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SCIENTIFIC ARTICLE

Studies of genetic variability, quantitative, and qualitative traits of Lilium cultivars (*Lilium x hybrida)* under shade net in North-West Himalayan region of India

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Abstract

An experiment was conducted to study genetic variability and performance of nine exotic lilium cultivars (*Lilium x hybrida*) for suitability for commercial cultivation in North Western hilly regions of Uttarakhand at Research Station and KVK, Lohaghat, GBPUA&T, Pantnagar, Champawat, Uttarakhand India. Bulbs of nine lilium hybrid cultivars viz., Acapulco (Pink), Sorbonne (White), Yelloween (Yellow), Tresor (Orange), Brindisi (Pink), Blackout (Red), Pavia (Yellow), Ercolano (White) and Samur (Pink) were selected as experimental material. There was significant difference in days taken for bud initiation among nine cultivars. It is evident from data that minimum days take for bud initiation in cultivar Blackout (44 days) followed by Tresor (45 days). The maximum number of flowers per plant reported in cultivars Acapulco (10.20) followed by Yelloween (8.20) and Sorbonne (7.80) which is at par with Blackout (7.40) and Pavia (7.20). Maximum vase life was recorded with Acapulco (12.4 days) followed by Sorbonne (11.80 days) which is at par with Yelloween (11.8 days) while Minimum vase life was recorded with Ercolano (8.40 days) and Tresor (8.40 days). Mean value was found maximum for flower stem length (87.29) and minimum mean value was exhibited by number of flowers per plant. Heritability value was found maximum for characters like days to flower bud opening followed by length of flower stalk and days taken to bud initiation.

Keywords*: Lilium*, variability, quantitative and qualitative traits, GCV and PCV.

Resumo

Estudos da variabilidade genética, tratamentos quantitativos e qualitativos em cultivares de Lírio **(*Lilium x hybrida)* sob tela de sombreamento na região noroeste do Himalaia, India**

Um experimento foi conduzido para estudar a variabilidade genética e o desempenho de nove cultivares exóticas de lilium (*Lilium x hybrida*) para adequação ao cultivo comercial nas regiões montanhosas do noroeste de Uttarakhand na Estação de Pesquisa e KVK, Lohaghat, GBPUA & T, Pantnagar, Champawat, Uttarakhand, India. Bulbos de nove cultivares híbridos de lilium viz., Acapulco (rosa), Sorbonne (branco), Yelloween (amarelo), Tresor (laranja), Brindisi (rosa), Blackout (vermelho), Pavia (amarelo), Ercolano (branco) e Samur (rosa) foram selecionados como material experimental. Houve diferença significativa nos dias de iniciação das gemas entre as nove cultivares. É evidente, a partir dos dados que demoram dias mínimos para o início da brotação na cultivar Blackout (44 dias), seguido de Tresor (45 dias). O número máximo de flores por planta relatado nas cultivares Acapulco (10,20) seguido por Yelloween (8,20) e Sorbonne (7,80) que está no mesmo nível de Blackout (7,40) e Pavia (7,20). A vida máxima de vaso foi registrada com Acapulco (12,4 dias) seguido por Sorbonne (11,80 dias), que está em paridade com Yelloween (11,8 dias), enquanto a vida mínima de vaso foi registrada com Ercolano (8,40 dias) e Tresor (8,40 dias). O valor médio encontrado foi máximo para o comprimento do caule da flor (87,29) e o valor médio mínimo foi exibido para o número de flores por planta. O valor de herdabilidade foi encontrado máximo para caracteres como dias para a abertura do botão da flor seguido pelo comprimento do caule da flor e dias necessários para o início da brotação.

Palavras-chave*: Lilium*, variabilidade, caracteres quantitativos e qualitativos, GCV e PCV.

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Introduction

Lilium is a diverse and highly classified genus of bulbous flower belonging to family Liliaceae with having different shape, size, colour and fragrant. Lilium holds 4th position among top 10 cut flower in World floriculture trade (Bahr and Compton, 2004). The lilium is native to Asia, Europe and North America and having more than 100 species (McRac, 1998). Lilium is grown mainly for cut flowers as well as for pot plants in landscape. The cultivars of genus *Lilium* are highly appreciated by the horticulturists for their outstanding range of colour, fragrance and adaptability to several environmental conditions. Lilium hybrids are gaining popularity in the Indian market due to their long-stemmed flowers of various colours/shades and a prolonged vase-life (Bahr and Compton, 2004). However, information on production of cut-flowers in lily is scarce. In India, lilium was introduced during 80's, and since then, a large number of varieties have been introduced from exotic sources at different Central and State Research Centers and Agricultural Universities. There is a tremendous scope for its commercial cultivation in Himachal Pradesh, Jammu & Kashmir, Uttarakhand and similar other hilly terrains of India. The main strength of lilium cultivation in these areas lies in the suitability of climate for quality cut flower production and bulb multiplication, availability of manpower, lesser cost of cultivation compared to major temperate bulb growing countries.

The study about the nature and extent genetic variability and heritability is of utmost importance for efficient breeding programme. Heritability gives an idea of transmission of characters from one generation to other, as consistency in the performance of selection depends upon the heritable portion of the variability, thus enabling the plant breeder in isolating the elite selection in the crop (Kumar et al., 2012; Yadava et al., 2011). For selecting the desirable genotypes, it is important to judge the heritability and know the degree of association existing between yield and components characters (Sahu and Sharma, 2014).

The performance of any crop or variety largely depends on genotypic and environmental interactions. As a result, cultivars which perform well at one region may not show same performance in other region having different climatic conditions. Therefore, it is necessary to evaluate the germpalsm to find out the most promising genotypes suitable for various quality traits. The Asiatic hybrids of lilium have originated from more than 12 very different lilium species (Graaff and Hornback, 1967; Wadekamper, 1977). For that reason, there is a great genetic variation among its cultivars. Thus, determining genetic diversity through variation between genotypes, genotype groups or populations is the most important breeding tool to select better genotypes for improvement in desired traits. With the background in view, the present study was undertaken to assess and estimate the magnitude and nature of variation among 9 lilium genotypes with respect to various vegetative and floral characteristics (quantitative and qualitative traits) under shade net condition for mid hills of North-West Himalaya regions of India that would be helpful for further crop improvement program.

Materials and Methods

The present investigation was conducted at Research Station and Krishi Vigyan Kendra, Lohaghat, (GBPUA&T, Pantnagar), Champawat, Uttarakhand, India which is situated at a latitude of $29^0$60'; Longitude of $80^0$1' and altitude of 1700-1800 m from MSL in North-West Himalaya of India. The soil of the experiment site was sandy loam with pH range of 6.5-7.5.The study was conducted during month of March-September, 2015-2016. The non-availability of any Indian cultivars has been the major constraint for expanding its area of cultivation and therefore each year new bulbs are imported from abroad (Dhiman et al., 2015). Bulbs of nine exotic commercial lilium cultivars viz., Acapulco (Pink), Sorbonne (White), Yelloween (Yellow), Tresor (Orange), Brindisi (Pink), Blackout (Red), Pavia (Yellow), Ercolano (White) and Samur (Pink) with 14"-16" circumference were procured from Florance Flora, Bengaluru, Karnataka, India where these varieties were imported from Holland. The bulbs were treated with Bavistin @ 2.0 g L^{-1} for 30 minutes and planted at a spacing of 30 x 30 cm on one-meter-wide raised beds under 50 % shade net house. Full dose of well-rotted farm yard manure, besides phosphorus and potassium in the form of single super phosphate (SSP) and muriate of potash (MoP), respectively, was incorporated into the soil before planting the bulbs. Nitrogen was applied in the form of calcium ammonium nitrate (CAN) at 20, 40 and 60 days after bulb sprouting. The crop was irrigated lightly through a drip irrigation system, and was raised under uniform cultural conditions.

The experiment was laid out in completely randomized block design with three replications. Five plants were selected from each replication for getting observation. The observations were recorded after bud initiation stage and continued until the senescence of last flower. Various data were recorded time to time for eleven growth and floral parameters on number of leaves per plant (total number of leaves on plant), days taken for bud initiation (days from planting of bulb to bud initiation), days to flower bud opening (days from planting of bulb to bud opening), bud length (cm), length of flower stalk (cm), flower diameter (cm), number of flowers/plant, flower stem length (cm), dry weight of flower (gm), duration of flowering and vase life (days). The collected data was analyzed as suggested by Cochran and Cox (1992) and genetic parameters were calculated according to Burton and De Vane (1953).

Result and Discussion

Growth and Yield parameters

Analysis of variance (ANOVA) revealed significant differences among the genotypes for all eleven morphological characters studied, except dry weight of flower indicating considerable amount of variability exist among the genotypes (Table 1).

Table 1. Analysis of variance (ANOVA) of eleven traits on 09 exotic lilium cultivars

Characters	Mean Sum of Square (df)		
	MSr (1)	MSg (24)	MSe(24)
No. of leaves per plant	19.07	252.25***	11.46
Days taken for bud initiation	1.64	1643.30***	4.25
Days to flower bud opening	0.91	121.97***	2.92
Bud length	0.81	6.63***	7.5
Length of flower stalk	0.34	8.742***	0.22
Flower diameter	0.56	9.23***	0.51
No. of flowers/plant	1.47	7.45***	0.67
Flower stem length	43.18	2141.49***	10.67
Dry weight of flower	480.03	547.91ns	418.98
Duration of flowering	2.14	1.80**	0.74
Vase life (days)	0.25	12.02***	0.48

** Significance at $p = 0.01$, *** Significance at $p = 0.001$, ns- non significance

MSr = mean square for replication, MSe = mean square for error; MSg = mean square for genotype;

The recorded eleven quantitative and qualitative traits on lilium cultivar are presented in table 2 and figure 1. There was significant difference in days taken for bud initiation among nine cultivars of lilium. It is evident from data that minimum days taken for bud initiation in cultivar Blackout (43.80 days) followed by Tresor (45.40 days), whereas maximum days taken for bud initiation in cultivar Acapulco (58.20 days) among nine cultivars evaluated (Table 2).

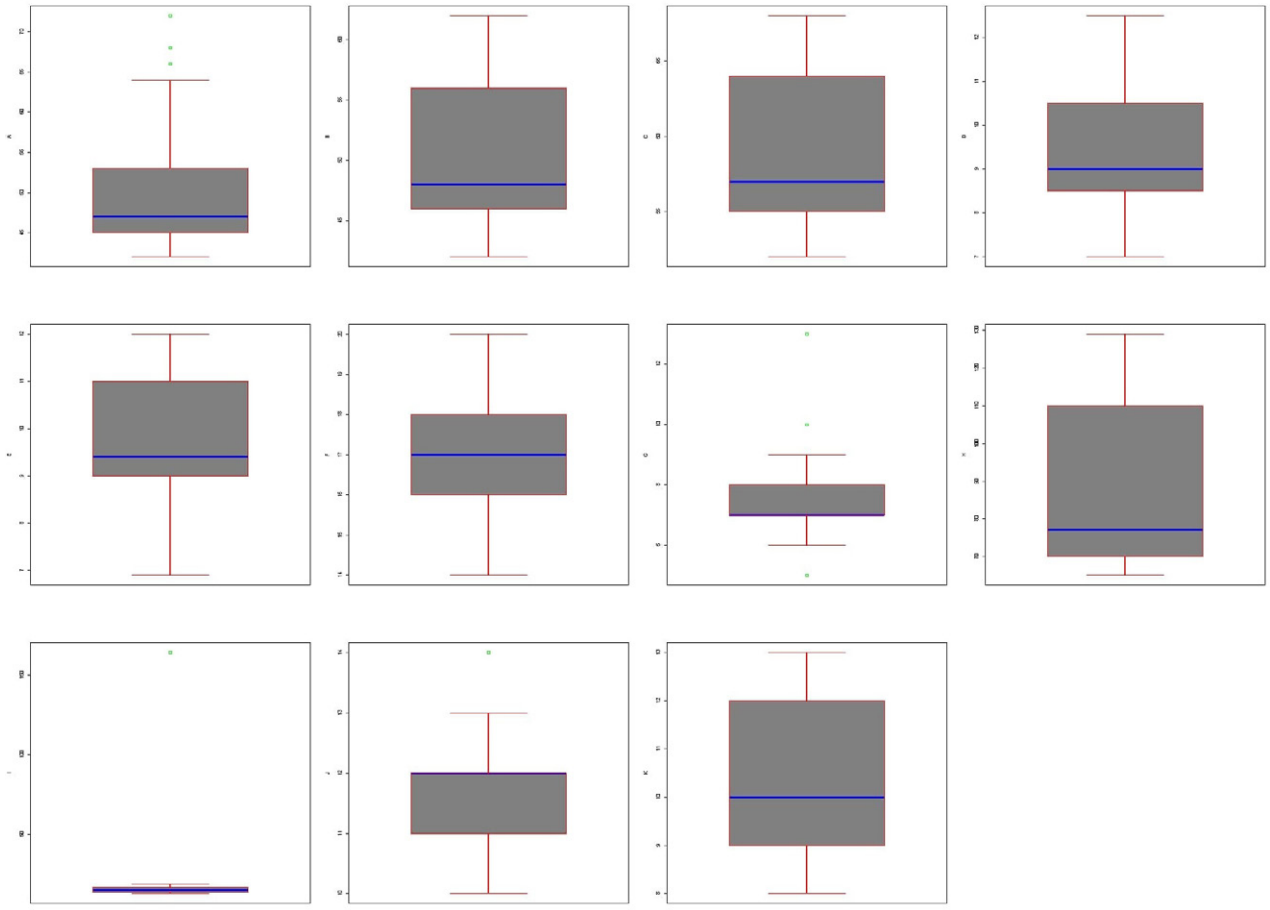

Figure 1: Box plots depicting variations for A = No. of leaves per plant, B = Days taken for bud initiation, C = Days to flower bud opening, D = Bud length, E = Length of flower stalk, F = Flower diameter, G = No. of flowers/plant, H = Flower stem length, I = Dry weight of flower, J = Duration of flowering K = Vase life (days).

Table 2. Performance of lilium cultivar for quantitative and qualitative traits under shade net house.

Sr. No.	Variety	Days taken for bud initiation	Days to flower bud opening	No. of leaves per plant	Bud length	Length of flower stalk	Flower diameter	No. of flowers/ plant	Flower stem length	Dry weight of flower	Duration of flowering	Vase life (days)
1.	Acapuleo	58.20	65.20	60.00	10.88	11.6	18.08	10.20	112.52	19.28	12.60	12.40
2	Sorborne	57.40	65.80	62.40	10.78	11.1	18.44	7.80	117.46	18.28	11.60	11.80
3.	Yellowin	58.00	65.40	54.20	10.90	10.84	18.40	8.20	112.68	17.34	12.00	11.80
4.	Tresor	45.40	54.60	46.00	8.70	8.86	17.04	6.40	82.46	14.52	12.40	8.40
5.	Brindisi	48.20	56.40	44.40	8.80	7.32	18.20	6.00	76.80	15.30	12.00	10.00
6.	Blackout	43.80	53.80	44.40	8.10	9.14	15.40	7.40	73.44	14.12	10.80	8.80
7.	Pavia	47.00	56.60	45.20	9.70	9.62	15.70	7.20	69.30	14.64	11.40	9.40
8.	Ercalano	49.20	56.80	46.40	8.80	9.10	15.24	6.80	73.78	14.32	11.80	8.40
9.	Samur	47.40	56.60	45.80	8.26	9.42	16.10	7.40	67.20	13.38	11.00	10.60
C.D. at 5%		2.66	2.20		1.12	0.61	0.92	1.06	4.21	28.28	1.11	0.89

Early bud initiation is desirable characteristics as cultivars consume fewer resources, and, time from planting to harvest of flowers (Sindhu et al., 2012; Barik and Mohanty, 2015).

Days taken for flower bud opening were differed significantly among nine cultivars. Minimum days take for flower bud opening was recorded with cultivar Blackout (53.8 days) which was at par with cultivar Tresor (54.60). However, maximum days taken to flower bud opening was observed with Sorbonne (65.80 days) which was at par with cultivar Yelloween (65.40 days), Acapulco (65.20 days). Similar variation in floral parameter of lilium has been reported by Kumar et al. (2011).

Number of leaves per flowering shoot is also an important character because it not only improves aesthetic value but also is also involved in photosynthesis. Production of photo assimilates is directly related to number of leaves/leaf area essential for growth and development of the flowering stem, survival of the mother bulb and development of new daughter–bulbs (Bhandari and Srivastava, 2016). In present study, highest leaf number was recorded in the cultivars Sorbonne (62.40), which is at par with Acapulco (60) and Yelloween (54.20). On the other hand, minimum number of leaves was recorded in Brindisi (44.40) which is at par with Blackout (44.40). Similar variation in the vegetative parameters of Asiatic lily was also reported by earlier workers (Kim et al*.,* 2013; Negi et al*.,* 2014 and Pandey et al., 2008). Differences in vegetative growth characters of different cultivars may be due to varied growth rate and their genetic makeup as a result, variation in phenotypic expression is expected to occur. Similar results with respect of vegetative characters were also observed by Mishra (1997).

Flower bud length of lilium flower crop was observed maximum in cultivar Yelloween (10.90 cm) which was at par with Acapulco (10.88 cm) and Sorbonne (10.78 cm) and minimum flower bud length was recorded with cultivar Blackout (8.10 cm). The length of flower stalk was maximum in cultivar Acapulco (11.6 cm) followed by Sorbonne (11.1 cm) and Yelloween (10.84 cm) and minimum flower bud stalk length was observed with Brindisi (7.32 cm) and other cultivar. Flower diameter is an important parameter in cut flowers. Longer blooms are preferred by consumer and these fetch a better price than the smaller ones. Data in Table 2 indicate that cultivar Sorbonne and Yelloween recorded maximum flower diameter (18.44 and 18.40 cm, respectively) followed by Acapulco (18.08 cm). The minimum flower diameter was recorded with Ercolano cultivar which was at par with Blackout (15.4 cm) and Pavia (15.70 cm). Similar results on flowering in gladiolus in favorable environment were reported by Muhammad et al. (2013) and variation in flower diameter may be result of genetic makeup of cultivar and environmental effect on cultivars.

The number of flowers per plant is also decisive factor for liking of cultivar in market. Generally, as many as 12 fragrant flowers per plant is ideal for commercial cultivation and more number of flower per plant leads to higher production and high in demand by consumers in market provided retaining other qualitative traits. The more flowers on a stem, the more attractive are the plant with a longer flowering duration. In present study, significant variation in number of flowers per plant was observed due to genetic variability among lilium cultivars. The maximum number of flowers per plant reported in cultivars Acapulco (10.20) followed by Yelloween (8.20) and Sorbonne (7.80) which is at par with Blackout (7.40) and Pavia (7.20). Significantly, minimum number of flowers per plant was observed with cultivar Brindsi (6) and Tresor (6.4). Similar trend of flower character has been observed by Chandrashekhar et al. (2018), Masoodi et al. (2019), Barik and Mohanty (2015), Negi et al. (2014), and Deka et al. (2010) in lilium cultivars. Wide variation in flower traits due to cultivars has also been reported by Dhiman (2003), Singh et al. (2016) Chandrashekhar et al. (2018), Sharma et al. (2018), Masoodi et al. (2019),

Plant height and flower stem length is an important criterion for selecting lilium cultivars, as taller plants are generally preferred for cut-flower production and shorter ones for pots. All the hybrids under this study differed significantly with respect to plant height and flower stem length. Results revealed that among all the cultivars, maximum flower stem length (117.46) was recorded in 'Sorbonne followed by Yelloween (112.68) and Acapulco (112.52) and minimum flower stem length was recorded with cultivar Samur. Similar result was recorded by Barik and Mohanty (2015), Sindhu and Singh (2012). The maximum dry weight of flower was recorded with cultivar Sorbonne (18.28 gm) followed by Yelloween (17.34) while minimum dry weight of flower was observed with cultivar Samur (13.38). The more flowers on a stem, the more attractive are the plant with a longer flowering duration. The durations of flowering were recorded highest in cultivar Acapuleo (12.6) followed by Tresor (12.40) which is at par with Sorbonne (11.28) and Brindisi (12.00). The vase life of cut flower play important role as there is positive correlation between vase life and quality of the flowers for cut purposes. Varieties with longer vase life are being preferred by consumer as the cut flower can be displayed for long period. The vase life of cultivar showed significant difference among the cultivars tested. Maximum vase life was recorded with Acapulco (12.4 days) followed by Sorbonne (11.80 days) which is at par with Yelloween (11.8 days). Minimum vase life was recorded with Ercolano (8.40 days) and Tresor (8.40 days). Similar result was also observed by Kim et al. (2013), Negi et al. (2014), Pandey et al. (2008), Bhandari et al. (2017) and Chandrashekhar et al. (2018).

Genetic variability analysis

The extent of variation with respect to ten characters of Nine cultivars of lilium was measured in terms of range, general mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance and genetic advance as per cent of mean (Table 3).

Table 3. Estimates of range, general mean, genotypic and phenotypic coefficient of variation, heritability, genetic advance and genetic advance as per cent of mean for various characters in lilium.

Characters	Range	General mean± SE	P.C.V.	G.C.V.	Heritability (h^2)%	Genetic advance	Genetic advance as per cent of mean
No. of leaves per plant	44.40-62.40	49.87±1.51	15.48	13.92	80.77	12.85	25.77
Days taken for bud initiation	43.80-58.20	50.51±0.92	11.92	11.20	88.26	10.95	21.68
Days to flower bud opening	53.80-65.80	59.02±0.77	8.76	8.26	88.90	94.70	16.05
Bud length	8.10-10.90	9.43±0.39	14.73	11.50	60.88	1.74	18.45
Length of flower stalk	7.32-11.6	9.67±0.21	14.36	13.50	88.34	2.53	26.16
Flower diameter	15.24-18.44	16.94±0.31	8.76	7.75	78.25	2.39	14.11
No. of flowers/plant	6.00-10.20	7.49±0.37	19.04	15.75	66.67	1.96	26.17
Flower stem length	67.20-117.46	87.29±1.47	23.94	23.65	97.55	42.00	48.11
Dry weight of flower	13.38-18.28	15.41±0.35	11.71	10.56	81.35	3.02	19.60
Duration of flowering	10.80-12.60	11.73±0.39	8.33	3.91	22.09	0.44	3.75
Vase life (days)	8.40-12.40	10.18±0.31	16.41	14.93	82.77	2.85	28.00

P.C.V.- Phenotypic coefficient of variation, G.C.V.- Genotypic coefficient of variation

Flower stem length exhibited maximum value (67.20-117.46) and minimum value (1.8) was found in duration of flowering. General mean was found maximum for flower stem length (87.29), followed by days to flower bud opening (59.02). Minimum value for general mean was recorded for number of flowers per plant (7.49). Estimates of phenotypic coefficient of variation (PCV) were slightly higher than genotypic coefficient of variation (GCV) for all the characters under study, indicating the apparent variation is not only due to genotypes, but also due to influence of the environment in the expression of the genotypes. Similar results were reported by Kumar et al. (2011) in snapdragon.

High genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was recorded for flower stem length (23.65 and 23.94), moderate value for GCV and PCV was found for number of flowers per plant (15.75 and 19.04) followed by vase life (14.93 and 16.41) and number of leaves per plant (13.92 and 15.48). Moderate values for PCV and GCV indicate that genotypes exhibit only some amount of variation among themselves with respect to these characters. However, GCV and PCV value was recorded minimum for duration of flowering (3.91 and 8.33). Low values for PCV and GCV indicates that genotypes do not exhibit much variation among themselves with respect to these characters. Narrow genetic difference among PCV and GCV indicates that phenotypic expression of all the genotypes may be under genetic control and environment might have less influence on their expression. Similar results were also reported in glory lily (Farooqi et al., 1999) and gladiolus (Kumar et al., 2011).

Estimates of heritability give an idea of degree of transmission of character from one generation to another, thus suggesting the extent of heritable portion of variability and enabling the breeder in isolating the elite selection in the crop. The perusal of data presented in Table 3 revealed that high heritability was recorded in days to flower bud opening (88.90), followed by length of flower stalk (88.34) and days taken to bud initiation (88.26), whereas minimum value for heritability was recorded for duration of flowering (22.09). Similar results were also reported by Kumar (2013) and Farooqi et al. (1999). High heritability estimates for these characters indicates that these are highly heritable and environment has less influence on their expression. Therefore, there is a good scope for improvement of these characters through direct selection.

High heritability along with high genetic advance was recorded for days to flower bud opening. The traits having high heritability along with high genetic advance appeared to be controlled by additive gene action and selection for such traits will be very effective. However, days taken to bud initiation and length of flower stalk exhibited high heritability (88.26 and 88.34) along with low genetic advance (10.95 and 2.53), respectively. Characters having high heritability along with low genetic advance may be controlled by non-additive gene action and selection for such characters may not be effective.

Conclusions

The present study was undertaken to assess and estimate the magnitude and nature of variation among 9 lilium genotypes with respect to various vegetative and floral characteristics (quantitative and qualitative traits) under shade net condition for mid hills of North-West Himalaya regions of India**.** There was significant difference in days taken for bud initiation among nine cultivars with minimum days taken for bud initiation in cultivar Blackout (44 days). The maximum number of flowers per plant reported in

cultivars Acapulco (10.20) and Maximum vase life was recorded with Acapulco (12.4 days). The existence of a wider variation for various vegetative and floral traits in nine genotypes of lilium would be helpful for further crop improvement program.

Author Contribution

AKS: conceptualization, data curation, methodology, write of original draft; **HK**: software, review and editing; **RK**: review and editing. All authors have read and agreed to the published version of the manuscript.

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