanting (DAT). The genotype Stock Katz Blue recorded the maximum plant height (72.00 cm) which was statistically on par with Stock Katz Ruby (68.44 cm), Stock Katz Purple (67.27 cm) and Early Iron White (66.65 cm) while, the minimum plant height was recorded in Quartet Deep Yellow (54.87 cm) which is on par with Early Iron Marine (55.61 cm), Early Iron Pink (56.08 cm) and Early Iron Deep Yellow (56.55 cm).

4.1.3 Number of leaves per plant

The data pertaining to number of leaves produced different genotypes of Stock at various growth stages after transplanting are presented in Table 5.

The maximum number of leaves per plant was recorded in case of genotype Early Iron Marine (14.87), which was on par with Stock Katz Ruby (14.60). While, the minimum number of leaves per plant was recorded in Early Iron White (8.93) in different genotypes of Stock at 30 days after transplanting (DAT).

The genotype Stock Katz Ruby (55.33), significantly recorded the maximum number of leaves per plant which is followed by Early Iron Marine (35.13) and Stock Katz Blue (33.67) while, the minimum number of leaves per plant recorded in the genotype Early Iron Deep Yellow (27.87) at 60 days after transplanting (DAT).

The number of leaves per plant in case of genotype Stock Katz Ruby (70.73), which was significantly maximum than other genotypes which was on par with Stock Katz Purple (66.47) and Early Arrow white (65.73) while, the minimum number of leaves per plant recorded in the genotype Early Iron Deep Yellow (47.33) among different genotypes of Stock at 90 days after transplanting.

Table 4. Performance of Stock (*Matthiola incana* L.) genotypes with respect to plant height under protected cultivation

Genotypes	Plant height (cm)		
	Days after transplanting (DAT)		
	30	**60**	**90**
G_1 - Early Arrow white	12.27	32.83	56.73
G_2 - Arrow White	12.89	33.42	61.79
G_3 - Quartet Deep Yellow	13.46	33.59	54.87
G_4 - Early Iron White	7.73	32.77	66.65
G_5 - Early Iron Yellow	9.26	30.69	56.59
G_6 - Early Iron Deep Yellow	10.21	27.39	56.55
G_7 - Early Iron Marine	12.30	45.10	55.61
G_8 - Early Iron Pink	9.98	30.49	56.08
G_9 - Stock Katz Ruby	13.50	53.99	68.44
G_{10} - Stock Katz Blue	11.46	33.49	72.00
G_{11} - Stock Katz Purple	10.81	37.71	67.27
S. Em ±	**0.42**	**2.73**	**2.12**
CD @ 5%	**1.25**	**8.05**	**6.24**

4.1.4 Leaf length (cm)

The data pertaining to leaf length of different genotypes of Stock at various growth stages after transplanting are presented in Table 5.

The maximum leaf length was recorded in case of genotype Early Iron Pink (10.29 cm), which was followed by Stock Katz Ruby (9.95 cm) and Stock Katz Blue (9.59 cm) while, the minimum leaf length was recorded in Early Iron Deep Yellow (6.91 cm) in different genotypes of Stock at 30 days after transplanting (DAT).

The leaf length varied significantly at 60 days after transplanting (DAT) in different genotypes of Stock. Among different genotypes, the maximum leaf length recorded in Stock Katz Purple (16.24 cm) which was on par with Stock Katz Ruby (16.01 cm) while, the minimum leaf length was recorded in Early Iron Yellow (11.98 cm).

The leaf length varied significantly among the different genotypes of Stock at 90 days after transplanting (DAT). Among different genotypes, the genotype Stock Katz Purple (18.55 cm) recorded the maximum leaf length and which was on par with Stock Katz Ruby (17.83 cm) while, the minimum leaf length recorded in Early Iron Yellow (12.77 cm).

4.1.5 Leaf width (cm)

The data related to leaf width of different genotypes of Stock at various growth stages after transplanting are presented in Table 5.

The leaf width varied significantly among the different genotypes of Stock at 30 days after transplanting (DAT). Among different genotypes, the maximum leaf width observed in Early Iron Marine (3.01 cm) which was on par with Quartet Deep Yellow (2.75 cm), Early Iron Pink (2.71 cm) and Early Iron White (2.68 cm) while, the minimum leaf width recorded in Early Iron Deep Yellow (1.73 cm).

At 60 days after transplanting (DAT) among different genotypes, the genotype Early Iron Marine (3.67 cm) recorded the maximum leaf width which was on par with Stock Katz Ruby (3.00 cm) and Early Iron White (3.49 cm) whereas the minimum leaf width recorded in Early Iron Yellow (2.62 cm).

The leaf width showed significant difference among different genotypes of Stock at 90 days after transplanting (DAT). Among the different genotypes, the genotype Quartet Deep Yellow (4.09 cm) recorded the maximum leaf width which was on par with Early Iron Marine (4.03 cm) and Early Iron White (3.87 cm) whereas, the minimum leaf width recorded in Early Iron Yellow (2.65 cm).

Table 5. Performance of Stock (*Matthiola incana* L.) genotypes with respect to number of leaves, leaf length, leaf width and leaf area under protected cultivation

Genotypes	Number of leaves per plant			Leaf length (cm)			Leaf width (cm)			Leaf area (cm^2/plant)
	Days after transplanting (DAT)			Days after transplanting (DAT)			Days after transplanting (DAT)			At grand growth stage
	30	60	90	30	60	90	30	60	90	
G_1 - Early Arrow white	13.20	32.67	65.73	7.87	12.89	14.33	2.04	2.85	3.02	1559.41
G_2 - Arrow White	13.60	32.27	54.53	9.25	13.68	17.10	2.47	3.32	3.38	1997.21
G_3 - Quartet Deep Yellow	13.27	31.60	51.27	9.32	13.82	13.87	2.75	3.45	4.09	1768.44
G_4 - Early Iron White	8.93	32.73	59.27	7.81	14.37	16.17	2.68	3.49	3.87	1668.91
G_5 - Early Iron Yellow	11.73	31.20	52.00	7.51	11.98	12.77	2.09	2.62	2.65	1868.49
G_6 - Early Iron Deep Yellow	10.20	27.87	47.33	6.91	12.03	13.75	1.73	2.68	3.35	1472.95
G_7 - Early Iron Marine	14.87	35.13	53.33	8.25	12.85	14.74	3.01	3.67	4.03	1864.78
G_8 - Early Iron Pink	14.40	32.07	59.33	10.29	13.14	14.75	2.71	3.00	3.08	2134.83
G_9 - Stock Katz Ruby	14.60	55.33	70.73	9.95	16.01	17.83	2.42	3.00	3.09	3199.94
G_{10} - Stock Katz Blue	12.53	33.67	53.87	9.59	14.84	16.65	2.46	3.17	3.40	2237.32
G_{11} - Stock Katz Purple	10.47	29.87	66.47	6.99	16.24	18.55	1.82	2.91	3.03	2880.85
S. Em ±	**0.51**	**1.60**	**1.95**	**0.11**	**0.74**	**0.28**	**0.11**	**0.17**	**0.12**	**67.23**
CD @ 5%	**1.49**	**4.71**	**5.76**	**0.32**	**2.18**	**0.83**	**0.33**	**0.51**	**0.36**	**198.33**

4.1.6 Leaf area (cm^2/plant)

The data refer to leaf area of different genotypes of Stock at peak growth stage is presented in Table 5. Leaf area varied significantly among the genotypes at peak growth stage.

At peak growth stage, Stock Katz Ruby had recorded significantly the maximum leaf area (3199.94 cm^2/plant) which was followed by Stock Katz Purple (2880.85 cm^2/plant) whereas, the minimum leaf area was recorded in the genotype Early Iron Deep Yellow (1472.95 cm^2/plant) which is on par with Early Iron White (1668.91 cm^2/plant).

4.1.7 Plant spread in East-West (E-W) direction (cm)

The data related to plant spread in East-West (E-W) direction in different genotypes of Stock at various growth stages after transplanting are presented in Table 6.

The significant differences were observed with respect to plant spread in East-West direction in different genotypes of Stock at 30 days after transplanting (DAT). Among the different genotypes, the genotype Stock Katz Ruby recorded the maximum plant spread (E-W) (17.25 cm) which is on par with Early Iron Pink (17.06 cm) and Stock Katz Blue (16.04 cm) while, the minimum plant spread (E-W) was recorded in the genotype Early Iron White (10.47 cm).

The genotype Stock Katz Ruby (30.11 cm) recorded the maximum plant spread (E-W) which is on par with Stock Katz Purple (28.90 cm) whereas, the minimum plant spread (E-W) (16.45 cm) observed in Early Arrow white at 60 days after transplanting (DAT).

Among the different genotypes of Stock, plant spread (E-W) varied significantly at 90 days after transplanting (DAT). Among different genotypes, the genotype Stock Katz Purple (39.00 cm) recorded the maximum followed by Stock Katz Blue (33.71 cm) whereas, the minimum plant spread (E-W) observed in Early Arrow white (20.02 cm).

4.1.8 Plant spread in North-south direction (N-S) (cm)

The data related to plant spread in North-South (N-S) direction in different genotypes of Stock at various growth stages after transplanting are presented in Table 6.

Among different genotypes of Stock, plant spread (N-S) varied significantly at 30 days after transplanting (DAT). The genotype Stock Katz Ruby (17.69 cm) observed the maximum plant spread (N-S) which was on par with Early Iron Pink (16.87 cm) and Stock Katz Blue (15.71 cm) whereas, the minimum plant spread (N-S) was recorded in Early Iron White (10.41 cm).

The genotype significantly Stock Katz Ruby the maximum plant spread (N-S) (27.69 cm) which is on par with Stock Katz Purple (27.03 cm), Early Iron White (26.16 cm) and Stock Katz Blue (23.56 cm) whereas, the minimum plant spread (N-S) observed in Early Arrow white (17.39 cm) at 60 days after transplanting (DAT).

At 90 days after transplanting (DAT), significantly the maximum plant spread (N-S) was observed in Stock Katz Purple (38.94 cm) which is followed by Early Iron White (29.73 cm) which is on par with Arrow White (28.43 cm) whereas, the minimum plant spread (N-S) observed in Early Iron Marine (20.63 cm).

4.1.9 Internodal length (cm)

The data pertaining to internodal length of different genotypes of Stock at various growth stages after transplanting are presented in Table 6.

Stock genotypes showed significant differences with respect to internodal length at 30 days after transplanting (DAT). Among the different genotypes, the genotype Quartet Deep Yellow (1.89 cm) recorded the maximum internodal length followed by Arrow White (1.58 cm) while, the minimum internodal length recorded in Early Iron Marine (0.86 cm).

The significant differences were observed among different genotypes of Stock for internodal length at 60 days after transplanting (DAT). Among the different genotypes, the genotype Early Arrow white (2.35 cm) showed the maximum internodal length and followed by Quartet Deep Yellow (2.07 cm) whereas, the minimum internodal length recorded in Early Iron White (1.15 cm).

The significant differences were observed among different genotypes of Stock for internodal length at 90 days after transplanting (DAT). Among the different genotypes, the maximum internodal length recorded in the genotype Stock Katz Blue (2.99 cm) which was on par with Stock Katz Purple (2.80 cm) and followed by Early Arrow white (2.53 cm) which was on par with Quartet Deep Yellow (2.42 cm) whereas, the minimum internodal length recorded in the genotype Early Iron Yellow (1.25 cm).

4.1.10 Chlorophyll content (mg/g)

The data pertaining to chlorophyll content of leaf of different genotypes of Stock at peak growth stage after transplanting are presented in Table 7.

4.1.10.1 Chlorophyll ‘a’ (mg/g)

Significant differences were observed among different genotypes of Stock for chlorophyll content in leaf. Chlorophyll ‘a’ content was significantly the maximum in genotype Arrow White (0.87 mg/g) and followed by Early Iron Marine (0.84 mg/g) whereas, the minimum chlorophyll ‘a’ was recorded in Stock Katz Ruby (0.30 mg/g).

Table 6. Performance of Stock (*Matthiola incana* L.) genotypes with respect to plant spread and internodal length under protected cultivation

Genotypes	Plant spread (cm)						Internodal length (cm)		
	EW			NS			Days after transplanting (DAT)		
	Days after transplanting (DAT)			Days after transplanting (DAT)					
	30	60	90	30	60	90	30	60	90
G_1 - Early Arrow white	12.73	16.45	20.02	12.37	17.39	23.68	1.33	2.35	2.53
G_2 - Arrow White	13.27	17.34	25.89	13.04	21.90	28.43	1.58	1.66	1.69
G_3 - Quartet Deep Yellow	14.90	19.87	24.73	13.55	18.45	23.60	1.89	2.07	2.42
G_4 - Early Iron White	10.47	25.92	28.58	10.41	26.16	29.73	1.12	1.15	1.42
G_5 - Early Iron Yellow	11.71	17.92	24.00	11.77	19.15	23.27	1.23	1.23	1.25
G_6 - Early Iron Deep Yellow	11.73	19.09	28.59	10.58	18.74	24.43	1.23	1.28	1.39
G_7 - Early Iron Marine	13.31	18.83	23.73	13.57	21.84	20.63	0.86	1.19	1.81
G_8 - Early Iron Pink	17.06	21.02	22.83	16.87	20.25	25.56	1.18	1.20	1.32
G_9 - Stock Katz Ruby	17.25	30.11	28.46	17.69	27.69	31.85	1.29	1.51	2.21
G_{10} - Stock Katz Blue	16.04	22.35	33.71	15.71	23.56	26.97	1.01	1.23	2.99
G_{11} - Stock Katz Purple	12.09	28.90	39.00	12.87	27.03	38.94	1.10	1.35	2.80
S. Em ±	**0.45**	**1.01**	**1.00**	**0.80**	**1.48**	**0.77**	**0.05**	**0.05**	**0.06**
CD @ 5%	**1.34**	**2.98**	**2.95**	**2.35**	**4.37**	**2.26**	**0.13**	**0.16**	**0.19**

Table 7. Performance of Stock (*Matthiola incana* L.) genotypes with respect to chlorophyll content under protected cultivation

Genotypes	Chlorophyll content (mg/g fr. wt.)		
	Chlorophyll a	Chlorophyll b	Total Chlorophyll
G_1 - Early Arrow white	0.37	0.44	0.82
G_2 - Arrow White	0.87	0.16	1.03
G_3 - Quartet Deep Yellow	0.50	0.37	0.87
G_4 - Early Iron White	0.69	0.36	1.05
G_5 - Early Iron Yellow	0.35	0.44	0.80
G_6 - Early Iron Deep Yellow	0.44	0.51	0.95
G_7 - Early Iron Marine	0.84	0.42	1.26
G_8 - Early Iron Pink	0.77	0.44	1.21
G_9 - Stock Katz Ruby	0.30	0.43	0.73
G_{10} - Stock Katz Blue	0.37	0.33	0.70
G_{11} - Stock Katz Purple	0.38	0.39	0.77
S. Em ±	**0.01**	**0.01**	**0.01**
CD @ 5%	**0.01**	**0.02**	**0.02**

4.1.10.2 Chlorophyll 'b' (mg/g)

Significant differences were observed among different genotypes of Stock for chlorophyll content in leaf. Chlorophyll 'b' content was significantly the maximum in genotype Early Iron Deep Yellow (0.51 mg/g) and followed by Early Arrow white (0.44 mg/g) and Early Iron Yellow (0.44 mg/g) whereas, the minimum chlorophyll 'b' was recorded in Arrow White (0.16 mg/g).

4.1.10.3 Total chlorophyll (mg/g)

Significant differences were observed among different genotypes of Stock for total chlorophyll content in leaf. Total chlorophyll content was significantly the maximum in genotype Early Iron Marine (1.26 mg/g) and followed by Early Iron Pink (1.21 mg/g) whereas, the minimum total chlorophyll was recorded in Stock Katz Blue (0.70 mg/g).

4.2 Flowering parameters

The data pertaining to flowering characters like days taken to flower, days taken to flower opening and flower duration are furnished in Table 8.

4.2.1 Days taken to flower stalk emergence

The data pertaining to days taken to flower stalk emergence of different genotypes of Stock are presented in Table 8. The genotypes varied significantly with respect to days taken to flower stalk emergence. Among the different genotypes, the genotype Stock Katz Ruby (43.60) recorded the minimum number of days to flower stalk emergence which is followed by Stock Katz Purple (49.53) and Stock Katz Blue (51.67) whereas, genotype Early Iron Deep Yellow (96.53) recorded the maximum number of days to flower stalk emergence.

4.2.2 Days taken to first visible flower

The data pertaining to days taken to first visible flower of different genotypes of Stock are presented in Table 8. The significant differences were obtained with respect to days taken to first visible flower. Among the different genotypes, the genotype Stock Katz Ruby recorded the minimum number of days to first visible flower (55.40) which is followed by Stock Katz Purple (60.20) and Stock Katz Blue (62.93) whereas, genotype Early Iron Deep Yellow recorded the maximum number of days to first visible flower (106.53).

4.2.3 Days taken to flower stalk harvest

The data related to days taken to flower stalk harvest of different genotypes of Stock are presented in Table 8. The genotypes varied significantly with respect to days taken to flower stalk harvest. Among the different genotypes, the genotype Stock Katz

Table 8. Performance of Stock (*Matthiola incana* L.) genotypes with respect to days taken for stalk emergence, first visible flower and stalk harvest under protected cultivation

Genotypes	Days taken for		
	Stalk emergence	First visible flower	Stalk harvest
G_1 - Early Arrow white	78.20	88.40	104.13
G_2 - Arrow White	79.20	89.93	109.67
G_3 - Quartet Deep Yellow	73.53	83.33	96.60
G_4 - Early Iron White	81.47	91.47	110.67
G_5 - Early Iron Yellow	87.40	97.47	113.93
G_6 - Early Iron Deep Yellow	96.53	106.53	129.13
G_7 - Early Iron Marine	72.27	81.53	97.47
G_8 - Early Iron Pink	81.60	91.60	106.60
G_9 - Stock Katz Ruby	43.60	55.40	74.40
G_{10} - Stock Katz Blue	51.67	62.93	83.11
G_{11} - Stock Katz Purple	49.53	60.20	81.07
S. Em ±	**0.84**	**1.12**	**2.00**
CD @ 5%	**2.49**	**3.29**	**5.90**

Ruby recorded the minimum number of days taken to flower stalk harvest (74.40) which was followed by Stock Katz Purple (81.07) and Stock Katz Blue (83.13) whereas, genotype Early Iron Deep Yellow recorded the maximum number of days taken to flower stalk harvest (129.13).

4.3 Flower quality parameters

The data pertaining to flower quality characters of different genotype of Stock were presented in Table 9.

4.3.1 Stalk length (cm)

The significant differences obtained with respect to stalk length in different genotypes of Stock is presented in Table 9. The maximum stalk length was recorded in the genotype Stock Katz Blue (93.93 cm) and followed by Stock Katz Ruby (89.07 cm) which is on par with Stock Katz Purple (87.07 cm) while, the minimum stalk length was recorded in the genotype Quartet Deep Yellow (64.87 cm).

4.3.2 Stalk girth (mm)

The significant differences obtained with respect to stalk girth in different genotypes of Stock is presented in Table 9. The maximum stalk girth was recorded in the genotype Arrow White (10.40 mm) and followed by Quartet Deep Yellow (9.00 mm) which is on par with Early Iron Yellow (8.47 mm) while, the minimum stalk girth was recorded in the genotype Stock Katz Blue (6.37 mm).

4.3.3 Stalk weight (g)

The genotypes differed significantly with respect to stalk weight in different genotypes of Stock is presented in Table 9. The maximum stalk weight was recorded in the genotype Early Iron Deep Yellow (169.87 g) and followed by Early Iron Yellow (160.07 g) while, the minimum stalk weight was recorded in the genotype Early Arrow white (61.27 g).

4.3.4 Number of florets per stalk

The genotypes differed significantly with respect to number of florets per stalk in different genotypes of Stock is presented in Table 9. The maximum number of florets per stalk was recorded in the genotype Stock Katz Blue (32.07) and followed by Stock Katz Ruby (27.13) which is on par with Arrow White (25.47) while, the minimum number of florets per stalk was recorded in the genotype Quartet Deep Yellow (13.20) which is on par with Stock Katz Purple (13.53).

4.3.5 Floret diameter (cm)

The significant differences obtained with respect to floret diameter in different genotypes of Stock are presented in Table 9. The maximum floret diameter was

Table 9. Performance of Stock (*Matthiola incana* L.) genotypes with respect to stalk length, stalk girth, stalk weight, number of florets per stalk and floret diameter under protected cultivation

Genotypes	Stalk length (cm)	Stalk girth (mm)	Stalk weight (g)	Number of florets/stalk	Floret diameter (cm)
G_1 - Early Arrow white	74.53	7.73	61.27	20.33	3.40
G_2 - Arrow White	78.87	10.40	106.60	25.47	4.22
G_3 - Quartet Deep Yellow	64.87	9.00	140.53	13.20	3.40
G_4 - Early Iron White	71.87	7.20	120.73	20.67	3.68
G_5 - Early Iron Yellow	74.27	8.47	160.07	20.13	3.46
G_6 - Early Iron Deep Yellow	79.13	7.87	169.87	24.33	3.43
G_7 - Early Iron Marine	69.20	7.80	86.93	16.07	3.31
G_8 - Early Iron Pink	70.27	8.60	109.73	16.40	4.02
G_9 - Stock Katz Ruby	89.07	6.70	94.87	27.13	3.31
G_{10} - Stock Katz Blue	93.93	6.37	88.13	32.07	3.97
G_{11} - Stock Katz Purple	87.07	6.77	86.60	13.53	3.39
S. Em ±	**1.35**	**0.36**	**1.58**	**0.64**	**0.05**
CD @ 5%	**3.97**	**1.07**	**4.65**	**1.89**	**0.15**

recorded in the genotype Arrow White (4.22 cm) and it was followed by Early Iron Pink (4.02 cm) while, the minimum floret diameter was recorded in the genotype Early Iron Marine and Stock Katz Ruby (3.31 cm).

4.3.6 Vase life (days)

The significant differences were obtained with respect to vase life of stalk among the different genotypes evaluated are presented in Figure 2. The maximum vase life was recorded in the genotype Stock Katz Blue (13.47 days) and followed by Early Iron Marine (11.00 days) which is on par with Early Arrow white and Stock Katz Ruby (10.20) while, the minimum vase life was recorded in the genotype Quartet Deep Yellow (7.33 days) and Early Iron Deep Yellow (7.33 days) which is on par with Early Iron Yellow (8.13 days).

4.3.7 Longevity in plants (days)

The significant differences were obtained with respect to longevity in plants among the different genotypes evaluated are presented in Figure 2. The maximum longevity was recorded in the genotype Stock Katz Ruby (36.61 days) followed by Stock Katz Purple (30.62 days) and Stock Katz Blue (29.02 days) while, the minimum longevity was recorded in the genotype Early Iron Deep Yellow (14.55 days) which is on par with Early Iron White (14.70 days).

4.3.8 Consumer acceptance

The Sensory scoring was done by different consumers for flower colour, fragrance, cut flower suitability and overall acceptability for different genotypes of Stock. The score was given using a 1-5 hedonic scale and the same was presented in Table 10.

The consumer preference was recorded the maximum score (4.67) for flower colour was obtained in the genotypes Early Iron Pink and followed by Stock Katz Purple (4.65), Stock Katz Blue (4.60) and Stock Katz Ruby (4.54) whereas, the minimum score (2.77) was obtained for the genotype Quartet Deep Yellow (2.58).

The maximum score (4.72) for cut flower suitability among the different genotypes of Stock was obtained in the genotype Early Iron Pink and followed by Stock Katz Purple (4.69), Stock Katz Blue (4.61) and Stock Katz Ruby (4.50) whereas, the minimum score (2.55) was obtained for the genotype Quartet Deep Yellow.

The maximum score (4.95) for fragrance among the different genotypes of Stock was obtained in the genotype Stock Katz Blue which was followed by Early Iron Pink (4.70) and Stock Katz Purple (4.67). The minimum score for cut flower suitability was obtained in the genotype Early Iron Deep Yellow (2.52).

Table 10. Consumer preference of Stock (*Matthiola incana* L.) genotypes

Genotypes	Consumer preference			
	Colour	Cut flower suitability	Fragrance	Overall acceptability
G_1 - Early Arrow white	4.10	4.03	4.03	4.03
G_2 - Arrow White	4.24	4.22	4.20	4.18
G_3 - Quartet Deep Yellow	2.58	2.55	2.52	2.48
G_4 - Early Iron White	4.35	4.38	4.37	4.32
G_5 - Early Iron Yellow	3.71	3.73	3.75	3.77
G_6 - Early Iron Deep Yellow	3.60	3.57	3.57	3.62
G_7 - Early Iron Marine	4.29	4.23	4.21	4.23
G_8 - Early Iron Pink	4.67	4.72	4.70	4.68
G_9 - Stock Katz Ruby	4.54	4.50	4.46	4.46
G_{10} - Stock Katz Blue	4.60	4.61	4.95	4.59
G_{11} - Stock Katz Purple	4.65	4.69	4.67	4.65

The maximum score (4.68) for overall acceptance was obtained in the genotype Early Iron Pink and followed by Stock Katz Purple (4.65) and Stock Katz Blue (4.59). The minimum score was obtained in the genotype Quartet Deep Yellow (2.48).

4.4 Yield parameters

The data related to yield parameters in different genotypes of Stock are presented in Table 11.

4.4.1 Number of cut flowers per plant

Among different genotypes of Stock, the maximum number of stalks per plant was recorded in the genotype Stock Katz Ruby (8.67) and followed by Quartet Deep Yellow (6.67), Stock Katz Purple (6.33) and Stock Katz Blue (3.67). However, all other genotypes yield single stalks per plant.

4.4.2 Number of cut flowers per sq.m

Among different genotypes of Stock significant differences were obtained with respect to number of stalks per sq. m. The maximum number of flowers per m^2 was recorded in the genotype Arrow White (25.00) which is on par with Early Iron White (24.67) and followed by Early Arrow white (23.67). However, the minimum number of stalks per sq. m was recorded in genotype Early Iron Pink (15.67) and Stock Katz Blue (15.67) which is on par with Early Iron Marine (16.67) and Stock Katz Ruby (16.67).

4.4.3 Number of cut flowers per 1000 sq. m

Among different genotypes of Stock significant differences were obtained with respect to number of stalks per 1000 sq. m. The maximum number of flowers per 1000 square meter was recorded in the genotype Arrow White (20000.00) which is on par with Early Iron White (19733.33) and Early Arrow White (18933.33) followed by Stock Katz Purple (17600.00). However, the minimum number of stalks per 1000 sq. m was recorded in genotype Early Iron Pink (12533.33) and Stock Katz Blue (12533.33)

4.5 Genetic variability studies

4.5.1 Analysis of variance

The analysis of variance was estimated to test the significance of difference among 11 genotypes of Stock for the characters, *viz.,* plant height (30 to 90 DAT), number of leaves per plant (30 to 90 DAT), leaf length (30 to 90 DAT), leaf width (30 to 90 DAT), internodal length (30 to 90 DAT), leaf area, plant spread (E-W) (cm), plant spread (N-S) (cm), chlorophyll content, days taken to flower stalk emergence, days taken to first visible flower emergence, days taken for flower stalk harvest, stalk

Table 11. Performance of Stock (*Matthiola incana* L.) genotypes with respect number of cut flower/plant, flowers/m^2 and flowers/1000m^2 under protected cultivation

Genotypes	Number of cut flowers/plant	Number of cut flowers/m^2	Number of cut flowers/1000 m^2
G_1 - Early Arrow white	1.00	23.67	18933.33
G_2 - Arrow White	1.00	25.00	20000
G_3 - Quartet Deep Yellow	6.67	19.67	15733.33
G_4 - Early Iron White	1.00	24.67	19733.33
G_5 - Early Iron Yellow	1.00	21.33	17066.67
G_6 - Early Iron Deep Yellow	1.00	21.67	17333.33
G_7 - Early Iron Marine	1.00	16.67	13333.33
G_8 - Early Iron Pink	1.00	15.67	12533.33
G_9 - Stock Katz Ruby	8.67	16.67	13333.33
G_{10} - Stock Katz Blue	3.67	15.67	12533.33
G_{11} - Stock Katz Purple	6.33	22.00	17600
S. Em ±	**0.21**	**0.58**	**461.18**
CD @ 5%	**0.61**	**1.70**	**1360.48**

length, stalk weight, stalk girth, number of florets per stalk, floret diameter, vase life, longevity in plants, number of cut flowers per plant, number of cut flowers per m^2, number of cut flowers per 1000 m^2.

The mean sum of squares due to various sources for different characters is presented in Table 12 and 13. Analysis of variance revealed that highly significant differences were observed among different genotypes of Stock for all characters evaluated.

4.5.2 Genetic variability, heritability and genetic advance

To understand the extent to which the observed variation was due to genetic factors *viz.,* genotypic variance (GV), phenotypic variance (PV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability (h^2), genetic advance (GA) and genetic advance over per cent mean (GAM) were worked out and presented in Table 14 and 15. The data revealed the existence of large amount of variability with respect to all the characters studied.

4.5.2.1 Growth parameters

The growth parameters were recorded in Table14. The results of the experiment are given as follows.

4.5.2.1.1 Plant height (cm)

The average plant height observed was 61.15 cm with range from 54.87 cm to 72.00 cm. The phenotypic coefficient of variation was more than genotypic coefficient of variation. The phenotypic and genotypic variances were 48.58 and 35.14, respectively. The estimates of phenotypic and genotypic coefficient of variation were moderate [11.40 and 9.69%, respectively]. The high heritability 72.33 per cent coupled with moderate genetic advance as per cent over mean 16.98 per cent and genetic advance (10.39) for this trait.

4.5.2.1.2 Number of leaves per plant

The number of leaves per plant ranged from 47.33 to 70.73 with a mean value of 57.62. The phenotypic and genotypic variances were 61.77 and 50.33, respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were moderate [13.64 and 12.31%, respectively]. The high heritability 81.48 per cent coupled with high genetic advance as per cent of mean 22.89 per cent.

4.5.2.1.3 Leaf length (cm)

The leaf length recorded mean value of 15.5 cm with range of 12.77 cm to 18.55 cm with phenotypic and genotypic variances of 3.63 and 3.39, respectively. Moderate phenotypic and low genotypic coefficient of variations were 12.30 per cent and 11.89 per cent, respectively. The estimates of broad sense heritability (93.44%) were coupled with genetic advance as per cent of mean (23.67%) were moderate for this character.

Table 12. Analysis of variance for vegetative and biochemical parameters in Stock (*Matthiola incana* L.) genotypes

SL. NO.	Characters	Mean sum of square		
		Replication df=2	Genotype df=10	Error df=20
1.	Plant height (cm) 30 DAT	10.23	0.37*	0.54
	Plant height (cm) 60 DAT	173.77	35.15*	22.31
	Plant height (cm) 90 DAT	118.86	6.17*	13.44
2.	Number of leaves per plant 30 DAT	11.59	2.01*	0.77
	Number of leaves per plant 60 DAT	160.48	13.89*	7.66
	Number of leaves per plant 90 DAT	162.44	14.48*	11.44
3.	Leaf length (cm) 30 DAT	4.33	0.07*	0.03
	Leaf length (cm) 60 DAT	6.26	2.56*	1.63
	Leaf length (cm) 90 DAT	10.42	0.17*	0.24
4.	Leaf width (cm) 30 DAT	0.50	0.04*	0.04
	Leaf width (cm) 60 DAT	0.41	0.18*	0.09
	Leaf width (cm) 90 DAT	0.64	0.06*	0.04
5.	Leaf area (cm^2/plant)	876664.46	10676.31*	13559.84
6.	Plant spread E-W (cm) 30 DAT	15.86	0.42*	0.62
	Plant spread E-W (cm) 60 DAT	66.15	8.53*	3.06
	Plant spread E-W (cm) 90 DAT	86.35	0.23*	3.00
7.	Plant spread N-S (cm) 30 DAT	17.04	0.69*	1.90
	Plant spread N-S (cm) 60 DAT	39.94	10.25*	6.59
	Plant spread N-S (cm) 90 DAT	78.41	10.91*	1.76
8.	Internodal length (cm) 30 DAT	0.24	0.02*	0.01
	Internodal length (cm) 60 DAT	0.02	0.01*	0.01
	Internodal length (cm) 90 DAT	1.19	0.01*	0.01
9.	Chlorophyll ‘a’ (mg/g)	0.14	0.00*	0.00
10.	Chlorophyll ‘b’ (mg/g)	0.02	0.00*	0.00
11.	Total chlorophyll (mg/g)	0.11	0.00*	0.00

*indicates significant at 5 % level

Table 13. Analysis of variance for flowering, quality and yield parameters in Stock (*Matthiola incana* L.) genotypes

SL. NO.	Characters	Replication df=2	Genotype df=10	Error df=20
	Flowering parameters			
1.	Days taken to flower stalk emergence	851.24	2.56*	2.14
2.	Days taken to first visible bud initiation	801.27	6.13*	3.74
3.	Days taken for flower stalk harvest	786.85	21.28*	12.00
	Quality parameters			
4.	Stalk length (cm).	249.50	1.95*	5.44
5.	Stalk weight (g)	3387.05	22.69*	7.45
6.	Stalk girth (mm)	4.16	0.36*	0.39
7.	Number of florets per stalk	106.29	3.22*	1.23
8.	Floret diameter (cm)	0.31	0.01*	0.01
9.	Vase life (days)	9.77	0.05*	0.23
10	Longevity in plants (days)	168.98	0.56*	0.45
	Yield parameters			
11.	Number of cut flowers/plant	25.52	0.03*	0.13
12.	Number of cut flowers/m^2	38.41	2.03*	1.00
13.	Number of cut flowers/1000 m^2	24579879	1299394*	638060.6

*indicates significant at 5 % level

Table 14. Estimates of mean, range, components of variance, genetic advance and genetic advance over per cent mean for growth parameters in Stock (*Matthiola incana* L.) genotypes

Parameters	Mean± S. Em	Range		PV	GV	PCV (%)	GCV (%)	h^2 (%)	GA	GA over mean (%)
		Minimum	Maximum							
Plant height (cm)	61.15 ± 2.12	54.87	72.00	48.58	35.14	11.40	9.69	72.33	10.39	16.98
Number of leaves per plant	57.62 ±1.95	47.33	70.73	61.77	50.33	13.64	12.31	81.48	13.19	22.89
Leaf length (cm)	15.5 ± 0.28	12.77	18.55	3.63	3.39	12.30	11.89	93.44	3.67	23.67
Leaf width (cm)	3.42 ± 0.12	2.65	4.09	0.24	0.20	14.65	13.24	81.72	0.83	24.66
Leaf area (cm^2/plant)	2059.38 ± 67.23	1472.95	3199.94	548.87	536.38	26.65	26.05	95.50	1079.79	52.43
Plant spread (E-W) (cm)	27.23 ± 1.00	20.02	39.00	30.78	27.78	20.37	19.36	90.26	10.32	37.88
Plant spread (N-S) (cm)	27.01 ± 0.77	20.63	38.94	27.31	25.55	19.35	18.71	93.54	10.07	37.29
Internodal length (cm)	1.98 ± 0.06	1.25	2.99	0.41	0.39	32.09	31.60	97.02	1.27	64.13
Chlorophyll 'a' (mg/g)	0.54 ± 0.01	0.30	0.87	0.05	0.05	40.09	40.06	99.83	0.44	82.45
Chlorophyll 'b' (mg/g)	0.39 ± 0.01	0.16	0.51	0.01	0.01	23.26	23.15	99.00	0.19	47.45
Total chlorophyll (mg/g)	0.93 ± 0.01	0.70	1.26	0.04	0.04	20.51	20.48	99.67	0.39	42.12

Where,
GCV: Genotypic coefficient of variation, PCV : Phenotypic coefficient of variation, h^2 : Heritability in broad sense, GA : Genetic advance GAM : Genetic advance as per cent.

4.5.2.1.4 Leaf width (cm)

The leaf width recorded mean value of 3.42 cm with range of 2.65 cm to 4.09 cm with phenotypic and genotypic variances of 0.24 and 0.20, respectively. Moderate phenotypic and low genotypic coefficient of variations were 14.65 per cent and 13.24 per cent, respectively. The estimates of broad sense heritability (10.07%) were coupled with high genetic advance as per cent of mean (37.29%) for this trait.

4.5.2.1.5 Leaf area (cm^2/ plant)

The leaf area recorded mean value of 2059.38 cm^2 with range of 1472.95 cm^2 to 3199.94 cm^2 with phenotypic and genotypic variances of 548.87 and 536.38, respectively. high phenotypic and genotypic coefficient of variations were 26.65 per cent and 26.05 per cent, respectively. The estimates of broad sense heritability (95.50%) were coupled with genetic advance as per cent of mean (52.43%) were high for this character.

4.5.2.1.6 Plant spread (E-W) (cm)

The plant spread in East-West recorded mean of 27.23 cm and range of 20.02 cm to 39.00 cm with phenotypic and genotypic variances of 30.78 and 27.78, respectively. The values of phenotypic coefficient of variation and genotypic coefficient of variation were 20.37 per cent and 19.36 per cent, respectively. The estimates of high heritability 90.26 per cent along with high genetic advance as per cent of mean 37.88 per cent were observed for this trait.

4.5.2.1.7 Plant spread (N-S) (cm)

The plant spread in North-South recorded mean of 27.01 cm and range of 20.63 cm to 38.94 cm with phenotypic and genotypic variances of 27.31 and 25.55, respectively. The values of phenotypic coefficient of variation and genotypic coefficient of variation were 19.35 per cent and 18.71 per cent, respectively. The high heritability (93.54%) along with high genetic advance as per cent of mean (37.29%) were observed for this trait.

4.5.2.1.8 Internodal length (cm)

The internodal length recorded mean value of 1.98 cm with range of 1.25 cm to 2.99 cm. The phenotypic and genotypic variances were 0.41 and 0.39, respectively. The values of phenotypic coefficient of variation and genotypic coefficient of variation were high [32.09 and 31.60%, respectively]. The estimates of broad sense heritability 97.02 per cent was coupled with genetic advance as per cent of mean 64.13 per cent were high for this trait.

4.5.2.1.9 Chlorophyll content (mg/g)

The average chlorophyll 'a' content observed was 0.54 mg/g with a range from 0.30 mg/g to 0.87 mg/g. The phenotypic and genotypic variances were 0.05 and 0.05, respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were moderate *viz.,* 40.09 per cent and 40.06 per cent, respectively. The high estimates of heritability (99.83%) coupled with high genetic advance as per cent over mean (82.45%) and genetic advance was 0.44 for this trait.

The average chlorophyll 'b' content observed was 0.39 mg/g with a range from 0.16 mg/g to 0.51 mg/g. The phenotypic and genotypic variances were 0.01 and 0.01, respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were high *viz.,* 23.26 per cent and 23.15 per cent, respectively. The high estimates of heritability (99.00%) coupled with high genetic advance as per cent over mean (47.45%) and genetic advance was 0.19 for this trait.

The average total chlorophyll content observed was 0.93 mg/g with a range from 0.70 mg/g to 1.26 mg/g. The phenotypic and genotypic variances were 0.04 and 0.04, respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were high *viz.,* 20.51 per cent and 20.48 per cent, respectively. The high estimates of heritability (99.67%) coupled with high genetic advance as per cent over mean (42.12%) and genetic advance was 0.39 for this trait.

4.5.2.2 Flowering parameters

The flowering parameters were recorded in Table 15. The results of the experiment are given as follows.

4.5.2.2.1 Days taken to stalk emergence

The days to flower stalk emergence exhibited phenotypic variance (285.17) and genotypic variance (283.03) with mean of 72.27 and range of 43.60 to 96.53. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were high *viz.* 23.37 per cent and 23.28 per cent, respectively. High heritability (99.25%) coupled with high genetic advance as per cent of mean (47.77%) was observed for this character.

4.5.2.2.2 Days taken to first visible flower

The days taken to first visible flower emergence exhibited phenotypic variance (269.58) and genotypic variance (265.84) with mean of 82.62 and range of 55.40 to 106.53. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were high 19.87 per cent and 19.74 per cent, respectively. High heritability (98.61%) coupled with high genetic advance as per cent of mean (40.37%) was observed for this character.

4.5.2.2.3 Days taken for flower stalk harvest

Days taken for flower stalk harvest exhibited phenotypic variance (270.28) and genotypic variance (258.29) with mean of 100.62 days and range of 74.40 days to 129.13 days. The estimates of phenotypic coefficient of variation and genotypic

Table 15. Estimates of mean, range, components of variance, genetic advance and genetic advance over per cent mean for flowering, quality and yield parameters in Stock (*Matthiola incana* L.) genotypes

Prameters	Mean± S. Em	Range		PV	GV	PCV (%)	GCV (%)	h^2 (%)	GA	GA over mean (%)
		Minimum	Maximum							
Flowering parameters										
Days taken to flower stalk emergence	72.27±0.84	43.60	96.53	285.17	283.03	23.37	23.28	99.25	34.53	47.77
Days taken to first visible flower	82.62±1.12	55.40	106.53	269.58	265.84	19.87	19.74	98.61	33.35	40.37
Days taken for flower stalk harvest	100.62±2.00	74.40	129.13	270.28	258.29	16.34	15.97	95.56	32.36	32.17
Quality parameters										
Stalk length (cm).	77.55±1.35	64.87	93.93	86.79	81.35	12.01	11.63	93.73	17.99	23.20
Stalk weight (grams)	111.39±1.58	61.27	169.87	1133.98	1126.53	30.23	30.13	99.34	68.91	61.87
Stalk girth (mm)	7.9±0.36	6.37	10.40	1.65	1.26	16.26	14.19	76.10	2.01	25.50
Number of florets per stalk	20.85±0.64	13.20	32.07	36.25	35.02	28.88	28.38	96.59	11.98	57.47
Floret diameter (cm)	3.6±0.05	3.31	4.22	0.11	0.10	9.21	8.86	92.58	0.63	17.56
Vase life (days)	9.48±0.28	7.33	13.47	3.41	3.18	19.48	18.82	93.31	3.55	37.45
Longevity in plants (days)	23.56±0.39	14.55	36.61	56.63	56.18	31.94	31.81	99.20	15.38	65.27
Yield parameters										
Number of cut flowers/plant	2.94±0.21	1.00	8.67	8.59	8.46	99.73	98.97	98.48	5.95	202.33
Number of cut flowers/m^2	20.24±0.58	15.67	25.00	13.47	12.47	18.13	17.44	92.60	7.00	34.58
Number of cut flowers/1000 m^2	178133.33±461.18	12533.33	20000	8618667	7980606	18.12	17.44	92.60	5599.94	34.58

Where,

GCV : Genotypic coefficient of variation, PCV : Phenotypic coefficient of variation, h^2 : Heritability in broad sense, GA : Genetic advance GAM : Genetic advance as percent.

coefficient of variation were moderate 16.34 per cent and 15.97 per cent, respectively. High heritability (95.56%) coupled with high genetic advance as per cent of mean (32.17%) was observed for this character.

4.5.2.3 Quality and yield parameters

4.5.2.3.1 Stalk length (cm)

The stem length varied from 64.87 cm to 93.93 cm with the mean of 77.55 cm. The phenotypic and genotypic variances were 86.79 and 81.35, respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were moderate 12.01 per cent and 11.63 per cent, respectively. The high heritability (93.73%) was observed along with high genetic advance as per cent of mean (23.20%) for this trait.

4.5.2.3.2 Stalk weight (g)

The stem weight varied from 61.27 g to 169.87 g with the mean of 111.39 g. The phenotypic and genotypic variances were 1133.98 and 1126.53, respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were high 30.23 per cent and 30.13 per cent, respectively. The high heritability (99.34%) was observed along with high genetic advance as per cent of mean (61.87%) for this trait.

4.5.2.3.3 Stalk girth (mm)

The stem girth varied from 6.37 mm to 10.40 mm with the mean of 7.90 mm. The phenotypic and genotypic variances were 1.65 and 1.26, respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were moderate 16.26 per cent and 14.19 per cent, respectively. The high heritability (76.10%) was observed along with high genetic advance as per cent of mean (25.50%) for this trait.

4.5.2.3.4 Number of florets per stalk

The number of florets per stalk varied from 13.20 to 32.07 with the mean of 20.85. The phenotypic and genotypic variances were 36.25 and 35.02, respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were high [28.88 and 28.38%, respectively]. The high heritability (96.59%) was observed along with high genetic advance as per cent of mean (57.47%) for this trait.

4.5.2.3.5 Floret diameter (cm)

The floret diameter varied from 3.31 cm to 4.22 cm with the mean of 3.6 cm. The phenotypic and genotypic variances were 0.11 and 0.10 , respectively. The estimates of phenotypic coefficient of variation and genotypic coefficient of variation were [9.21 and 8.86%, respectively]. The high heritability (92.58%) was observed along with moderate genetic advance as per cent of mean (17.56%) for this trait.

4.5.2.3.6 Vase life (days)

The vase life recorded mean of 9.48 days and ranged from 7.33 days to 13.47 days with phenotypic and genotypic variances of 3.41 and 3.18, respectively. The moderate phenotypic coefficient of variation (19.48%) and moderate genotypic coefficient of variation (18.82%) were observed. The high heritability (93.31%) was observed along with moderate genetic advance as per cent of mean (37.45%).

4.5.2.3.7 Longevity in plants (days)

The longevity in plants recorded mean of 23.56 days and ranged from 14.55 days to 36.61 days with phenotypic and genotypic variances of 56.63 and 56.18, respectively. The high phenotypic coefficient of variation (31.94%) and genotypic coefficient of variation (31.81%) were observed. The high heritability (99.20%) was observed along with moderate genetic advance as per cent of mean (65.27%).

4.5.2.3.8 Number of cut flowers per plant

The number of stalks per plant recorded mean of 2.94 with range of 1.00 to 8.67. The phenotypic and genotypic variances were 8.59 and 8.46, respectively. The values of phenotypic coefficient of variation and genotypic coefficient of variation were moderate [99.73 and 98.97%, respectively]. The high heritability (98.48%) was coupled with high genetic advance as per cent of mean (202.33%) for this trait.

4.5.2.3.9 Number of cut flowers per sq. m

The number of stalks per sq. m recorded mean of 20.24 with range of 15.67 to 25.00. The phenotypic and genotypic variances were 13.47 and 12.47, respectively. The values of phenotypic coefficient of variation and genotypic coefficient of variation were high [18.13 and 17.44%, respectively]. The high heritability (92.60%) was coupled with high genetic advance as per cent of mean (34.58%) for this trait.

4.5.2.3.10 Number of cut flowers 1000 sq. m

The number of cut stalks per 1000 sq. m recorded mean of 17,813.33 with range of 12,533.33 to 20,000. The phenotypic and genotypic variances were 86186.67 and 79806.06, respectively. The values of phenotypic coefficient of variation and genotypic coefficient of variation were high [18.12 and 17.44%, respectively]. The high heritability (92.60%) was coupled with high genetic advance as per cent of mean (34.58%) for this trait.

4.6 Correlation coefficient analysis

The genotypic and phenotypic correlation analysis were carried out for all the fifteen characters to know the nature of relationship existing between number of stalks per square meter and its other contributing characters.

In general, genotypic correlation coefficients were higher than the phenotypic correlation coefficients. This indicates the presence of strong inherent association between various characters. The values of correlation co-efficient at genotypic and phenotypic level for the characters studied with respect to growth, flowering, yield and quality parameters are presented in Table 16 and 17.

4.6.1 Genotypic correlation coefficient analysis

The data related to genotypic correlation coefficient analysis is presented in Table 16.

4.6.1.1 Plant height (cm)

Plant height exhibited highly significant positive correlation with leaf length (0.867) and stalk length (0.885) while, significant positive correlation was noticed with leaf area (0.665). It showed highly significant negative correlation with days taken for stalk emergence (-0.782) whereas, it recorded significant negative correlation with stalk girth (-0.688).

4.6.1.2 Number of leaves per plant

Number of leaves per plant recorded significant positive correlation with leaf length (0.653) and leaf area (0.678) while, significant negative correlation was noticed with days taken for stalk emergence (-0.657) and stalk weight (-0.712).

4.6.1.3 Leaf length (cm)

Leaf length observed highly significant positive correlation with plant height (0.867) and leaf area (0.780) while significant positive correlation was noticed with number of leaves per plant (0.653), stalk length (0.700) and longevity (0.608). It showed highly significant negative correlation with days taken for stalk emergence (-0.778).

4.6.1.4 Leaf area (cm^2/plant)

Leaf area showed highly significant positive correlation with leaf length (0.780) and longevity (0.834) while, significant positive correlation was noticed with plant height (0.665), number of leaves per plant (0.678) and stalk length (0.670). It showed highly significant negative correlation with days taken for stalk emergence (-0.874) and correlations with other characters were non-significant.

4.6.1.5 Internodal length (cm)

Internodal length recorded highly significant negative correlation with days taken for stalk emergence (-0.767) whereas, significant negative correlation with stalk weight (-0.621).

4.6.1.6 Days taken for stalk emergence

The days taken for stalk emergence had a significant positive correlation with stalk girth (0.627) and stalk weight (0.610). It showed highly significant negative correlation with Plant height (-0.782), leaf length (-0.778), leaf area (-0.874), internodal length (-0.767) and longevity (-0.880) whereas, significant negative correlation with number of leaves per plant (-0.657) and stalk length (-0.686).

4.6.1.7 Number of florets per stalk

Number of florets per stalk had significant positive correlation with stalk length (0.691) while, the correlations with other characters were non-significant.

4.6.1.8 Stalk length (cm)

Stalk length showed highly positive correlation with plant height (0.885) whereas significant correlation with leaf length (0.700), leaf area (0.670) and number of florets per stalk (0.691). It recorded negative significant correlation with days taken for stalk emergence (-0.686) and stalk girth (-0.619).

4.6.1.9 Stalk girth (mm)

Stalk girth had significant positive correlation with days taken for stalk emergence (0.627) whereas, negative significant correlation with plant height (-0.688) and stalk length (-0.619).

4.6.1.10 Stalk weight (g)

Stalk weight showed significant positive correlation with days taken for stalk emergence (0.610) whereas, negative significant correlation with number of leaves per plant (-0.712) internodal length (-0.621) and vase life (-0.665).

4.6.1.11 Vase life (days)

Vase life had negative significant correlation with stalk weight (-0.665) while, correlations with other characters were non-significant.

4.6.1.12 Longevity in plants (days)

Longevity in plants recorded highly significant positive leaf area (0.834) while, significant positive correlation with leaf length (0.608). Highly significant negative correlation was noticed with days taken for stalk emergence (-0.880) and significant negative correlation on yield per square meter (-0.634).

4.6.1.13 Number of cut flowers per square meter

Number of cut flowers per square meter had significant negative correlation with longevity (-0.634) whereas, correlations with other characters were non-significant.

Table 16. Genotypic correlation coefficients for growth, flowering, quality and yield characters in Stock (*Matthiola incana* L.) genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1 **	0.459	0.867 **	0.061	0.665 *	0.540	-0.782 **	0.596	0.241	0.885 **	-0.688*	-0.401	0.578	0.458	-0.096
2		1 **	0.653 *	-0.123	0.678 *	0.396	-0.657 *	-0.026	-0.227	0.395	-0.485	-0.712*	0.249	0.424	-0.004
3			1 **	0.135	0.780 **	0.492	-0.778 **	0.263	0.224	0.700 *	-0.388	-0.560	0.322	0.608*	-0.004
4				1 **	-0.046	0.097	-0.176	-0.073	-0.189	-0.273	-0.033	-0.043	0.135	0.356	-0.196
5					1 **	0.420	-0.874 **	0.132	-0.085	0.670 *	-0.449	-0.386	0.217	0.834**	-0.397
6						1 **	-0.767 **	0.117	-0.155	0.543	-0.501	-0.621 *	0.414	0.590	-0.190
7							1 **	-0.196	0.120	-0.686 *	0.627 *	0.610 *	-0.501	-0.880 **	0.438
8								1 **	0.396	0.691 *	-0.249	-0.056	0.494	0.022	-0.105
9									1 **	0.144	0.434	-0.065	0.255	-0.120	0.048
10										1 **	-0.619 *	-0.310	0.448	0.435	-0.191
11											1 **	0.356	-0.598	-0.316	0.364
12												1 **	-0.665 *	-0.414	0.154
13													1 **	0.309	-0.522
14														1**	-0.634*
15															1 **

Where, * & ** indicates significant @ 5 % and 1 % level, respectively.

1. Plant height (cm)	2. Number of leaves per plant	3. Leaf length (cm)	4, Leaf width (cm)	5, Leaf area (cm^2/plant)
6. Internodal length (cm)	7. Days taken to stalk emergence	8. Number of florets per stalk	9. Floret diameter (cm)	10. Stalk length (cm)
11. Stalk girth (cm)	12. Stalk weight (g)	13. Vase life (days)	14. Longevity in plants (days)	15. Number of cut flowers per m^2

4.6.2 Phenotypic correlation coefficient analysis

The data related to phenotypic correlation coefficient analysis is presented in Table 17.

4.6.2.1 Plant height (cm)

Plant height showed highly significant positive correlation with leaf length (0.760), leaf area (0.572) stalk length (0.730), number of florets per stalk (0.514) and vase life (0.450) while, significant positive correlation with number of leaves (0.435), internodal length (0.419) and longevity (0.400). Highly significant negative correlation was recorded with days taken for stalk emergence (-0.660) and stalk girth (-0.526).

4.6.2.2 Number of leaves per plant

Number of leaves per plant recorded highly significant positive correlation with leaf length (0.572) and leaf area (0.679) while, significant positive correlation with plant height (0.435), internodal length (0.369) and longevity (0.381). Highly significant negative correlation was noticed with days taken for stalk emergence (-0.592) and stalk weight (-0.628) whereas, significant negative correlation with stalk girth (-0.378).

4.6.2.3 Leaf length (cm)

Leaf length observed highly significant positive correlation with plant height (0.760), number of leaves per plant (0.572), leaf area (0.733), internodal length (0.461), stalk length (0.634) and longevity (0.585) while, highly significant negative correlation with days taken for stalk emergence (-0.758) and stalk weight (-0.538).

4.6.2.4 Leaf area (cm^2/plant)

Leaf area showed highly significant positive correlation with plant height (0.572), number of leaves per plant (0.679), leaf length (0.733), stalk length (0.609) and longevity (0.811) while, significant positive correlation was noticed with internodal length (0.414). It showed highly significant negative correlation with days taken for stalk emergence (-0.849) whereas, significant negative correlation with stalk girth (-0.386), stalk weight (-0.370) and yield per square meter (-0.402).

4.6.2.5 Internodal length (cm)

The trait was found to be highly significant negative correlation with days taken for stalk emergence (-0.849) and stalk weight (-0.609) whereas, significant negative correlation with stalk girth (-0.433). It was showed highly significant positive correlation with leaf length (0.461), stalk length (0.512) and longevity (0.575) while, significant positive correlation with plant height (0.419), number of leaves per plant (0.369), leaf area (0.414) and vase life (0.400).

Table 17. Phenotypic correlation coefficients for growth, flowering, quality and yield characters in Stock genotypes (*Matthiola incana* L.) genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1 **	0.435 *	0.760 **	0.053	0.572 **	0.419 *	-0.659 **	0.515 **	0.199	0.730 **	-0.526 **	-0.323	0.450 **	0.399 *	-0.050
2		1 **	0.572 **	-0.143	0.679 **	0.369 *	-0.592 **	-0.039	-0.141	0.301	-0.378 *	-0.628 **	0.238	0.381 *	-0.028
3			1 **	0.114	0.733 **	0.461 **	-0.758 **	0.242	0.210	0.634 **	-0.326	-0.538 **	0.292	0.585 **	0.008
4				1 **	-0.059	0.091	-0.152	-0.061	-0.136	-0.230	-0.051	-0.038	0.092	0.324	-0.172
5					1 **	0.414 *	-0.849 **	0.119	-0.052	0.609 **	-0.386 *	-0.370 *	0.218	0.811 **	-0.402 *
6						1 **	-0.753 **	0.102	-0.141	0.502 **	-0.433 *	-0.609 **	0.399 *	0.575 **	-0.181
7							1 **	-0.192	0.123	-0.661 **	0.534 **	0.607 **	-0.490 **	-0.870 **	0.411 *
8								1 **	0.368 *	0.677 **	-0.204	-0.054	0.485 **	0.021	-0.090
9									1 **	0.115	0.373 *	-0.062	0.219	-0.108	0.016
10										1 **	-0.510 **	-0.298	0.409 *	0.423 *	-0.165
11											1 **	0.299	-0.476 **	-0.281	0.320
12												1 **	-0.643 **	-0.411 *	0.151
13													1 **	0.287	-0.509 **
14														1 **	-0.607 **
15															1 **

Where, * & ** indicates significant @ 5 % and 1 % level, respectively.

1. Plant height (cm)	2. Number of leaves per plant	3. Leaf length (cm)	4, Leaf width (cm)	5, Leaf area (cm^2/plant)
6. Internodal length (cm)	7. Days taken to stalk emergence	8. Number of florets per stalk	9. Floret diameter (cm)	10. Stalk length (cm)
11. Stalk girth (cm)	12. Stalk weight (g)	13. Vase life (days)	14. Longevity in plants (days)	15. Number of cut flowers per m^2

4.6.2.6 Days taken for stalk emergence

The days taken for stalk emergence had highly significant positive correlation with stalk girth (0.534) and stalk weight (0.607) whereas, significant positive correlation with yield per square meter (0.411). It showed highly significant negative correlation with plant height (-0.659), number of leaves per plant (-0.592) leaf length (-0.758), leaf area (-0.849), internodal length (-0.753), stalk length (-0.661), vase life (-0.490) and longevity (-0.870) whereas, correlations with other characters were non-significant.

4.6.2.7 Number of florets per stalk

Number of florets per stalk had highly significant positive correlation with plant height (0.515), stalk length (0.677) and vase life (0.485) while, significant positive correlation with floret diameter (0.368).

4.6.2.8 Floret diameter (cm)

Floret diameter had significant positive correlation with number of florets per stalk (0.368) and stalk girth (0.373).

4.6.2.9 Stalk length (cm)

Stalk length showed highly positive correlation with plant height (0.730), leaf length (0.634), leaf area (0.609), internodal length (0.502) and number of florets per stalk (0.677) whereas significant positive correlation with vase life (0.409) and longevity (0.423). It recorded highly negative significant correlation with days taken for stalk emergence (-0.661) and stalk girth (-0.510).

4.6.2.10 Stalk girth (mm)

Stalk girth had highly significant positive correlation with days taken for stalk emergence (0.534) whereas, significant positive correlation with floret diameter (0.373). Highly negative significant correlation with plant height (-0.526) and stalk length (-0.510) and vase life (-0.476) while, negative significant correlation with number of leaves per plant (-0.378), leaf area (-0.386) and internodal length (-0.433).

4.6.2.11 Stalk weight (g)

Stalk weight showed highly significant positive correlation with days taken for stalk emergence (0.607) whereas, highly negative significant correlation with number of leaves per plant (-0.628), leaf length (-0.538), leaf area (-0.370), internodal length (-0.609) and vase life (-0.643). It showed negative significant correlation with longevity (-0.411).

4.6.2.12 Vase life (days)

Vase life had highly significant positive correlation with plant height (0.450) and number of florets per plant (0.485) whereas, significant positive correlation with internodal length (0.400) and stalk length (0.410). Highly negative significant correlation with days taken for stalk emergence (-0.490), stalk girth (-0.476), stalk weight (-0.643) and yield per square meter (-0.510) while, correlations with other characters were non-significant.

4.6.2.13 Longevity in plants (days)

Longevity in plants recorded highly positive correlation with leaf length (0.585), leaf area (0.811) and internodal length (0.575) while, significant positive correlation with plant height (0.399), number of leaves (0.381) and stalk length (0.423). Highly significant negative correlation was noticed with days taken for stalk emergence (-0.870) and yield per square meter (-0.607) while, significant negative correlation with stalk weight (-0.411).

4.6.2.14 Number of cut flowers per square meter

Number of cut flowers per square meter had highly significant negative correlation with vase life (-0.509) and longevity (-0.607) whereas, significant negative correlation with leaf area (-0.402). It also showed significant positive correlations with days taken for stalk emergence (0.411).

4.7 Path coefficient analysis

The correlation coefficients only indicate the relationship of independent variable with the dependent variable without specifying cause and effect relationship. Using path coefficient analysis, it is possible to resolve the correlations, which will provide direct and indirect contribution of different quantitative traits. The analysis was done for number of cut flowers per square meter, which is dependent variable and are presented in Table 18 and 19.

4.7.1 Genotypic path co-efficient analysis

The data related to genotypic path co-efficient analysis is presented in Table 18.

4.7.1.1 Plant height (cm)

The plant height had positive direct effect (0.479) on cut flowers per square meter, while indirect positive effects through leaf length (0.0798), leaf width (0.010), leaf area (0.666), days taken for stalk emergence (1.323), florets per stalk (0.248), stalk weight (0.459) while indirect negative effect on number of leaves per plant (-0.487), internodal length (-0.020), floret diameter (-0.069), stalk length (-0.640), stalk girth (-0.308), vase life (-0.655) and longevity (-1.163).

4.7.1.2 Number of leaves per plant

The number of leaves per plant had negative direct effect (-1.060) on cut flowers per square meter, while indirect positive effects through plant height (0.220), leaf length (0.060), leaf area (0.679), days taken for stalk emergence (1.110), floret diameter

Table 18. Genotypic path coefficient analysis for fourteen different characters on number of stalks per m^2 of Stock (*Matthiola incana* L.) genotypes through direct and indirect effects

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	rG
1	**0.479**	-0.487	0.080	0.010	0.666	-0.020	1.323	0.248	-0.087	-0.640	-0.308	0.459	-0.655	-1.163	-0.096
2	0.220	**-1.060**	0.060	-0.021	0.679	-0.014	1.110	-0.011	0.082	-0.286	-0.217	0.814	-0.281	-1.077	-0.004
3	0.415	-0.692	**0.092**	0.023	0.781	-0.018	1.315	0.110	-0.081	-0.507	-0.174	0.640	-0.365	-1.543	-0.004
4	0.029	0.130	0.012	**0.170**	-0.046	-0.004	0.298	-0.031	0.068	0.198	-0.015	0.049	-0.153	-0.903	-0.196
5	0.318	-0.719	0.072	-0.008	**1.001**	-0.015	1.478	0.055	0.031	-0.485	-0.201	0.441	-0.246	-2.118	-0.397
6	0.258	-0.420	0.045	0.017	0.421	**-0.036**	1.296	0.049	0.056	-0.393	-0.225	0.710	-0.470	-1.498	-0.190
7	-0.374	0.696	-0.072	-0.030	-0.875	0.028	**-1.691**	-0.082	-0.043	0.497	0.281	-0.698	0.568	2.233	0.438
8	0.285	0.028	0.024	-0.012	0.133	-0.004	0.331	**0.417**	-0.143	-0.500	-0.112	0.064	-0.561	-0.055	-0.105
9	0.115	0.240	0.021	-0.032	-0.085	0.006	-0.202	0.165	**-0.360**	-0.104	0.194	0.074	-0.289	0.306	0.0481
10	0.423	-0.419	0.065	-0.047	0.671	-0.020	1.159	0.288	-0.052	**-0.724**	-0.277	0.354	-0.508	-1.105	-0.191
11	-0.329	0.514	-0.036	-0.006	-0.450	0.018	-1.059	-0.104	-0.156	0.448	**0.448**	-0.407	0.678	0.803	0.364
12	-0.192	0.755	-0.052	-0.007	-0.386	0.023	-1.032	-0.023	0.023	0.224	0.160	**-1.143**	0.754	1.051	0.154
13	0.277	-0.263	0.030	0.023	0.217	-0.015	0.847	0.206	-0.092	-0.324	-0.268	0.760	**-1.134**	-0.785	-0.522
14	0.219	-0.450	0.056	0.061	0.835	-0.021	1.487	0.009	0.043	-0.315	-0.142	0.473	-0.351	**-2.539**	-0.634*

Residual effect = 0.0609 Bold : Direct effect Above and Below diagonal : Indirect effect

Where, * & ** indicates significant @ 5 % and 1 % level, respectively

1. Plant height (cm)	2. Number of leaves per plant	3. Leaf length (cm)	4, Leaf width (cm)	5, Leaf area (cm^2/plant)
6. Internodal length (cm)	7. Days taken to stalk emergence	8. Number of florets per stalk	9. Floret diameter (cm)	10. Stalk length (cm)
11. Stalk girth (cm)	12. Stalk weight (g)	13. Vase life (days)	14. Longevity in plants (days)	

(0.082), stalk weight (0.814). Besides, it had negative indirect effect through leaf width (-0.021), internodal length (-0.014), florets per stalk (-0.011), stalk length (-0.286), stalk girth (-0.217), vase life (-0.281) and longevity (-1.077).

4.7.1.3 Leaf length (cm)

The leaf length had positive direct effect (0.0921) on cut flowers per square meter, while indirect positive effects through plant height (0.415), leaf width (0.023), leaf area (0.781), days taken for stalk emergence (1.315) florets per stalk (0.110), stalk weight (0.640) and remaining characters had negative indirect effects.

4.7.1.4 Leaf width (cm)

The leaf width positive direct effect (0.170) on cut flowers per square meter, while indirect positive effects through plant height (0.029), number of leaves per plant (0.130), leaf length (0.012), days taken for stalk emergence (0.298), floret diameter (0.068), stalk length (0.198) and stalk weight (0.049). Besides, it had negative indirect effect through leaf area (-0.046), internodal length (-0.004), florets per stalk (-0.031), stalk girth (-0.015), vase life (-0.153) and longevity (-0.903).

4.7.1.5 Leaf area (cm^2/plant)

The leaf area had positive direct effect (1.001) on cut flowers per square meter, while indirect positive effects through plant height (0.318), leaf length (0.072), days taken for stalk emergence (1.478), florets per stalk (0.055), floret diameter (0.031), stalk weight (0.441). Besides, it had negative indirect effect through number of leaves per plant (-0.719), leaf width (-0.008), internodal length (-0.015), stalk length (-0.485), stalk girth (-0.201), vase life (-0.246) and longevity (-2.118).

4.7.1.6 Internodal length (cm)

The internodal length exhibited negative direct effect (-0.036) on cut flowers per square meter, while indirect positive effects through plant height (0.258), leaf length (0.045), leaf width (0.017), leaf area (0.421), days taken for stalk emergence (1.296), florets per stalk (0.049), floret diameter (0.056) and stalk weight (0.710). Besides, it had positive indirect effect through number of leaves per plant (-0.420), stalk length (-0.393), stalk girth (-0.225), vase life (-0.470) and longevity (-1.498).

4.7.1.7 Days taken for stalk emergence

The days taken for stalk emergence had negative direct effect (-1.691) on cut flowers per square meter, while it had negative indirect effect through plant height (-0.374), leaf length (-0.072), leaf width (-0.030), leaf area (-0.875), florets per stalk (-0.082), floret diameter (-0.043), stalk weight (-0.698). Besides, indirect positive effects through number of leaves per plant (0.696), internodal length (0.028), stalk length (0.497), stalk girth (0.281), vase life (0.568) and longevity (2.233).

4.7.1.8 Number of florets per stalk

Florets per stalk had positive direct effect (0.417) on cut flowers per square meter, while indirect positive effects through plant height (0.285), number of leaves per plant (0.028leaf length (0.024), leaf area (0.133), days taken for stalk emergence (0.331) and stalk weight (0.064). Besides, it had negative indirect effect through), leaf width (-0.028), internodal length (-0.012), floret diameter (-0.143), stalk length (-0.500), stalk girth (-0.112), vase life (-0.561) and longevity (-2.233).

4.7.1.9 Floret diameter (cm)

The floret diameter had negative direct effect (-0.360) on cut flowers per square meter, while indirect positive effects through plant height (0.115), number of leaves per plant (0.240), leaf length (0.021), internodal length (0.006), florets per stalk (0.165), stalk girth (0.194), stalk weight (0.074) and longevity (0.306). Besides, it had negative indirect effect through, leaf width (-0.032), leaf area (-0.085), days taken for stalk emergence (-0.202), stalk length (-0.104) and vase life (-0.289).

4.7.1.10 Stalk length (cm)

The stalk length had negative direct effect (-0.724) on cut flowers per square meter, while indirect positive effects through plant height (0.423), leaf length (0.065), leaf area (0.671), days taken for stalk emergence (1.159), florets per stalk (0.288), stalk weight (0.354). Besides, it had indirect effect through number of leaves per plant (-0.419), leaf width (-0.047), internodal length (-0.020), floret diameter (-0.052), stalk girth (-0.277), vase life (-0.508) and longevity (-1.105).

4.7.1.11 Stalk girth (mm)

The stalk girth had positive direct effect (0.448) on cut flowers per square meter, while indirect positive effects through number of leaves per plant (0.514), internodal length (0.018), stalk length (0.448), vase life (0.678) and longevity (0.803). Besides, it had negative indirect effect through plant height (-0.329), leaf length (-0.036), leaf width (-0.006), leaf area (-0.450), days taken for stalk emergence (-1.059), florets per stalk (-0.104), floret diameter (-0.156), stalk weight (-0.407).

4.7.1.12 Stalk weight (g)

The stalk weight exhibited negative direct effect (-1.143) on cut flowers per square meter. Besides, indirect positive effects through number of leaves per plant (0.755), internodal length (0.023), floret diameter (0.023), stalk length (0.224), stalk girth (0.160), vase life (0.754) and longevity (1.051). Besides, it had negative indirect effect through plant height (-0.192), leaf length (-0.052), leaf width (-0.007), leaf area (-0.386), days taken for stalk emergence (-1.032), florets per stalk (-0.023).

4.7.1.13 Vase life (days)

The vase life had negative direct effect (-1.134) on cut flowers per square meter, while indirect positive effects through plant height (0.277), leaf length (0.030), leaf width (0.023), leaf area (0.217), days taken for stalk emergence (0.847), florets per stalk (0.206), stalk weight (0.760). Besides, it had negative indirect effect through number of leaves per plant (-0.277), internodal length (-0.015), floret diameter (-0.092), stalk length (-0.324), stalk girth (-0.268) and longevity (-0.785).

4.7.1.14 Longevity in plants (days)

The longevity in plants had negative direct effect (-2.539) on cut flowers per square meter, while indirect positive effects through plant height (0.219), leaf length (0.056), leaf width (0.061), leaf area (0.835), days taken for stalk emergence (1.487), florets per stalk (0.009), floret diameter (0.043), stalk weight (0.473). Besides, it had negative indirect effect through number of leaves per plant (-0.450), internodal length (-0.021), stalk length (-0.315), stalk girth (-0.142) and vase life (-0.351).

4.7.1.15 Number of cut flowers per square

The number of cut flowers per square meter was directly and positively influenced by plant height (0.479), leaf length (0.092), leaf width (0.170), leaf area (1.001), florets per stalk (0.417), stalk girth (0.448) and negative direct effect through number of leaves per plant (-1.060), internodal length (-0.036), days taken for stalk emergence (-1.691), floret diameter (-0.360), stalk length (-0.724), stalk weight (-1.143), vase life (-1.134) and longevity (-2.539).

4.7.2 Phenotypic path co-efficient analysis

The data related to phenotypic path co-efficient analysis is presented in Table 19.

4.7.2.1 Plant height (cm)

The plant height had positive direct effect (0.221) on cut flowers per square meter, while indirect positive effects through leaf length (0.179), leaf width (0.004), days taken for stalk emergence (0.799), florets per stalk (0.129), stalk weight (0.145) while indirect negative effect on number of leaves per plant (-0.089), leaf area (-0.069), internodal length (-0.011), floret diameter (-0.020), stalk length (-0.201), stalk girth (-0.136) vase life (-0.416) and longevity (-0.585).

4.7.2.2 Number of leaves per plant

The number of leaves per plant had negative direct effect (-0.204) on cut flowers per square meter, while indirect positive effects through plant height (0.096), leaf length (0.135), days taken for stalk emergence (0.718), floret diameter (0.014), stalk weight

Table 19. Phenotypic path coefficient analysis for fourteen different characters on number of stalks per m^2 of Stock (*Matthiola incana* L.) genotypes through direct and indirect effects

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	rP
1	**0.221**	-0.089	0.179	0.004	-0.069	-0.011	0.799	0.129	-0.020	-0.201	-0.136	0.145	-0.416	-0.585	-0.0498 NS
2	0.096	**-0.204**	0.135	-0.010	-0.082	-0.010	0.718	-0.010	0.014	-0.083	-0.098	0.282	-0.220	-0.558	-0.0281 NS
3	0.168	-0.117	**0.236**	0.008	-0.088	-0.012	0.919	0.061	-0.021	-0.174	-0.085	0.242	-0.270	-0.858	0.008 NS
4	0.012	0.029	0.027	**0.067**	0.007	-0.002	0.184	-0.015	0.014	0.063	-0.013	0.017	-0.086	-0.475	-0.1716 NS
5	0.126	-0.138	0.173	-0.004	**-0.121**	-0.011	1.029	0.030	0.005	-0.167	-0.100	0.166	-0.201	-1.189	-0.4019 *
6	0.092	-0.075	0.109	0.006	-0.050	**-0.027**	0.912	0.026	0.014	-0.138	-0.112	0.273	-0.369	-0.843	-0.1814 NS
7	-0.146	0.121	-0.179	-0.010	0.102	0.020	**-1.212**	-0.048	-0.012	0.182	0.138	-0.273	0.453	1.275	0.4114 *
8	0.114	0.008	0.057	-0.004	-0.014	-0.003	0.233	**0.251**	-0.037	-0.186	-0.053	0.024	-0.448	-0.031	-0.089 NS
9	0.044	0.029	0.050	-0.009	0.006	0.004	-0.149	0.092	**-0.100**	-0.032	0.097	0.028	-0.202	0.159	0.0156 NS
10	0.161	-0.061	0.150	-0.015	-0.073	-0.013	0.801	0.170	-0.012	**-0.275**	-0.132	0.134	-0.379	-0.620	-0.1654 NS
11	-0.116	0.077	-0.077	-0.003	0.047	0.011	-0.647	-0.051	-0.037	0.140	**0.259**	-0.134	0.440	0.412	0.3199 NS
12	-0.071	0.128	-0.127	-0.003	0.045	0.016	-0.736	-0.014	0.006	0.082	0.078	**-0.449**	0.594	0.602	0.1507 NS
13	0.099	-0.048	0.069	0.006	-0.026	-0.011	0.594	0.122	-0.022	-0.113	-0.123	0.289	**-0.925**	-0.420	-0.5092 **
14	0.088	-0.078	0.138	0.022	-0.098	-0.015	1.055	0.005	0.011	-0.116	-0.073	0.184	-0.265	**-1.466**	-0.6074 **

Residual effect = 0.0623   Bold : Direct effect   Above and Below diagonal : Indirect effect

Where, * & ** indicates significant @ 5 % and 1 % level, respectively

1. Plant height (cm)	2. Number of leaves per plant	3. Leaf length (cm)	4, Leaf width (cm)	5, Leaf area (cm^2/plant)
6. Internodal length (cm)	7. Days taken to stalk emergence	8. Number of florets per stalk	9. Floret diameter (cm)	10. Stalk length (cm)
11. Stalk girth (cm)	12. Stalk weight (g)	13. Vase life (days)	14. Longevity in plants (days)	

(0.282). Besides, it had negative indirect effect through leaf area (-0.082), leaf width (-0.010), internodal length (-0.010), florets per stalk (-0.010), stalk length (-0.083), stalk girth (-0.098), vase life (-0.220) and longevity (-0.558).

4.7.2.3 Leaf length (cm)

The leaf length had positive direct effect (0.236) on cut flowers per square meter, while indirect positive effects through plant height (0.168), leaf width (0.008), days taken for stalk emergence (0.919) florets per stalk (0.061), stalk weight (0.242) and remaining characters had negative indirect effects.

4.7.2.4 Leaf width (cm)

The leaf width positive direct effect (0.067) on cut flowers per square meter, while indirect positive effects through plant height (0.012), number of leaves per plant (0.029), leaf length (0.027), leaf area (0.007), days taken for stalk emergence (0.184), floret diameter (0.014), stalk length (0.063) and stalk weight (0.017). Besides, it had negative indirect effect through internodal length (-0.002), florets per stalk (-0.015), stalk girth (-0.013), vase life (-0.086) and longevity (-0.4475).

4.7.2.5 Leaf area (cm^2/plant)

The leaf area had negative direct effect (-0.121) on cut flowers per square meter, while indirect positive effects through plant height (0.126), leaf length (0.173), days taken for stalk emergence (1.029), florets per stalk (0.030), floret diameter (0.005), stalk weight (0.166). Besides, it had negative indirect effect through number of leaves per plant (-0.138), leaf width (-0.004), internodal length (-0.011), stalk length (-0.167), stalk girth (-0.100), vase life (-0.201) and longevity (-1.189).

4.7.2.6 Internodal length (cm)

The internodal length exhibited negative direct effect (-0.027) on cut flowers per square meter, while indirect positive effects through plant height (0.092), leaf length (0.109), leaf width (0.006), days taken for stalk emergence (0.912), florets per stalk (0.026), floret diameter (0.014) and stalk weight (0.273). Besides, it had positive indirect effect through number of leaves per plant (-0.075), leaf area (-0.050), stalk length (-0.138), stalk girth (-0.112), vase life (-0.369) and longevity (-0.843).

4.7.2.7 Days taken for stalk emergence

The days taken for stalk emergence had negative direct effect (-1.212) on cut flowers per square meter, while it had negative indirect effect through plant height (-0.146), leaf length (-0.179), leaf width (-0.010), florets per stalk (-0.048), floret diameter (-0.012), stalk weight (-0.273). Besides, indirect positive effects through number of leaves per plant (0.121), leaf area (0.102), internodal length (0.020), stalk length (0.182), stalk girth (0.138), vase life (0.453) and longevity (1.275).

4.7.2.8 Number of florets per stalk

Florets per stalk had positive direct effect (0.251) on cut flowers per square meter, while indirect positive effects through plant height (0.114), number of leaves per plant (0.008), leaf length (0.024), days taken for stalk emergence (0.233) and stalk weight (0.024). Besides, it had negative indirect effect through leaf width (-0.004), leaf area (-0.014), internodal length (-0.003), floret diameter (-0.037), stalk length (-0.186), stalk girth (-0.053), vase life (-0.448) and longevity (-0.031).

4.7.2.9 Floret diameter (cm)

The floret diameter had negative direct effect (-0.100) on cut flowers per square meter, while indirect positive effects through plant height (0.044), number of leaves per plant (0.029), leaf length (0.150), leaf area (0.006), internodal length (0.004), florets per stalk (0.092), stalk girth (0.097), stalk weight (0.028) and longevity (0.159). Besides, it had negative indirect effect through, leaf width (-0.009), days taken for stalk emergence (-0.149), stalk length (-0.032) and vase life (-0.202).

4.7.2.10 Stalk length (cm)

The stalk length had negative direct effect (-0.275) on cut flowers per square meter, while indirect positive effects through plant height (0.161), leaf length (0.150), days taken for stalk emergence (0.801), florets per stalk (0.170), stalk weight (0.134). Besides, it had indirect effect through number of leaves per plant (-0.061), leaf width (-0.015), leaf area (-0.073), internodal length (-0.013), floret diameter (-0.012), stalk girth (-0.132), vase life (-0.379) and longevity (-0.620).

4.7.2.11 Stalk girth (mm)

The stalk girth had positive direct effect (0.259) on cut flowers per square meter, while indirect positive effects through number of leaves per plant (0.077), leaf area (0.047), internodal length (0.011), stalk length (0.140), vase life (0.440) and longevity (0.412). Besides, it had negative indirect effect through plant height (-0.116), leaf length (-0.077), leaf width (-0.003), days taken for stalk emergence (-0.647), florets per stalk (-0.647), floret diameter (-0.037), stalk weight (-0.134).

4.7.2.12 Stalk weight (g)

The stalk weight exhibited negative direct effect (-0.449) on cut flowers per square meter. Besides, indirect positive effects through number of leaves per plant (0.128), leaf area (0.045), internodal length (0.016), floret diameter (0.006), stalk length (0.082), stalk girth (0.078), vase life (0.594) and longevity (0.602). Besides, it had negative indirect effect through plant height (-0.071), leaf length (-0.127), leaf width (-0.003), days taken for stalk emergence (-0.736), florets per stalk (-0.014).

4.7.2.13 Vase life (days)

The vase life had negative direct effect (-0.925) on cut flowers per square meter, while indirect positive effects through plant height (0.099), leaf length (0.069), leaf width (0.006), days taken for stalk emergence (0.594), florets per stalk (0.122), stalk weight (0.289). Besides, it had negative indirect effect through number of leaves per plant (-0.048), leaf area (-0.026), internodal length (-0.011), floret diameter (-0.022), stalk length (-0.113), stalk girth (-0.123) and longevity (-0.420).

4.7.2.14 Longevity in plants (days)

The longevity in plants had negative direct effect (-1.466) on cut flowers per square meter, while indirect positive effects through plant height (0.088), leaf length (0.138), leaf width (0.022), days taken for stalk emergence (1.055), florets per stalk (0.005), floret diameter (0.011), stalk weight (0.184). Besides, it had negative indirect effect through number of leaves per plant (-0.078), leaf area (-0.098), internodal length (-0.015), stalk length (-0.116), stalk girth (-0.073) and vase life (-0.265).

4.7.2.15 Number of cut flowers per square meter

The number of cut flowers per square meter was directly and positively influenced by plant height (0.221), leaf length (0.236), leaf width (0.067), florets per stalk (0.251), stalk girth (0.259) and negative direct effect through number of leaves per plant (-0.204), leaf area (-0.121), internodal length (-0.027), days taken for stalk emergence (-1.212), floret diameter (-0.100), stalk length (-0.275), stalk weight (-0.449), vase life (-0.925) and longevity (-1.466).

4.8 Incidence of pests and Diseases

The pests like Grass hopper and Diamond Back Moth (DBM) were observed during experimentation on vegetative and reproductive phase, respectively. These were controlled by application of Chlorpyrifos at 2 ml/l, Flubendiamide 39.35% at 3ml/10l and Neem oil at 2ml/l. However, Disease like Damping off which is caused by *Pythium* and *Rhizoctonia* was observed during the experimentation and it was controlled by application of Carbendazim 12% + Mancozeb 63% (SAAF) at 1.5 to 2 g/l.

4.9 Economics

The gross returns, net returns and benefit cost ratio of Stock genotypes grown under protected cultivation per 1000 m^2 were presented in Table 20 and Figure 3.

The maximum gross returns (₹ 5,00,000) were obtained in the genotype Arrow White followed by Early Iron Deep Yellow (₹ 4,33,333) whereas, the minimum gross returns (₹ 2,66,667) were obtained in the genotype Early Iron Marine.

Table 20. Economics of Stock genotypes (*Matthiola incana* L.) for 1000 m^2

Genotypes	Total cost (₹)	Number of stalks per 1000 m^2	Gross return (₹)	Net return (₹)	BCR
G_1 - Early Arrow white	1,07,606	18,933	3,78,667	2,71,061	2.52
G_2 - Arrow White	1,07,606	20,000	5,00,000	3,92,394	3.65
G_3 - Quartet Deep Yellow	1,07,606	15,733	3,14,667	2,07,061	1.92
G_4 - Early Iron White	1,07,606	19,733	3,94,667	2,87,061	2.67
G_5 - Early Iron Yellow	1,07,606	17,066	3,41,333	2,33,727	2.17
G_6 - Early Iron Deep Yellow	1,07,606	17,333	4,33,333	3,25,727	3.03
G_7 - Early Iron Marine	1,07,606	13,333	2,66,667	1,59,061	1.48
G_8 - Early Iron Pink	1,07,606	12,533	3,13,333	2,05,727	1.91
G_9 - Stock Katz Ruby	87,256	13,333	3,33,333	2,46,077	2.82
G_{10} - Stock Katz Blue	87,256	12,533	3,13,333	2,26,077	2.59
G_{11} - Stock Katz Purple	87,256	17,600	3,52,000	2,64,744	3.03

The maximum net returns (₹ 3,92,394) were obtained in the genotype Arrow White followed by Early Iron Deep Yellow (₹ 2,33,727) whereas, the minimum net returns (₹ 2,66,667) were obtained in the genotype Early Iron Marine.

The maximum benefit cost ratio (3.65) was obtained in the genotype Arrow White followed by Early Iron Deep Yellow (3.03) and Stock Katz Purple (3.03) whereas, the minimum benefit cost ratio (1.48) was obtained in the genotype Early Iron Marine.

DISCUSSION

V DISCUSSION

Stock is a newly introduced, high-value cut flower with attractive colours in India. *Matthiola incana* is an herbaceous annual that would be fascinating as a new species for the cut flower market. Stock production has increased dramatically in recent years, owing to the development of excellent cultivars in a wide range of colours. Stock is a crop that has gained popularity as a cut flower across the world. However, its commercial potential has yet to be achieved for different purpose. As a result, it is necessary to evaluate the suitability of various genotypes for hilly region under Naturally Ventilated Polyhouse (NVPH).

Character association on correlation is a measure of the degree of association between two characters. Correlation studies helps to know the association prevailing between highly heritable characters with most economic characters and gives better understandings on the contribution of each trait in building up of the genetic makeup of the crop. The phenotypic correlations indicate the extent of observed relationship because it includes both heritable and non-heritable association. Genotypic correlations provide an estimate of inherent association between genes controlling any two characters. Hence, it is of greater significance and could be effectively utilized in formulating an effective selection scheme whereas, path coefficient analyses will assist in determining the direct and indirect effects of various characters on the economic trait. Using these results, a selection index can be created, enabling the breeder to select accessions for further crop improvement.

With this perspective, 11 Stock genotypes were evaluated under NVPH, Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, in the year 2022-23. To estimate the phenotypic and genotypic association between the characters, as well as their direct and indirect effects on stalk yield. The experiment's findings are discussed in this chapter with the supporting data and available literature.

5.1 Growth parameters

Growth parameters such as days taken for germination, plant height, leaf length, leaf width, internodal length, plant spread, number of leaves per plant of Stock genotypes were recorded at 30 days interval after transplanting. Whereas, leaf area and chlorophyll content were recorded at grand growth stage. In general, growth rate of all the genotypes with respect to vegetative parameters increased as the days advanced.

The plant height is an important growth-related morphological character of crop plants. Significant differences were observed among the genotypes studied for plant height at different growth stages (Table 4). The genotype Stock Katz Blue recorded the maximum plant height (72.00 cm) while, the minimum plant height was recorded in Quartet Deep Yellow (54.87 cm). The variations in plant height among the Stock genotypes might be due to genetic factor, which was tested under this trial. These results were in tune with results obtained by Bhargav *et al.* (2020), Uddin *et al.* (2013) and Ahmad *et al.* (2017) in Lisianthus. The leaves are the functional unit of photosynthesis, which greatly influenced the growth and flower stalk yield of the crop. The maximum number of leaves per plant in case of genotype Stock Katz Ruby (70.73) whereas, the minimum number of leaves per plant was recorded in the genotype Early Iron Deep Yellow (47.33) (Table 5). The production of more leaves might be due to increased plant height. Similar variations in production of leaves amongst varieties have been reported by Ahmad *et al.* (2017), Bhargav *et al.* (2020) in Lisianthus, Sandesh (2019) in Liliums. The leaf length was significantly maximum throughout its growth period in the genotype Stock Katz Purple (18.55 cm). While the minimum leaf length recorded in Early Iron Yellow (12.77 cm) (Table 6). Length of the leaves differed from genotype to genotype, it might be due to the genetic makeup of the plant. These results were in tune with results obtained by Shwetha (2013) in Asiatic lily, Shivaprasad *et al.* (2016) in Rose, Sankari *et al.* (2020) in Liliums. The leaf width was significantly maximum throughout its growth period in the genotype Quartet Deep Yellow (4.09 cm) whereas, the minimum leaf width recorded in Early Iron Yellow (2.65 cm) (Table 6). The variation in leaf width might be attributed to varied growth rate and their genetic makeup. These results were in tune with results obtained by Shwetha (2013) in Asiatic lily and Shivaprasad *et al.* (2016) in Rose. The leaf area is one of the important factors which affect the photosynthesis of the plant and it helps to induce more stalk yield and flowering. Stock Katz Ruby had recorded significantly maximum leaf area (3199.94 cm^2/plant) at peak growth stage which could be due to a greater number of large sized leaves ,whereas, it was minimum in the genotype Early Iron Deep Yellow (1472.95 cm^2/plant) which could be due to lesser number of leaves per plant and shorter leaf length (Table 7). These results are in accordance with the findings of Anitha *et al.* (2016) in Lisianthus. Karrow and Sharma (2008) in Carnation, Bhat *et al.* (2016) and Nataraj *et al.* (2014) in Asiatic Lily, Sandesh (2019) in Liliums.

The plant spread varied significantly in East-West and North-South direction, respectively (Table 8), the maximum plant spread was observed in the genotype Stock Katz Purple (39.00 cm) whereas, the minimum plant spread observed in Early Arrow white (20.02 cm) in East-West direction. The maximum plant spread was observed in Stock Katz Purple (38.94 cm) while, the minimum plant spread observed in Early Iron Marine (20.63 cm) in North-South direction. Different genotypes have a significant impact on plant spread or canopy spread, which is regarded a crucial factor that indicates the rate of vegetative growth. It helps to utilize sunlight to the maximum extent. The results were in agreement with those of Shivaprasad *et al.* (2016) in Rose, Amreen (2012) in Gerbera, Aditya *et al.* (2019) Manjula and Nataraj (2016) in Dahlia, Sarkar *et al.* (2020) in China aster. The significant differences were observed among different genotypes of Stock for internodal length (Table 9). The maximum internodal length recorded in the genotype Stock Katz Blue (2.99 cm) whereas, minimum internodal length recorded in the genotype Early Iron Yellow (1.25 cm). The variation in the internodal length among the genotypes might be genetic control. In addition to this, higher the internodal length more will be the plant height. Anitha *et al.* (2013a) in Stock, Mukund *et al.* (2004a), in Carnation reported similar results. The chlorophyll content in leaf enhanced photosynthetic activity, which produce carbohydrates. Carbohydrates serve as energy source for growing bud, flower opening and longevity in plants. The chlorophyll content varied significantly among the genotype of Stock (Table 10). Chlorophyll 'a' content was significantly maximum in genotype Arrow White (0.87 mg/g) and minimum in Stock Katz Ruby (0.30 mg/g). The Chlorophyll 'b' content was significantly maximum in genotype Early Iron Deep Yellow (0.51 mg/g) and minimum in Arrow White (0.16 mg/g). The total chlorophyll content was significantly maximum in genotype Early Iron Marine (1.26 mg/g) and minimum in Stock Katz Blue (0.70 mg/g). The leaf chlorophyll content is a genetic character that differs according to the genotype. The variation in chlorophyll content was previously observed in Uddin *et al.* (2013) and Ahmad *et al.* (2017) in Lisianthus, Soujanya *et al.* (2018) in Rose and Tarannum and Naik (2012) in Carnation.

Performance of any cultivar is determined by its genetic makeup and environmental conditions. The variation in plant vigour among cultivars could be attributed to genetic variations. Variations among cultivars are observed because these characteristics are genetically controlled. As a result, the vigorous growing genotypes outperformed other genotypes in some or all vegetative characteristics such as plant height, number of branches, leaf length, leaf width, leaf area, number of leaves, internodal length, chlorophyll content and so on, some of which are interdependent.

5.2 Flowering parameters

The genotypes varied significantly with respect to days taken to flower stalk emergence (Table 11). The minimum days required for flower stalk emergence was observed in the genotype Stock Katz Ruby (43.60) and the maximum days required for the genotype Early Iron Deep Yellow (96.53). Early stalk emergence leads to the early harvesting of cut stalks, thus takes to market early. This variation might be mainly governed by genetic makeup of the genotypes. Similar variations were also reported by Harbaugh *et al.* (2000), Anitha *et al.* (2013a) and Ahmad *et al.* (2017) in Lisianthus. The genotypes varied significantly with respect to days taken to first visible flower (Table 11). The genotype Stock Katz Ruby recorded early flower opening (55.40) and the late flower opening recorded by the genotype Early Iron Deep Yellow (106.53). This variation could be attributed due to their genetic factor. Similar variations were also observed by Anitha *et al.* (2013a), Wazir (2014) and

Bhargav *et al.* (2020) in Lisianthus. The genotypes varied significantly with respect to days taken for stalk harvest (Table 11). The minimum days taken for stalk harvest was recorded by the genotype Stock Katz Ruby (74.40) whereas, Early Iron Deep Yellow recorded the maximum number of days taken to stalk harvest (129.13). This variation might be mainly governed by the genomic constitution of the genotypes. Similar variations were also reported by Uddin *et al.* (2013), Anitha *et al.* (2013a) and Bhargav *et al.* (2020) and Ahmad *et al.* (2017) in Lisianthus.

5.3 Flower quality parameters

The quality of Stock flowers is the most desirable as consumer preference keeps on changing market scenario for commercial cut flower production on the basis of various characters. The quality characters *viz*., stalk length, stalk girth, stalk weight, number of florets per stalk, floret diameter, vase life and consumer acceptance were considered to be of prime importance and should be more stressed upon as pre-requisites for cut flower purpose. Various characters of the 11 Stock genotypes are discussed below with regard to their importance in cut flower production. Significant differences were observed among the varieties for these quality parameters (Table 12 to 14).

The maximum Stalk length was recorded in the genotype Stock Katz Blue (93.93 cm), while minimum of stalk length was recorded in the genotype Quartet Deep Yellow (64.87 cm). Stalk length varied significantly among the different genotypes of Stock (Table 12). The variation might be due to accumulation of more dry matter in sink due to enhanced vegetative growth and also genetic makeup of the genotype. Increased number of internodes with increased internodal length resulted in increased stalk length. The results were in agreement with those of Uddin *et al.* (2013) in Stock, Shivaprasad *et al.* (2016) in Rose and Chandrashekar *et al.* (2018) in Asiatic Lily. The maximum stalk girth was recorded in the genotype Arrow White (10.04 mm) while, minimum stalk girth was recorded in the genotype Stock Katz Blue (6.37 mm). The stalk girth determines the sturdiness of the flower (Table 12). The variation in flower stalk girth might be due to the inherent genetic characters of the Stock genotypes. The results were in agreement with those of Harbaugh *et al.* (2000), Ahmad *et al.* (2017) in Lisianthus, Jose *et al.* (2017) in Carnation and Shivaprasad *et al.* (2016) in Rose. The maximum stalk weight recorded in the genotype Early Iron Deep Yellow (169.87 g) whereas, the minimum stalk weight was recorded in the genotype Early Arrow white (61.27 g) (Table 12). The variation in stalk weight of the Stock genotypes is might be the differences in the genetic makeup. Similar findings on differences in stalk weight in Stock were found in Anitha *et al.* (2013a) and Medeo *et al.* (2019) in Carnation and Sandesh (2019) in Liliums.

The maximum number of florets per stalk was recorded in the genotype Stock Katz Blue (32.07), while minimum number of florets per stalk was recorded in the

Plate 5. Variation in leaves and stalk length among different Stock (*Matthiola incana* L.) genotypes

genotype Quartet Deep Yellow (13.20). Number of florets per stalk varied significantly among the different genotypes of Stock (Table 13). The variation might be due to length of the stalk and also genetic makeup of the genotype. Similar findings were reported previously by Uddin *et al.* (2013) in Stock, Shivaprasad *et al.* (2016) in Rose and Chandrashekar *et al.* (2018) in Asiatic Lily. The maximum floret diameter was observed in the genotype Arrow White (4.22 cm) whereas, the minimum flower diameter was recorded in the genotype Early Iron Marine (3.31 cm) (Table 13). The differences in the flower diameter might be due to inherent character of individual genotypes and bigger sized florets. These results are in conformity with Harbaugh *et al.* (2000), Anitha *et al.* (2013a) ,Wazir (2014) in Stock, Medeo *et al.* (2019) and Verma *et al.* (2012) in Carnation, Chandrashekar *et al.* (2018) in Asiatic lily.

The maximum vase life was recorded in the genotype Stock Katz Blue (13.47 days) while, minimum vase life was recorded in the genotype Quartet Deep Yellow (7.33 days) and Early Iron Deep Yellow (7.33 days) (Table 14). This variation in vase life could also be attributed to fact that, the variation in ability to produce ethylene and sensitivity to it among the different genotypes. Similar variations were observed in by Harbaugh *et al.* (2000), Anitha *et al.* (2013), Uddin *et al.* (2013) and Bhargav *et al.* (2020) in Lisianthus. The maximum longevity in plants was recorded in the genotype Stock Katz Ruby (36.61 days) while, minimum longevity in plants was recorded in the genotype Early Iron White (14.70 days). This variation in longevity in plants, plant height and leaf area (Table 14). As its longevity in plants is more than a month, we can use this as a potted plants and also as bedding plants, The results were in coincidence with the results obtained by Harbaugh *et al.* (2000), Anitha *et al.* (2013), Uddin *et al.* (2013) and Bhargav *et al.* (2020) in Lisianthus.

Based on consumer preference the genotype Early Iron Pink (4.67), Stock Katz Purple (4.65), Stock Katz Blue (4.60) and Stock Katz Ruby (4.54) was more attractive with respect to flower colour. For cut flower suitability among the different genotypes of Stock, the genotypes Early Iron Pink (4.67), Stock Katz Purple (4.65), Stock Katz Blue (4.60) and Stock Katz Ruby (4.54) were highly preferred. For fragrance among the different genotypes of Stock, Stock Katz Blue, Early Iron Pink (4.70) and Stock Katz Purple (4.67) were preferred more whereas, overall acceptance was recorded highest for genotype Early Iron Pink and followed by Stock Katz Purple (4.65) and Stock Katz Blue (4.59) (Appendix-II). This might be due to more attractive to the consumers. The results were in coincidence with the results obtained by Perk *et al.* (2009) in flower crops.

5.4 Yield parameters

Flower stalk yield is the most important criterion for commercial cut flower production under protection and productivity is the standard by which any genotype's performance is assessed. The genotype Arrow White (25.00 & 20000.00, respectively) and Early iron White (24.67 & 19733.33, respectively) produced the maximum number of cut flowers per square meter and per 1000 square meter. However, minimum number of cut flowers per square meter and per 1000 square meter was observed in the genotype Early Iron Pink (15.67 & 12533.33, respectively) and Stock Katz Blue (15.67 & 12533.33, respectively) (Table 15). The increase stalk yield might be attributed to more number double type flowers production and the variation in number of doubleness of the Stock genotypes is might be the differences in the genetic makeup. Similar variation for stalk yield was also observed by Anitha *et al.* (2013a), Uddin *et al.* (2013), Wazir (2014) and Ahmad *et al.* (2017) in Lisianthus.

5.5 Variability, heritability and genetic advance over per cent mean

The success of crop improvement programmes depends on the extent of genetic variability existing in the population or germplasm stocks of the traits for which the improvement is aimed at. The information of genetic architecture of various quantitative characters particularly of those which contribute to economic characters would be very useful in planning breeding programme. Further, variability studies will provide information regarding the amount and direction of association between two characters at a time, with the help of these results a selection index can be framed that would enable the breeder to select accessions for further crop improvement.

Analysis of variance (Table 16 and 17) of all the 11 genotypes of Stock revealed significant variation among the different genotypes for all the characters studied. This suggested the presence of wide range of variability for different characters among the genotypes which can be exploited through selection. However, the analysis of variance by itself is not enough and conclusive to explain all the inherent genotypic variance one of the collections. One of the ways in which variability of these characters assessed is through a simple approach of range of variation. Range of variation observed for all the traits in the present study indicated the presence of sufficient amount of variation among the characters studied. The range in the values reflect the amount of variability, which is not very reliable since it includes genotypic, environmental and genotypic × environmental interaction components and does not reveal as to which character showing higher degrees of variability. Further, the phenotype of the crop is influenced by additive gene effect (heritable), dominance (non-heritable) and epistasis (non-allelic interaction). Hence, it becomes necessary to work out observed variability into phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), which ultimately indicates the extent of variability existing for various traits. The estimation of heritability has a greater role to play in determining the effectiveness of selection of a character provided it is considered in conjunction with the predicted genetic advances as suggested by Panse and Sukhatme (1967) and Johnson *et al.* (1955), since

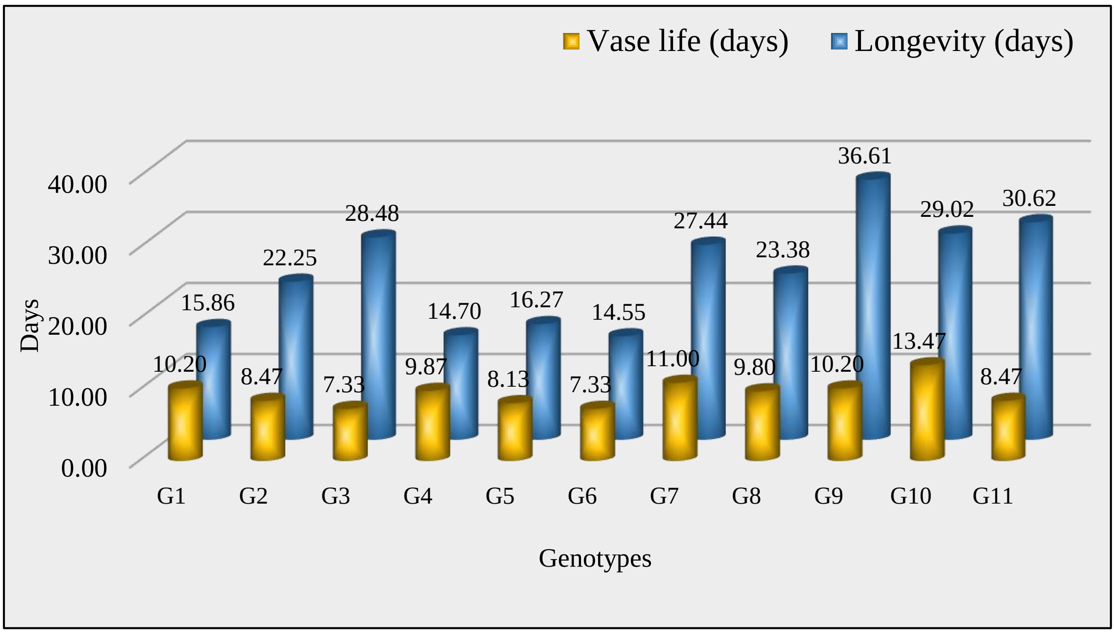

Fig 2. Performance of Stock (*Matthiola incana* L.) genotypes with respect to longevity in plants and vase life under protected cultivation

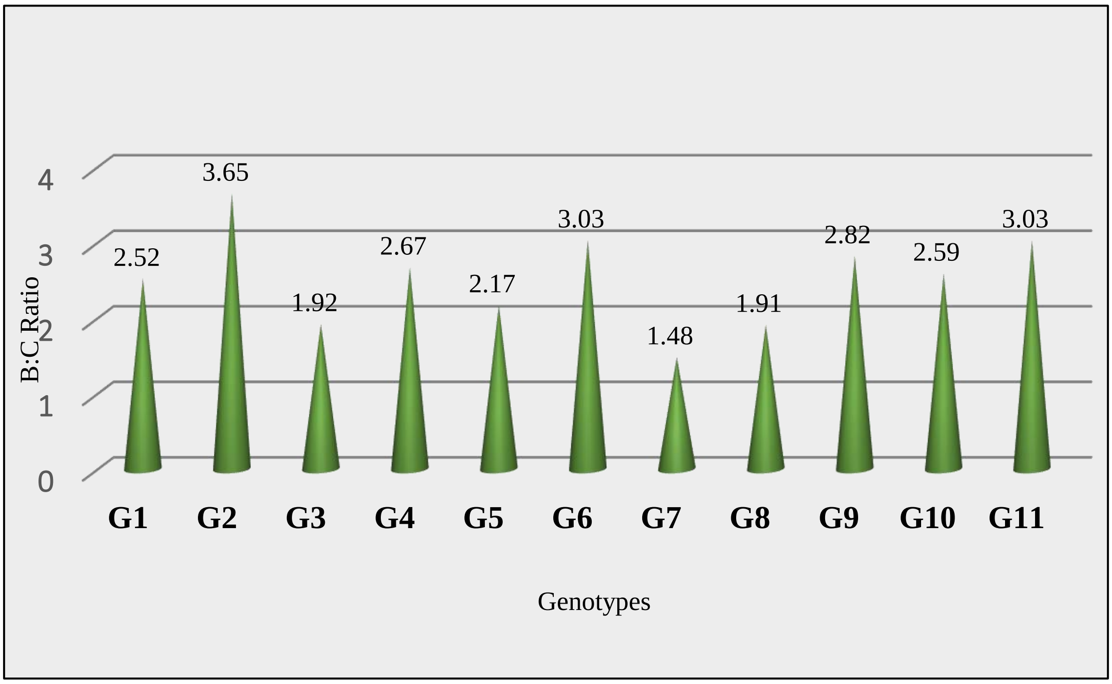

Fig 3. Benefit:Cost ratio of different Stock (*Matthiola incana* L.) genotypes

G_1 - Early Arrow white	G_2 - Arrow White	G_3 - Quartet Deep Yellow
G_4 - Early Iron White	G_5 - Early Iron Yellow	G_6 - Early Iron Deep Yellow
G_7 - Early Iron Marine	G_8 - Early Iron Pink	G_9 - Stock Katz Ruby
G_{10} - Stock Katz Blue	G_{11} - Stock Katz Purple	

Plate 6. Vase life studies among the different Stock (*Matthiola incana* L.) genotypes

heritability is influenced by biometrical method, generation of hybrid, sample size of experimental material and environment.

In the present investigation, phenotypic coefficient of variation was observed higher than genotypic coefficient of variation for all the traits evaluated, indicating the role of environmental factors for the expression of these characters (Table 18 and 19).

Estimates of PCV values were relatively higher than GCV values for all the characters studied with narrow differences indicating less environmental influence on the expression of traits. This also suggests the presence of sufficient genetic variability which can be exploited by practicing pure line selection. Similar results were obtained in Stock Anitha *et al.* (2013b), Vikas *et al.* (2011) in Dahlia, Rashmi *et al.* (2015) in Gladiolus, Santhosh *et al.* (2017) in Heliconia and Ramya *et al.* (2018) in China aster.

High values of PCV and GCV were recorded by leaf area, internodal length, chlorophyll ‘a’, chlorophyll ‘b’, total chlorophyll, days taken to flower stalk emergence, number of florets per stalk, stalk weight, longevity in plants indicating wider variation in the population and less environmental influence on the expression of characters. Similar findings were reported in Anitha *et al.* (2013b) in Lisianthus, Rajiv *et al.* (2014), Ramya *et al.* (2018) in China aster, Arulmani *et al.* (2016) in Gaillardia and Balaram and Janakiram (2009) in gladiolus for internodal length and stalk weight.

Moderate PCV and GCV were recorded by plant height, number of leaves per plant, plant spread in East-West and North-South direction, leaf length, leaf width, days taken to first visible flower, days taken to flower stalk harvest, stalk length, stalk girth, vase life, number of cut flowers per square meter and per 1000 square meter indicating greater scope for selection improve upon these traits could be achieved. The results were in conformity with Hegde and Patil (1995), Bichoo *et al.* (2002), Verma *et al.* (2004), Ghimray (2005) in gladiolus and Gangadharappa *et al.* (2008) in tuberose for spike length at harvest and Anuradha and Gowda (1990), Balaram *et al.* (2000), Ghimray (2005), Bichoo *et al.* (2002), Lepcha *et al.* (2007) and Bhatia and Grewal (2009) in gladiolus for number of florets per spike.

Low PCV and GCV were recorded for floret diameter. This is in accordance with the findings of Bhatia and Grewal (2009) in gladiolus and Giranje *et al.* (2017) in Gaillardia.

Broad sense of heritability and genetic advance as percent over mean estimates higher number of leaves per plant, leaf length, leaf width, leaf area, plant spread, internodal length, chlorophyll contents, days taken for stalk emergence, days taken for harvest, stalk length, stalk weight, stalk girth, number of florets per stalk, vase life, longevity in plants and stalk yield indicating the effectiveness of selection through phenotypic performance but it does not mean a high genetic gain. However, high heritability associated with high genetic advance proves more useful for efficient improvement of a character through simple selection. These results are in agreement with the findings of Sarangi *et al.*(1994), Verma *et al.* (2004), Ghimray (2005), Nimbalkar *et al.* (2007), Bhatia and Grewal (2009) in gladiolus for stalk length. Anitha *et al.* (2013b) in Lisianthus for days taken to bud emergence. Vikas *et al.* (2011) in Dahlia, Telem *et al.* (2017), Prakash *et al.* (2017) in Chrysanthemum, Ramya *et al.* (2018) in China aster and Byadwal *et al.*(2018) in Gaillardia for number of stalks per plant.

High heritability with moderate genetic advance as per cent over mean recorded for plant height and floret diameter indicating additive gene action conditioning their expression and phenotypic selection for their amenability can be brought about. The findings are in confirmity with the reports of Verma *et al.* (2004), Ghimray (2005), Manoj and Dwivedi (2006), Archana *et al.* (2008) in gladiolus, Suma and Patil (2006) in Daisy and Gangadharappa *et al.* (2008) in tuberose for floret diameter and plant height.

5.6 Correlation coefficient analysis

The potential progress anticipated in achieving the objectives demands a knowledge of the interrelationships among several component features that contribute to stalk yield, which aids the breeder in developing simultaneous selection schemes. Character associations might vary based on the environment. As a selection basis, the association of economically important yield traits of quantitative nature is extremely effective. It is impossible to analyze the population for each and every quantitative trait because the breeder has to handle a very large population in achieving the objectives. Therefore, it is necessary to have the estimates of correlation of yield with other traits for which the genotypes could be assessed visually or measured easily. Thus, correlation analysis helps in examining the possibility of improving yield through indirect selection of its component traits which are highly correlated with yield.

In present investigation, the estimates of genotypic correlation in general were higher than phenotypic correlations, indicating the presence of inherent association between various characters (Table 20 and 21). In all instances, however, more reliance might be placed on the genotypic correlation and the estimates of genetic correlations in general were higher than phenotypic correlations by Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Ramya *et al.* (2018), Kumar *et al.* (2017) in Gerbera and Beeralingappa *et al.* (2016) in Chrysanthemum.

5.6.1 Genotypic correlation coefficient analysis

Plant height showed highly significant positive correlation with leaf length and stalk length while, significant positive correlation was noticed with leaf area. It showed highly significant negative correlation with days taken for stalk emergence whereas, it recorded significant negative correlation with stalk girth. This association of plant height with the characters mentioned is a desirable feature in this crop. The results were in agreement with Lal *et al.* (1985), Gowda (1989), Misra and Saini (1990), Jhon *et al.* (2002) in gladiolus, Mousavi *et al.* (2008), Cordea *et al.* (2008) in Stock, Rakesh Kumar and Santhosh Kumar (2010) in snapdragon. Number of leaves per plant recorded significant positive correlation with leaf length and leaf area while, significant negative correlation was noticed with days taken for stalk emergence and stalk weight. The results are in consonance with Neeraj *et al.* (2001), Jhon *et al.* (2002) in gladiolus, Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Gangadharappa *et al.* (2008) in tuberose and Rakesh Kumar and Santhosh Kumar (2010) in snapdragon. Leaf length observed highly significant positive correlation with plant height and leaf area while significant positive correlation was noticed with number of leaves per plant, stalk length and longevity in plants. It showed highly significant negative correlation with days taken for stalk emergence. Similar findings were reported in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Tarannum and Naik (2012) in Carnation Prakash *et al.*(2017) in Chrysanthemum. Leaf area showed highly significant positive correlation with leaf length and longevity in plants while, significant positive correlation was noticed with plant height, number of leaves per plant and stalk length. It showed highly significant negative correlation with days taken for stalk emergence. Similar findings were reported in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Prakash *et al.*(2017) and Beeralingappa *et al.* (2016) in Chrysanthemum, Amreen (2012) in Gerbera. Internodal length recorded highly significant negative correlation with days taken for stalk emergence whereas, significant negative correlation with stalk weight. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Manjula and Nataraj (2016) in Dahlia and Tarannum and Naik (2012) in Carnation.

The days taken for stalk emergence had a significant positive correlation with stalk girth and stalk weight. It showed highly significant negative correlation with Plant height, leaf length, leaf area, internodal length and longevity in plants whereas, significant negative correlation with number of leaves per plant and stalk length. Similar findings were observed in Mukund *et al.* (2004) in Carnation, Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock and Dhiman *et al.* (2020) in Lisianthus. Stalk length showed highly positive correlation with plant height whereas significant correlation with leaf length, leaf area and number of florets per stalk. It recorded negative significant correlation with days taken for stalk emergence and stalk girth.

Number of florets per stalk had significant positive correlation with stalk length. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Gangadharappa *et al.* (2008) in tuberose and Rakesh Kumar and Santhosh Kumar (2010) in snapdragon, Sharma and Srivastava (2014) in Carnation and Dhiman *et al.* (2020) in Lisianthus. Stalk girth had significant positive correlation with days taken for stalk emergence whereas, negative significant correlation with plant height and stalk length. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Mukund *et al.* (2004) in Carnation and Dhiman *et al.* (2020) in Lisianthus. Stalk weight showed significant positive correlation with days taken for stalk emergence whereas, negative significant correlation with number of leaves per plant internodal length and vase life. Vase life had negative significant correlation with stalk weight. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock and Dhiman *et al.* (2020) in Lisianthus. Longevity in plants recorded highly significant positive leaf area while, significant positive correlation with leaf length. Highly significant negative correlation was noticed with days taken for stalk emergence and significant negative correlation for yield per square meter. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock and Dhiman *et al.* (2020) in Lisianthus. The number of cut flowers per square meter had significant negative correlation with longevity in plants. Similar results were observed by Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock.

<u>5.6.2 Phenotypic correlation coefficient analysis</u>

Plant height showed highly significant positive correlation with leaf length, leaf area stalk length, number of florets per stalk and vase life while, significant positive correlation with number of leaves, internodal length and longevity in plants. Highly significant negative correlation was recorded with days taken for stalk emergence and stalk girth. The results were in agreement with Lal *et al.* (1985), Gowda (1989), Misra and Saini (1990), Jhon *et al.* (2002) in gladiolus, Mousavi *et al.* (2008), Cordea *et al.* (2008) in Stock. Number of leaves per plant recorded highly significant positive correlation with leaf length and leaf area while, significant positive correlation with plant height, internodal length and longevity in plants. Highly significant negative correlation was noticed with days taken for stalk emergence and stalk weight whereas, significant negative correlation with stalk girth. The results are in consonance with Neeraj *et al.* (2001), Jhon *et al.* (2002) in gladiolus, Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Gangadharappa *et al.* (2008) in tuberose. Leaf length observed highly significant positive correlation with plant height, number of leaves per plant, leaf area, internodal length, stalk length and longevity in plants while, highly significant negative correlation with days taken for stalk emergence and stalk weight. Similar findings were reported in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Tarannum and Naik (2012) in Carnation and

Prakash *et al.*(2017) in Chrysanthemum. Leaf area showed highly significant positive correlation with plant height, number of leaves per plant, leaf length, stalk length and longevity in plants while, significant positive correlation was noticed with internodal length. It showed highly significant negative correlation with days taken for stalk emergence whereas, significant negative correlation with stalk girth, stalk weight and yield per square meter. Similar findings were reported in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Prakash *et al.*(2017) and Beeralingappa *et al.* (2016) in Chrysanthemum and Amreen (2012) in Gerbera. Internodal length recorded highly significant negative correlation with days taken for stalk emergence and stalk weight whereas, significant negative correlation with stalk girth. It was showed highly significant positive correlation with leaf length, stalk length and longevity in plants while, significant positive correlation with plant height, number of leaves per plant, leaf area and vase life. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Manjula and Nataraj (2016) in Dahlia and Tarannum and Naik (2012) in Carnation.

The days taken for stalk emergence had highly significant positive correlation with stalk girth and stalk weight whereas, significant positive correlation with yield per square meter. It showed highly significant negative correlation with plant height, number of leaves per plant leaf length, leaf area, internodal length, stalk length, vase life and longevity in plants. Similar findings were observed by Mukund *et al.* (2004) in Carnation, Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock and Dhiman *et al.* (2020) in Lisianthus. Stalk length showed highly positive correlation with plant height, leaf length, leaf area, internodal length and number of florets per stalk whereas significant positive correlation with vase life and longevity in plants. Number of florets per stalk had highly significant positive correlation with plant height, stalk length and vase life while, significant positive correlation with floret diameter. It recorded highly negative significant correlation with days taken for stalk emergence and stalk girth. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Gangadharappa *et al.* (2008) in tuberose and Rakesh Kumar and Santhosh Kumar (2010) in snapdragon, Sharma and Srivastava (2014) in Carnation and Dhiman *et al.* (2020) in Lisianthus. Floret diameter had significant positive correlation with number of florets per stalk and stalk girth. Stalk girth had highly significant positive correlation with days taken for stalk emergence whereas, significant positive correlation with floret diameter. Highly negative significant correlation with plant height and stalk length and vase life while, negative significant correlation with number of leaves per plant, leaf area and internodal length. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Mukund *et al.* (2004) in Carnation and Dhiman *et al.* (2020) in Lisianthus. Stalk weight showed highly significant positive correlation with days taken for stalk emergence whereas, highly negative significant correlation with number of leaves per plant, leaf length, leaf area, internodal length and vase life. It showed negative significant correlation with longevity in plants. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock and Dhiman *et al.* (2020) in Lisianthus. Vase life had highly significant positive correlation with plant height and number of florets per plant whereas, significant positive correlation with internodal length and stalk length. Highly negative significant correlation with days taken for stalk emergence, stalk girth, stalk weight and stalk yield per square meter while. Similar findings were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Mukund *et al.* (2004) in Carnation and Dhiman *et al.* (2020) in Lisianthus. Longevity in plants recorded highly positive correlation with leaf length, leaf area and internodal length while, significant positive correlation with plant height, number of leaves and stalk length. Highly significant negative correlation was noticed with days taken for stalk emergence and stalk yield per square meter while, significant negative correlation with stalk weight. Similar findings were reported in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock, Prakash *et al.*(2017) and Beeralingappa *et al.* (2016) in Chrysanthemum, Amreen (2012) in Gerbera. number of cut flowers per square meter had highly significant negative correlation with vase life and longevity in plants whereas, significant negative correlation with leaf area. It also showed significant positive correlations with days taken for stalk emergence. Similar results were observed in Mousavi *et al.* (2008) and Cordea *et al.* (2008) in Stock.

5.7 Path coefficient analysis

As the correlation value is the sum total of direct and indirect effects of several independent characters on a dependent character like stalk yield, it is quite possible that the correlation (positive or negative) might be of small magnitude and non-significant in spite of its high direct effect or some of the indirect effects operating in the opposite direction. Path analysis enables to partition the correlation value of independent characters on dependent character into direct and indirect effects to get a correct picture of the association between the characters. Further, for the same reason, as many independent characters as possible, whether or not they are showing significant correlations with the dependent character are to be considered for path co-efficient analysis.

Path analysis is a useful technique to understand more clearly the association among different variables considering simple correlation coefficients. It helps to partition the overall association of particular variables with dependent variable into direct and indirect effects. When the influence of a set of variables on the dependent variable is to be understood, it is possible with the help of path analysis that estimates the extent of direct contribution of a particular variable and the extent of its indirect contribution through other variables in a set to the total influence it has on the dependent variable. While dealing with a more complex character like stalk yield, it

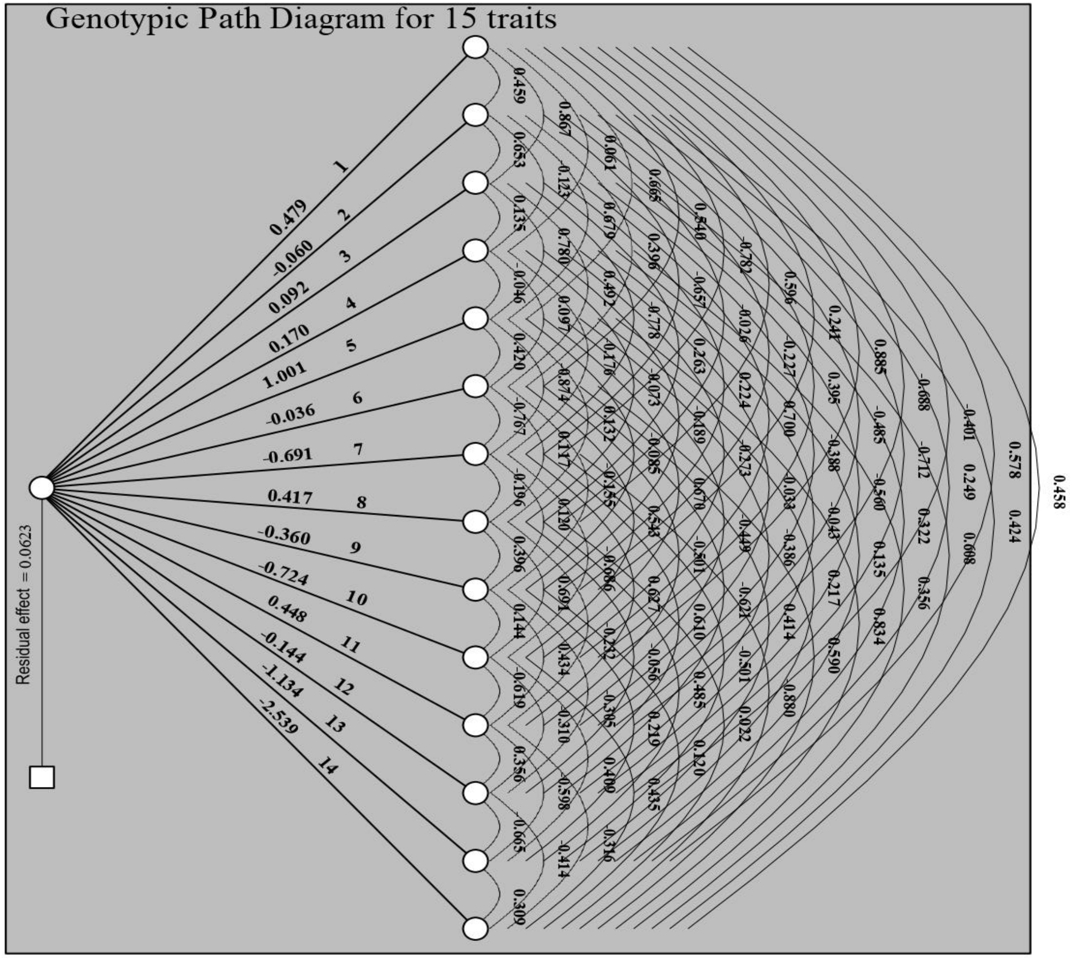

Fig 4. Pictorial representation of genotypic path diagram for 14 different characters on number of cut flowers/m^2 of Stock genotypes (*Matthiola incana* L.) through direct and indirect effects

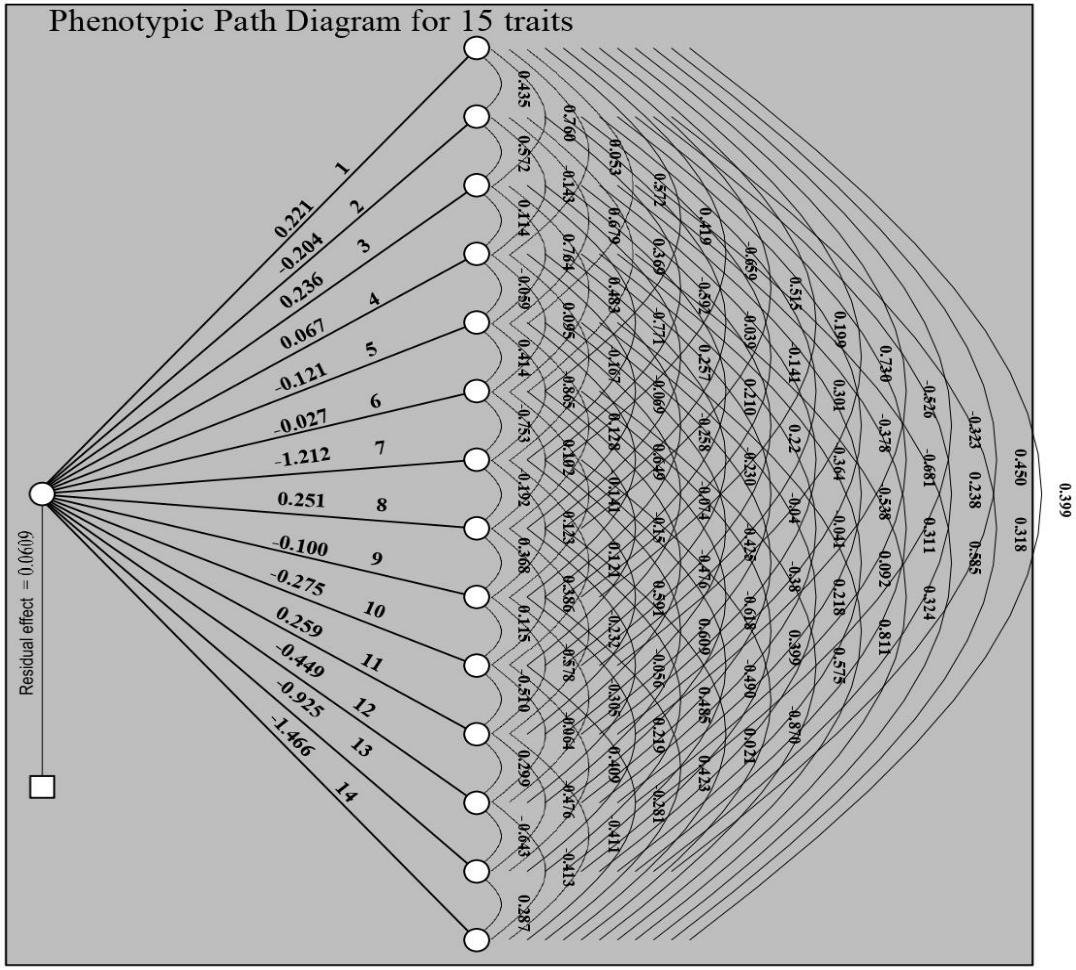

Fig 5. Pictorial representation of phenotypic path diagram for 14 different characters on number of cut flowers/m^2 of Stock genotypes (*Matthiola incana* L.) through direct and indirect effects

enables the breeders to identify the important component traits of such a nature, so that differential emphasis can be laid on such component characters for selection.

Assessment of direct and indirect effects of characters on stalk yield through path analysis indicated the maximum positive direct effect of total leaf area followed by plant height, leaf length, leaf width, number of florets per stalk and stalk girth. Thus, the higher magnitude of the positive direct effect of these traits explains the higher value of association between these traits and flower stalk yield per square meter. Therefore, direct selection for these traits would reward for improvement of yield while, the number of leaves per plant, internodal length, days taken to stalk emergence, floret diameter, stalk length, stalk weight, vase life and longevity in plants were negatively contributed towards yield per plant (Table 22 and 23). The results are in accordance with reports of Jhon *et al.* (2002) and Balaram and Janakiram (2009) in gladiolus. Magar *et al.* (2010) in Gerbera, Sharma *et al.* (2012) in Carnation, Sankari *et al.* (2020) in Liliums.

5.8 Incidence of pests and diseases

Matthiola incana observed average incidence of pests during the crop growth stage starting from seedling stage to flowering stage. Grass hopper observed minimum incidence during initial growth stages. Diamond Back Moth (DBM) incidence observed during the stalk emergence stage. This result is in conformity with Ho *et al.* (2021) in stock.

5.9 Economics:

The total cost of cultivation (₹ 87,256) for Katz series and for other genotypes (₹ 1,07,606). The genotype Arrow White realized the maximum gross returns of ₹ 5,00,000 and net returns of ₹ 3,92,394 per 1000 sq. m with BCR (3.65) which was followed by Early Iron Deep Yellow and Stock Katz Purple as compared to other genotypes. The genotype Early Iron Marine recorded minimum with BCR (1.48). The increase in net returns and B: C ratio in these genotypes is mainly due to production of a greater number of double types and quality flowers (Table 24 and Appendix III).

Conclusion

Results of the experiment clearly confirmed that, the genotype Stock Katz Blue followed by Stock Katz Ruby, Stock Katz Purple and Early Iron Pink were found to be superior with regard to most of the morphological, flowering and quality traits while, Arrow White followed by Early Iron Deep Yellow were found to be superior with regard to yield parameters. The parameters such as leaf area, internodal length, chlorophyll 'a', chlorophyll 'b', total chlorophyll, days taken to flower stalk emergence, number of florets per stalk, stalk weight, longevity in plants exhibited high PCV and GCV while, plant height, number of leaves per plant, plant spread in East-West and North-South direction, leaf length, leaf width, days taken to first visible flower, days taken to flower stalk harvest, stalk length, stalk girth, vase life, number of cut flowers per square meter showed moderate PCV and GCV. High heritability coupled with high genetic advance over per cent mean was observed for all the traits studied except for plant height and floret diameter which have high heritability coupled with moderate genetic advance over per cent mean .

Correlation studies revealed that the stalk length showed significant positive correlation with plant height, leaf length, leaf area, number of florets per stalk. The number of florets per stalk exhibited significant positive correlation with stalk length. Vase life showed significant negative correlation with weight and girth of the stalk. Whereas, stalk yield has not showed significance correlation with any traits at genotypic level.

Path analysis for stalk yield per plant revealed that the plant height, leaf length, leaf width, leaf area, number of florets per stalk and stalk girth have high positive effect indicating the possibility of increasing stalk yield by selecting these characters directly.

Future line of work

By looking into the salient findings of the present study, the future line of work might be thought in the following direction.

1. Promising genotypes among the collection might be utilized in the crop improvement programme.
2. Crop improvement through hybridization among the elite Stock genotypes for higher quality characters.
3. Screening for major pests and diseases incidence need to be studied in the Stock genotypes.

SUMMARY

VI SUMMARY

The present investigation entitled "Studies on character association and path analysis for yield and quality parameters in Stock (*Matthiola incana* L.) genotypes" was carried out with the primary objective to study the correlation and path analysis for growth, yield and quality parameters. The experiment was carried out at the Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere under Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga during 2022-23. The salient outcomes of this experiment are concised in this chapter.

Growth performance of 11 genotypes of Stock indicated significant variations at all growth stages of the crop. The genotype Stock Katz Blue recorded the maximum plant height (72.00 cm) while, the minimum plant height was recorded in Quartet Deep Yellow (54.87 cm). The maximum number of leaves per plant in case of genotype Stock Katz Ruby (70.73) whereas, the minimum number of leaves per plant was recorded in the genotype Early Iron Deep Yellow (47.33).

The leaf length recorded the maximum in the genotype Stock Katz Purple (18.55 cm) whereas the minimum in the genotype Early Iron Yellow (12.77 cm). The leaf width recorded the maximum in the genotype Quartet Deep Yellow (4.09 cm) whereas the minimum in the genotype Early Iron Yellow (2.65 cm).

Stock Katz Ruby (3199.94 cm^2/plant) had recorded significantly the maximum leaf area which was followed by Stock Katz Purple (2880.85 cm^2/plant) whereas, the minimum leaf area was recorded in the genotype Early Iron Deep Yellow (1472.95 cm^2/plant) which is on par with Early Iron White (1668.91 cm^2/plant).

Plant spread in East-West direction recorded the maximum in the genotype Stock Katz Purple (39.00 cm) whereas, the minimum plant spread in East-West direction was observed in the genotype Early Arrow white (20.02 cm). Plant spread in North- South direction recorded the maximum in the genotype Stock Katz Purple (38.94 cm) whereas, the minimum was observed in the genotype Early Iron Marine (20.63 cm).

Among the different genotypes, the maximum internodal length recorded in the genotype Stock Katz Blue (2.99 cm) whereas, the minimum internodal length was recorded in the genotype Early Iron Yellow (1.25 cm).

The Chlorophyll 'a' content was significantly the maximum in genotype Arrow White (0.87 mg/g) and the minimum in Stock Katz Ruby (0.30 mg/g). The Chlorophyll 'b' content was significantly the maximum in genotype Early Iron Deep Yellow (0.51 mg/g) and the minimum in Arrow White (0.16 mg/g). The total chlorophyll content was significantly the maximum in genotype Early Iron Marine (1.26 mg/g) and the minimum in Stock Katz Blue (0.70 mg/g).

The genotype Stock Katz Ruby (43.60) recorded the minimum number of days to flower stalk emergence whereas, the genotype Early Iron Deep Yellow (96.53) recorded the maximum number of days. The genotype Stock Katz Ruby (55.40) recorded the minimum number of days to first visible flower while, the maximum number of days was taken by the genotype Early Iron Deep Yellow (106.53). The minimum days taken for stalk harvest was recorded by the genotype Stock Katz Ruby (74.40) whereas, the maximum days taken for stalk harvest was recorded by the genotype Early Iron Deep Yellow (129.13).

The maximum stalk length was recorded in the genotype Stock Katz Blue (93.93 cm), while the minimum stalk length was recorded in the genotype Quartet Deep Yellow (64.87 cm). The maximum stalk girth was recorded in the genotype Arrow White (10.04 mm) while, minimum stalk girth was recorded in the genotype Stock Katz Blue (6.37 mm). The maximum stalk weight recorded in the genotype Early Iron Deep Yellow (169.87 g) whereas, the minimum stalk weight was recorded in the genotype Early Arrow white (61.27 g).

The maximum number of florets per stalk was recorded in the genotype Stock Katz Blue (32.07), while minimum number of florets per stalk was recorded in the genotype Quartet Deep Yellow (13.20). The maximum floret diameter was observed in the genotype Arrow White (4.22 cm) whereas, the minimum flower diameter was recorded in the genotype Early Iron Marine (3.31 cm).

The maximum vase life was recorded in the genotype Stock Katz Blue (13.47 days) while, minimum vase life was recorded in the genotype Quartet Deep Yellow (7.33 days) and Early Iron Deep Yellow (7.33 days). The maximum longevity in plants was recorded in the genotype Stock Katz Ruby (36.61 days) while, minimum longevity in plants was recorded in the genotype Early Iron White (14.70 days).

Significant differences were observed among the different genotypes of Stock with respect yield attributes. The maximum number of cut flowers per sq. m, per 1000 sq. m recorded in the genotype Arrow White (25.00 & 20000.00, respectively) and Early Iron White (24.67 & 19733.33, respectively), whereas the minimum in the genotype Early Iron Pink (15.67 & 12533.33, respectively).

The analysis of variance revealed highly significant differences among the genotypes for all the characters studied. The parameters such as leaf area, internodal length, chlorophyll ‘a’, chlorophyll ‘b’, total chlorophyll, days taken to flower stalk emergence, number of florets per stalk, stalk weight, longevity in plants exhibited high PCV and GCV, whereas by plant height, number of leaves per plant, plant spread in East-West and North-South direction, leaf length, leaf width, days taken to first visible flower, days taken to flower stalk harvest, stalk length, stalk girth, vase life, number of cut flowers per square meter exhibited moderate PCV and GCV. While, other parameters such as floret diameter exhibited low PCV and GCV.

High heritability coupled with high genetic advance was observed for number of leaves per plant, leaf length, leaf width, leaf area, plant spread, internodal length, chlorophyll contents, days taken for stalk emergence, days taken for harvest, stalk length, stalk weight, stalk girth, number of florets per stalk, vase life, longevity in plants and number of cut flowers per square meter.

Correlation studies revealed that the stalk length showed significant positive correlation with plant height, leaf length and leaf area. The number of florets per stalk exhibited significant positive correlation with stalk length. Days taken for stalk emergence showed significant negative correlation with plant height, leaf area, intermodal length and stalk length. Vase life showed significant negative correlation with weight and girth of the stalk. Whereas, stalk yield hasn't showed significant correlation with any traits at genotypic level.

Path analysis for stalk yield per plant revealed that the plant height, leaf length, leaf width, leaf area, number of florets per stalk and stalk girth have high positive effect indicating the possibility of increasing stalk yield by selecting these characters directly.

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APPENDICES

VIII APPENDICES

Appendix I: Monthly mean meteorological data recorded during the experimental year 2022–23 recorded at the KVK, Mudigere

Month	Rain fall (mm)	Mean Temperature (°C)		Mean Relative Humidity (%)	
		Minimum	Maximum	Minimum	Maximum
September - 2022	294.00	18.76	25.79	95.43	99.50
October - 2022	23.50	18.00	28.01	85.80	99.00
November - 2022	7.50	17.04	28.28	75.97	94.07
December - 2022	14.00	15.73	28.05	63.40	92.83
January - 2023	0.50	12.35	29.20	50.07	96.27
February - 2023	4.50	17.84	29.08	77.00	82.71
March - 2023	5.00	23.94	24.21	66.63	78.67
April - 2023	10.00	18.30	33.11	62.70	95.93
May - 2023	76.00	19.93	30.92	81.43	98.07
June - 2023	101.00	20.10	27.23	92.30	97.73
July - 2023	553.00	19.91	24.04	97.03	99.57
August - 2023	61.00	19.01	26.63	90.23	98.97
Total	1150	-	-	-	-

The total rainfall was 1150 mm

Appendix II: Cost of cultivation of Stock (*Matthiola incana* L.) per 1000 m^2 under polyhouse condition

Sl No.	Particulars	Cost (₹)	Shelf life (in years)	Cost per year (₹)	Per crop rotation/ season (₹)
I	**Non-recurring contingency (NRC).**				
a)	Polyhouse	9.2 Lakhs	15	61,333.33	20,444.44
b)	Polythene sheet	51000	5	10,200	3,400
c)	Fertigation	2.25 Lakhs	15	15,000	5,000
d)	Netting	20,900	4	5,225	1,741.66
e)	Control box	12000	10	1,200	400
f)	Portrays (210pc)	3150	1	3,150	1,050
g)	Cocopeat (210 kgs)	9450	One season	-	9,450
	Total				**41,486.1**
II.	**Recurring contingency (ORC)**				
SL No.	Particulars	Quantity	Rate /unit (₹.)	Total cost (₹/1000 m^2)	
1.	**Inputs**				
a.	Seeds – Katz series	22,000	1.075/seed	23,650.00	
	Seeds – Others	22,000	2.00/seed	44,000.00	
2.	**Fertilizers**				
	Radiform	2,000 ml	600/500ml	2,400.00	
a	Urea	20 kg	7/kg	140.00	
b	DAP	20 kg	24/kg	480.00	
c	MOP	20 kg	20/kg	00.00	
d	19:19:19	15kg	110/kg	,650.00	
e	Micronutrients	10kg	90/kg	900.00	
3.	**Plant protecting chemicals**				
a)	Sprint	1kg	360/kg	360.00	
b)	Chlorpyrifos	500ml	145/250ml	290.00	
c)	Neem oil	1,000ml	700/500ml	1,400.00	
4.	**Labour charges**				
a	Land preparation	-	Tractor	2,000.00	
	Sowing, Planting and Manure application	**10**	300	**3,000.00**	
b	Earthing up andweeding	6	-	1,800.00	
e	Harvesting	6	-	1,800.00	
g	Packing, transportation and marketing		-	4,500.00	
h	Miscellaneous			1000.00	
	Total – Katz	-		45,770.00	
	Total – Others	-		**66,120.00**	
	Grand total (NRC+ORC) – Katz			**87,256.00**	
	Grand total (NRC+ORC) – Others			**1,07,606.00**	

Appendix III: List of symbols and abbreviations used

Abbreviations	Full form
&	And
et al.	And other
cm	Centimetre
kg	Kilogram
l	Litre
ha	Hectares
No.	Number
°C	Degree centigrade
DAT	Days after planting
g	Gram
%	Per cent
PCV	Phenotypic coefficient of variation
GCV	Genotypic coefficient of variation
h^2	Heritability
GA	Genetic advance
GAM	Genetic advance over mean
@	At the rate of
Viz.,	For example,
i.e.,	That is
cm^2	Centimetre square
m^2	Meter square
GV	Genotypic variance
PV	Phenotypic variance
mg	Milligram
mm	Millimetre
ml	Millilitre
/	Per
cv's	Cultivars
N-S	North-South
E-W	East-West
via.	By way of
RHS	Royal Horticultural Society
MSL	Mean Sea Level
>	Greater than
<	Less than
=	Equals
h^2	Heritability
hrs	Hours
etc.	And so on