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Genotypic stability analysis among *Lilium* genotypes for growth and yield contributing traits

Sangeeta Kumari[1]*, S.R. Dhiman[1], M.R. Dhiman[2], Puja Sharma[1] and R.K. Dogra[3]

[1]Department of Floriculture and Landscape Architecture, Dr YSP, UHF, Solan-173230, HP, India; [2]ICAR-IARI, Regional Station, Katrain Kullu, HP, India; [3]Department of Fruit Sciences, Dr YSP, UHF, Solan-173230, HP, India.
**E-mail: sngta2017@gmail.com*

Abstract

Genotypes grown in multi-environmental trials may respond differently to a range of climatic factors, soil characteristics and cultural management practices. As such, the proportion of the variation in the phenotypic traits due to the main effects of genotype, environment and their interaction is routinely assessed when selecting best-performing lines. Keeping this in mind, the present study was conducted to find the stable *Lilium* genotypes evaluated over two locations for two years in a Randomized Block Design along with three replications. Eighteen diverse genotypes of *Lilium* were assessed for twenty different vegetative, flowering and bulb parameters. Genotype "Eyeliner" indicated stability for the majority of the parameters, including days to bulb sprout emergence, bud length, number of flowers/stem, weight of bulblets, and vase life. At the same time, genotype "Yelloween" exhibited stability for various parameters, including leaf length, bud length, size of flower, and days to first flower, and is suitable for various environments.

Keywords: Lilium, stability, regression coefficient, environment, yield

Introduction

Among bulbous crops, *Lilium* is one of the most popular ornamental crops followed by Tulip. It belongs to the family Liliaceae and is native to the Northern Hemisphere, centered around Asia, North America and Europe. The genus *Lilium* comprises around 110 species and more than 10,000 cultivars, which can be classified into about nine groups. *Lilium* hybrids are available in a wide range of colours, and forms and are commonly used as cut flowers, pot plants and landscaping. Some cultivars are highly fragrant and possess medicinal properties (Rigat *et al.,* 2015 & Michele *et al.,* 2020). *Lilium* is important in the international flower market, ranking 4th among the top ten cut flowers (Annual Report, 2020). The major production areas are located in hilly states of the country like Himachal Pradesh, Uttrakhand and Jammu and Kashmir. In the past few years, Haryana state has emerged as a leading and potential hub for *Lilium* cultivation (Anon., 2018).

Lilium bulb production is the major economic activity of farmers in cold regions of Himachal Pradesh. Identifying suitable, high-yielding genotypes possessing stability over the seasons or varying environments for economically important traits is important for progressive but sustainable cultivation. Knowledge of genotype × environment interaction is essential for developing improved cultivars, which can be recommended for growing in a particular climate. The adaptability of different genotypes by subjecting them to multi-location yield tests for several years is useful for recommending cultivars for known conditions of cultivation and should be a requirement in a breeding program. Moreover, cultivar interaction with environmental factors is important for plant breeders. Hence, estimation of the nature and magnitude of genotype × environment interaction for yield and its contributing traits is essential to identify a stable genotype over environments and will also help the grower for successful cultivation of this high-value crop. Therefore, the present investigation assessed Lilium genotypes' stability and response to varying environmental conditions.

Materials and methods

The present study was carried out at two locations (one at the experimental farm of Dept. of Floriculture and Landscape Architecture, Dr YSP, UHF, Nauni, HP and another at ICAR, IARI-Regional Station, Katrain, HP) for two years during 2016-17 and 2017-18 (making four environments) in a Randomized Block Design along with three replications. The experimental farm at Nauni is located at 1276m amsl at the latitude of 32°5'10" North and longitude of 77°11'30" East, while the Experimental farm of Katrain location is situated at an altitude of 1688m amsl at the latitude of 32°10'49" North and 77°11'42" East. Eighteen *Lilium* genotypes belonging to four different groups *viz.*, seven Asiatic hybrids ('Navona', 'Prato', 'Tresor', 'Shiraj', 'Brunello', 'Pollyana', and 'Elite'), seven LA hybrids ('Eyeliner', 'Ercolano', Ceb Dazzle', 'Best Seller', 'Pavia', 'Salmon Classic' and 'Cilesta'), two OT hybrids ('Yelloween' and 'Montego Bay') and two Oriental hybrids ('Viviana' and 'Sapporo') were tested for their stability for growth and yield attributes. Planting of bulb was done in a growing medium comprised of soil, well rotten farm yard manure (FYM), sand and vermicompost in the ratio of 2:1:1:1 (v/v), spread in raised (20 cm) beds of 60 cm length and 60 cm width with a path of 30 cm width between the beds. A basal dose of nitrogen (6.52 g/m^2), phosphorus (18.75 g/m^2) and potassium (5.0 g/m^2) was applied by mixing urea (3.9 g/0.6 m^2), single super phosphate (11.25 g/0.6 m^2) and muriate of potash

(3.0 g/0.6 m^2) in the medium thoroughly. Planting depth was kept at 8-10 cm deep in lines separated by 30 cm distance from line to line. After planting, beds were drenched with a solution comprising Bavistin (0.1 %) and Dithane M-45 (0.2 %). All the standard cultural practices were carried out throughout the growing period. The data was recorded for twenty quantitative parameters on ten randomly selected plants in each genotype in each replication. Three stability parameters as per Eberhart and Russell (1966), *i.e.,* mean performance (m), regression coefficient (b_i), and squared deviation from regression coefficient were estimated, which indicates that the most stable variety should have a significantly higher mean (m) than the overall mean and unit regression (b_i=1) or regression near unity and zero or near deviation from regression.

Results and discussions

Vegetative parameters: Out of 18 diverse genotypes, only one genotype, 'Eyeliner' was found most stable over all four environments regarding days taken to bulb sprouting. However, 'Best Seller' was observed as early while 'Yelloween' 'Montego Bay' 'Viviana' and 'Sapporo' were late for sprouting. However, these genotypes were not stable (Table 1). The lowest mean value was considered desirable, denoting early flowering genotypes for characters such as days taken for bulb sprout emergence, days taken for flower bud formation, and days to first flower, while high mean values were preferred for the remaining parameters. The emergence of bulb sprouts displayed notable variation across different genotypes in various environments, underscoring the substantial impact of genotype × environment interaction. This phenomenon has been previously investigated in Lilium (Dhiman *et al.*, 2019) and gladiolus (Desh Raj and Misra, 1998).

In case of plant height, genotypes 'Prato' (80.72 cm), 'Pollyana' (82.40 cm), 'Elite' (84.77 cm), 'Salmon Classic' (74.75 cm), 'Yelloween' (97.73 cm), and 'Cilesta' (87.29 cm) recorded significantly more plant height than overall mean (72.31 cm) however these genotypes were unstable over environments. Similar studies were also reported in marigold (Patel *et al.,* 2020). Significantly high mean value for number of leaves/plant than overall mean (51.18) observed in 'Prato' (58.98), 'Tresor' (56.50), 'Brunello' (63.80), 'Pollyana' (68.06), 'Elite' (65.22), 'Eyeliner' (83.62) and 'Cilesta' (70.56) indicating these genotypes produced more number of leaves per plant. However, regarding stability, 'Salmon Classic' was a stable performer. Naik *et al.* (2005) also reported 15 genotypes of African Marigold Orange superior with higher mean values and stability across the three environments.

Genotypes such as 'Prato' (14.61 cm), 'Tresor' (10.58 cm), 'Brunello' (11.09 cm), 'Pollyana' (10.95 cm), 'Elite' (11.11 cm), 'Eyeliner' (13.47 cm), 'Ercolano' (10.67 cm), 'Ceb Dazzle' (11.27 cm), 'Best Seller' (12.92 cm), 'Salmon Classic' (11.74 cm) and 'Cilesta' (11.67 cm) exhibited high mean values than overall mean for leaf length but these were unpredictable performer with respect to leaf length while 'Yelloween' was most stable genotype.

'Brunello', 'Pavia' and 'Viviana' were the most stable as they satisfied all criteria for stability concerning leaf width along with significantly high mean values (2.20 cm, 2.27 cm and 3.51 cm, respectively) than overall mean (2.14 cm) as in Table 2.

Regarding stem length, 'Salmon Classic' was the most stable genotype, with a significantly higher mean (54.75 cm) than the overall mean (52.32 cm). In contrast, genotypes such as 'Yelloween' (77.73 cm) and 'Eyeliner' (68.07 cm) exhibited higher mean values for stem length than the overall mean, yet these were unstable. Negi *et al.* (2020) also reported similar results in diverse chrysanthemum genotypes. Stem diameter signifies the strength of the cut flower. 'Best Seller', 'Pavia' and 'Salmon Classic' were found to be stable genotypes for this trait.

Flowering parameters: Among all the eighteen genotypes, 'Pollyana' was the most stable with respect to days to flower bud formation (Table 2). However, 'Best Seller' (41.60 days) took minimum days for flower bud formation but was found to be unstable. Genotype, 'Tresor' was stable with unit regression for this character, but the same genotype did not satisfy the rest of the two parameters. Late flowering genotypes such as 'Montego Bay' and 'Viviana' were also unpredictable for this trait. Stable genotypes interact less with the environment, thus exhibiting consistent performance across environments.

Trait bud length observed a significantly high mean (10.01 cm, 9.93 cm and 12.79 cm, respectively) than the overall mean (9.50 cm) in 'Pollyana', 'Eyeliner' and 'Yelloween', respectively. Moreover, these genotypes also recorded the most stability for bud length over the environments. Other genotypes such as 'Prato' (10.50 cm), 'Brunello' (10.42 cm), 'Ercolano' (9.86 cm), 'Best Seller' (10.04 cm), 'Pavia' (9.68 cm) and 'Sapporo' (10.94 cm) recorded significantly high mean value than the overall mean (9.50 cm) but were unpredictable performer.

Genotypes such as 'Montego Bay' and 'Sapporo' were observed as the most stable genotypes for days to first flower; however, they were late flowering over all the environments. On the other hand, genotypes 'Tresor', 'Ceb Dazzle', 'Pavia', 'Salmon Classic', and 'Yelloween' exhibited stability with unit regression for this character but rest of the other two stability parameters were not fulfilled. 'Best Seller' was observed as an early flowering genotype but was unstable (Table 3). This type of variations were also reported by Kirtimala *et al.* (2011) in gladiolus.

The flower size is an aesthetic quality of any ideal cut flower. All the genotypes were unpredictable to this trait, indicating the high influence of genotype × environment interaction. Among all the genotypes, 'Yelloween' and 'Sapporo' produced large-sized flowers with a maximum mean value (20.39 cm and 20.20 cm, respectively) than the overall mean (16.46 cm), but these were unpredictable performers.

The yield component, *i.e.* maximum number of flowers/plant recorded in 'Eyeliner' (7.97) and was an average performer over different environment while 'Salmon Classic' with high mean value (5.28) than the population mean (4.58) was also observed as stable performer. The yield component is the most important aspect that gets affected due to genotypes and environment interaction. Moreover, variability in yield could have been due to the diverse group of planting materials selected for the study. Similar type of variation was observed in yield over the environment in chrysanthemums (Vaidya, 2006; Priyanka, 2012; Kumar *et al.,* 2018) and in marigolds (Patil *et al.,* 2011).

Data about tepal length shows that genotype 'Viviana' was the most stable. However, genotypes 'Prato', 'Yelloween' and 'Sapporo' exhibited higher mean (10.92 cm, 12.43 cm and 11.90

Table 1. Estimation of stability parameters for days taken for bulb sprout emergence, plant height, number of leaves/plant and leaf length in 18 *Lilium* genotypes

Genotypes	Days taken for bulb sprout emergence				Plant height (cm)				Number of leaves/ plant				Leaf length (cm)			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	103.57	-4.40	0.97	26.10	56.59	-0.28	-15.73	0.30	46.11	-5.07	-0.72	82.55	8.64	-1.78	-5.06	0.89
Prato	101.37	-7.30	0.99	20.91	80.72	3.82	8.40	3.78	58.98	7.80	3.58	44.39	14.61	4.19	4.20	0.33
Tresor	108.36	0.70	1.04	23.66	57.60	1.69	-14.72	11.63	56.60	5.42	1.90	13.53	10.58	0.15	11.38	-0.01
Shiraj	105.33	-4.44	1.01	6.11	58.13	-1.50	-14.19	13.60	48.68	-2.50	1.70	19.84	8.14	-2.28	-8.03	3.32
Brunello	113.49	5.07	1.10	25.17	78.71	1.40	6.39	24.95	63.80	12.62	-1.68	10.52	11.09	0.67	0.21	0.37
Pollyana	102.32	-7.29	0.95	3.63	82.40	-0.90	10.08	12.59	68.06	16.88	6.30	-0.04	10.95	0.53	-3.27	0.00
Elite	108.86	-2.67	0.93	9.78	84.77	3.24	12.45	9.68	65.22	14.04	-0.19	1.72	11.11	0.69	-0.04	0.89
Eyeliner	112.02	1.41	0.99	0.50	88.07	-0.50	15.75	7.57	83.62	32.44	1.70	18.69	13.47	3.05	4.24	0.29
Ercolano	108.16	-2.53	0.96	0.49	66.37	-0.86	-5.95	27.29	50.45	-0.73	4.89	119.82	10.67	0.25	-1.82	0.08
Ceb Dazzle	108.51	-1.12	1.04	8.72	66.63	-2.49	-5.69	8.87	42.27	-8.91	-0.09	1.34	11.27	0.85	2.31	0.01
Best Seller	95.68	-12.79	0.96	10.18	53.65	2.26	-18.67	1.12	41.11	-10.07	1.49	2.06	12.92	2.50	8.76	0.98
Pavia	108.92	-1.61	1.01	-0.03	65.94	4.14	-6.38	3.23	43.62	-7.56	-0.52	11.53	8.75	-1.67	-2.34	1.07
Salmon Classic	108.74	-5.17	0.91	55.82	74.75	2.64	2.43	15.72	64.22	13.04	1.33	0.43	11.74	1.32	0.07	0.48
Yelloween	116.36	4.89	0.98	11.06	97.73	3.41	25.41	12.46	49.89	-1.29	-2.95	29.09	11.51	1.09	1.07	0.47
Celesta	102.37	-8.76	0.94	4.05	87.29	3.57	14.97	6.63	70.56	19.38	-0.66	12.15	11.67	1.25	3.18	0.14
Montego Bay	130.28	16.05	1.08	25.07	71.82	-1.72	-0.50	29.71	31.33	-19.85	1.47	7.65	6.92	-3.50	2.42	-0.02
Viviana	128.26	14.98	1.08	18.07	65.59	-1.25	-6.73	5.41	18.07	-33.11	0.20	3.20	6.94	-3.48	1.19	-0.01
Sapporo	127.23	14.96	1.06	7.05	64.97	1.35	-7.35	1.73	18.73	-32.45	0.26	3.06	6.62	-3.80	-0.48	0.01
Overall mean	110.54	SE (m) = 2.20 SE (b) = 0.03			72.31	SE (m) = 1.95 SE (b) = 2.16			51.18	SE (m) = 2.72 SE (b) = 0.88			10.42	SE (m) = 0.43 SE (b) = 2.19		

P_i: Phenotypic index, b_i: Regression coefficient, S^2_{di} Squared deviation from regression coefficient

Table 2. Estimation of stability parameters in 18 *Lilium* genotypes for leaf width, stem length, days to flower bud formation and bud length

Genotypes	Leaf width (cm)				Stem length (cm)				Days to flower bud formation				Bud length (cm)			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	1.63	-0.51	1.07	0.00	36.59	-15.73	-0.49	0.09	55.69	1.80	0.64	27.56	8.22	-1.28	0.93	0.34
Prato	1.99	-0.15	1.68	0.20	60.72	8.40	2.94	10.06	57.19	4.32	1.29	74.90	10.50	1.00	2.11	0.32
Tresor	1.42	-0.72	0.77	0.01	37.60	-14.72	0.72	14.46	55.77	-1.92	1.00	138.34	7.61	-1.90	1.48	-0.01
Shiraj	1.58	-0.56	-0.53	0.26	38.13	-14.19	-0.55	15.97	60.13	4.49	0.84	62.64	6.72	-2.78	1.57	0.13
Brunello	2.20	0.06	1.43	0.05	58.71	6.39	1.79	22.99	58.16	-3.74	1.44	130.14	10.42	0.92	2.28	0.22
Pollyana	1.87	-0.27	1.82	0.16	62.40	10.08	-0.42	13.34	60.41	11.56	0.96	-1.12	10.01	0.51	1.69	0.48
Elite	1.86	-0.28	0.35	0.12	64.77	12.45	2.74	12.40	54.74	0.29	0.98	42.73	7.68	-1.82	1.23	2.33
Eyeliner	2.28	0.14	3.77	0.17	68.07	15.75	-0.83	6.95	59.72	0.51	0.62	14.37	9.93	0.43	1.23	0.20
Ercolano	2.08	-0.06	2.08	0.14	46.37	-5.95	0.39	28.01	55.91	6.91	0.93	56.36	9.86	0.36	1.80	0.52
Ceb Dazzle	1.93	-0.21	0.61	0.13	46.63	-5.69	-1.44	13.68	57.01	5.91	1.23	29.55	9.11	-0.39	0.42	1.02
Best Seller	2.09	-0.05	0.64	0.11	33.65	-18.67	1.86	2.72	41.60	-4.21	0.85	4.42	10.04	0.54	1.79	0.52
Pavia	2.27	0.13	1.09	0.03	45.94	-6.38	3.22	10.26	53.13	-1.80	0.93	4.50	9.68	0.18	2.68	0.23
Salmon Classic	2.15	0.01	1.64	0.06	54.75	2.43	1.35	21.88	47.29	0.29	0.84	226.59	9.22	-0.28	0.65	1.79
Yelloween	1.91	-0.23	-0.29	0.11	77.73	25.41	2.51	18.25	60.96	-0.94	0.95	27.91	12.79	3.29	1.14	0.06
Celesta	1.92	-0.22	2.85	0.02	67.29	14.97	3.23	8.18	53.07	-1.48	0.84	28.62	9.39	-0.11	1.09	0.89
Montego Bay	2.42	0.28	-1.47	0.09	51.82	-0.50	-0.12	33.36	73.48	-5.64	1.20	23.24	10.10	0.60	-0.81	0.26
Viviana	3.51	1.37	0.89	0.04	45.59	-6.73	-0.46	7.05	71.08	-7.88	1.30	20.61	8.84	-0.66	-1.55	0.02
Sapporo	3.44	1.30	-0.41	-0.01	44.97	-7.35	1.56	0.67	55.69	-8.51	1.16	4.42	10.94	1.44	-1.73	0.36
Overall mean	2.14	SEm (m) = 0.18 SEm (b) = 1.54			52.32	SEm (m) = 2.15 SEm (b) = 2.27			54.19	SE (m) = 4.19 SE (b) = 0.22			9.50	SE (m) = 0.43 SE (b) = 0.82		

cm, respectively) and were average performers.

Regarding tepal width, genotypes 'Brunello' and 'Montego Bay' were the most stable genotypes with comparatively higher mean values (3.37 cm and 3.21 cm, respectively) than the overall mean (2.95 cm). However, genotype 'Sapporo' recorded a maximum mean value (3.62 cm), indicating average genotype performance over environments. A similar study was observed in marigold by Mahanta *et al.* (2020) and Naik *et al.* (2005).

The maximum duration of flowering (23.81 days) was recorded in genotype 'Eyeliner'; however, the performance of this genotype was unstable while 'Salmon Classic' was most stable performer for flowering duration. Genotypes such as 'Prato' (22.82 days) and 'Brunello' (20.93 days) exhibited comparatively more duration of flowering as compared to overall mean (17.37 days) yet their performance was unstable over the environment (Table 4). Similar findings were reported previously by Negi *et al.* (2020) in chrysanthemum genotypes.

With regards to vase life, genotypes 'Eyeliner' (10.28 days) and 'Sapporo' (7.54 days) recorded a maximum mean value than the overall mean (7.24 days) and also observed as stable genotypes over different environments. Genotypes such as 'Navona', 'Pollyana' and 'Ercolano' were adaptable to average environments.

Table 3. Estimation of stability parameters for days to first flower, stem diameter, size of the flower and number of flowers/plant

Genotypes	Days to first flower				Stem diameter (cm)				Size of the flower (cm)				Number of flowers/plant			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	79.91	-0.25	0.61	3.041	0.69	0.04	0.78	0.01	15.07	-1.38	1.72	-0.01	3.97	-0.61	0.08	0.03
Prato	79.67	-3.15	0.85	62.64	0.72	0.07	2.11	0.01	18.51	2.06	2.81	0.62	7.43	2.85	1.47	1.00
Tresor	89.08	-8.54	1.07	115.19	0.60	-0.05	1.58	0.00	15.03	-1.42	0.96	0.00	4.23	-0.36	0.92	0.33
Shiraj	87.60	-0.20	1.12	2.10	0.44	-0.22	0.74	0.00	13.23	-3.22	1.26	0.00	3.90	-0.68	0.73	0.20
Brunello	85.95	-17.08	1.20	63.41	0.60	-0.05	1.21	0.00	17.24	0.79	0.75	-0.05	6.28	1.70	2.22	0.33
Pollyana	87.43	3.63	0.96	11.58	0.55	-0.10	0.26	0.00	16.45	0.00	2.23	0.34	4.74	0.16	1.79	0.22
Elite	88.97	-1.56	0.88	26.99	0.64	-0.01	1.17	0.00	14.83	-1.62	2.82	0.23	5.26	0.68	1.84	0.58
Eyeliner	86.22	-5.29	0.89	11.32	0.74	0.09	1.27	0.00	15.94	-0.51	1.47	0.30	7.97	3.39	2.07	-0.03
Ercolano	86.56	1.14	0.69	44.36	0.67	0.02	0.93	0.01	16.64	0.19	2.10	0.02	2.86	-1.73	0.03	0.06
Ceb Dazzle	86.37	1.58	1.03	54.62	0.67	0.02	0.93	0.01	15.41	-1.05	0.85	-0.05	3.06	-1.52	0.22	0.06
Best Seller	63.73	-7.31	0.82	2.56	0.75	0.10	0.69	0.00	15.97	-0.48	0.04	-0.03	4.02	-0.56	-0.38	1.64
Pavia	86.59	-1.45	1.03	9.38	0.79	0.14	0.80	0.00	16.77	0.32	2.82	0.56	4.52	-0.06	0.09	-0.04
Salmon Classic	73.47	1.96	1.04	100.27	0.77	0.12	0.99	0.00	15.89	-0.56	2.29	0.87	5.28	0.70	1.31	0.42
Yelloween	89.40	11.39	1.06	2.69	0.64	-0.01	1.18	0.00	20.39	3.94	0.55	0.05	4.37	-0.21	1.23	0.32
Celesta	79.11	-8.03	0.72	35.61	0.75	0.10	1.33	0.01	15.91	-0.54	-1.87	1.10	5.89	1.31	2.20	-0.02
Montego Bay	101.32	12.14	1.37	0.00	0.62	-0.03	1.50	0.00	16.80	0.35	0.36	0.36	3.72	-0.86	1.34	0.20
Viviana	99.63	11.35	1.40	18.05	0.49	-0.16	0.62	0.00	15.91	-0.54	-3.00	1.17	2.33	-2.26	0.26	0.04
Sapporo	99.29	9.69	1.24	1.01	0.65	0.00	-0.08	0.00	20.20	3.75	-0.15	0.04	2.67	-1.91	0.59	-0.02
Overall mean	86.13	SE (m) = 3.28 SE (b) = 0.12			0.65	SE (m) = 0.37 SE (b) = 0.31			16.46	SE (m) = 0.35 SE (b) = 0.99			4.58	SE (m) = 0.34 SE (b) = 0.22		

P_i: Phenotypic index, b_i: Regression coefficient, : Squared deviation from regression coefficient

Table 4. Estimation of stability parameters in 18 *Lilium* genotypes for tepal length, tepal width, duration of flowering and bulb diameter

Genotypes	Tepal length (cm)				Tepal width (cm)				Duration of flowering (days)				Bulb diameter (cm)			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	8.94	-0.51	1.16	0.81	2.50	-0.45	0.62	0.06	17.02	-0.35	0.77	-0.11	5.01	0.33	1.14	-0.04
Prato	10.92	1.47	-0.80	0.05	3.36	0.41	0.28	0.00	22.82	5.45	0.49	2.28	5.75	1.07	1.72	0.20
Tresor	8.43	-1.02	0.34	-0.01	2.72	-0.23	0.48	0.11	19.40	2.03	1.47	2.07	4.42	-0.26	1.41	0.03
Shiraj	6.95	-2.50	-0.72	0.00	2.38	-0.57	0.68	0.10	15.39	-1.98	1.39	0.41	4.22	-0.46	1.76	0.30
Brunello	9.51	0.06	1.64	0.26	3.37	0.42	0.67	0.02	20.93	3.56	1.76	3.40	5.15	0.47	1.17	0.10
Pollyana	9.21	-0.24	1.67	0.03	2.28	-0.67	0.57	-0.01	15.95	-1.42	1.08	2.29	4.41	-0.27	0.58	0.94
Elite	7.88	-1.57	-0.76	-0.03	2.46	-0.49	-0.50	-0.01	16.81	-0.56	1.95	1.73	4.76	0.08	0.99	0.03
Eyeliner	9.61	0.16	2.03	-0.03	2.93	-0.02	0.50	0.02	23.81	6.44	1.39	4.14	5.54	0.86	0.70	-0.05
Ercolano	9.30	-0.15	1.84	1.17	3.00	0.05	1.53	0.02	12.24	-5.13	0.10	14.41	4.55	-0.13	0.79	0.02
Ceb Dazzle	9.37	-0.08	2.57	0.13	3.13	0.18	1.54	0.05	13.69	-3.68	0.42	5.36	4.77	0.09	0.79	0.03
Best Seller	9.37	-0.08	0.94	-0.03	3.18	0.23	2.60	0.01	13.00	-4.37	-0.91	4.84	4.90	0.22	1.42	0.11
Pavia	9.69	0.24	1.77	1.12	3.15	0.20	1.64	-0.01	18.38	1.01	-1.03	1.06	5.17	0.49	1.41	0.15
Salmon Classic	8.04	-1.41	1.77	0.97	2.99	0.04	2.41	0.11	18.53	1.16	1.43	-0.14	4.81	0.13	1.27	0.04
Yelloween	12.43	2.98	-0.11	-0.03	2.85	-0.10	2.62	0.04	18.66	1.29	1.31	8.61	4.65	-0.03	1.45	-0.04
Celesta	9.09	-0.36	1.47	0.03	2.81	-0.14	1.64	0.00	17.57	0.20	2.13	4.15	4.36	-0.32	0.06	0.10
Montego Bay	9.85	0.40	2.48	0.04	3.21	0.26	1.15	-0.01	18.56	1.19	2.62	0.28	5.10	0.42	1.49	0.03
Viviana	9.65	0.20	0.93	0.36	3.22	0.27	0.28	0.03	14.70	-2.68	0.97	8.58	3.33	-1.35	-0.03	-0.03
Sapporo	11.90	2.45	-0.21	-0.03	3.62	0.67	-0.69	-0.01	15.28	-2.09	0.67	0.80	3.41	-1.27	-0.12	0.02
Overall mean	9.45	SE (m) = 0.32 SE (b) = 0.51			2.95	SE (m) = 0.11 SE (b) = 0.43			17.37	SE (m) = 1.13 SE (b) = 0.38			4.68	SE (m) = 0.23 SE (b) = 0.31		

P_i: Phenotypic index, b_i: Regression coefficient, : Squared deviation from regression coefficient

Bulb parameters: The size of the bulb has a direct relationship with number of flowers produced in a plant. A more vigorous and healthy bulb will produce more number of flowers. Genotypes 'Navona', 'Brunello', 'Elite' and 'Eyeliner' exhibited stable performance for bulb diameter over the environments. Furthermore, 'Prato', 'Pavia' and 'Montego Bay' recorded higher mean values (5.75 cm, 5.17 cm and 5.10 cm) than the overall mean, yet these genotypes showed unstable performance. A similar response of genotypes in changing environments was studied previously in the corm diameter of gladiolus (Kirtiman *et al.,* 2011).

Table 5 indicates the maximum weight of bulbs in 'Navona' (50.40 g), 'Prato' (60.80 g), 'Ceb Dazzle' (58.26 g), 'Salmon Classic' (58.11 g) and 'Montego Bay' (61.34 g) compared to overall mean (47.11 g) however, these genotypes were unstable. Among different genotypes, 'Elite' and 'Eyeliner' recorded high mean (49.19 g and 64.05 g, respectively) than overall mean (47.11 g), high phenotypic index (2.08 and 16.94, respectively), regression coefficient (1.23 and 1.15, respectively) was greater than unity and high deviation from linearity (1.53 and 3.17, respectively) thus indicating these genotypes were suitable to rich environment, below average stability.

Table 5. Estimation of stability parameters in 18 *Lilium* genotypes for weight of bulb, number of bulblets/plant, weight of bulblets and vase life

Genotypes	Weight of bulb (g)				Number of bulblets/plant				Weight of bulblets (g)				Vase life (days)			
	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}	Mean	P_i	b_i	S^2_{di}
Navona	50.40	3.29	0.91	69.86	1.83	-1.14	0.19	0.04	1.91	0.00	1.79	0.04	6.59	-0.65	1.04	0.26
Prato	60.80	13.69	2.00	60.83	3.70	0.73	1.49	0.78	1.81	-0.10	1.65	0.21	7.25	0.01	1.56	0.86
Tresor	40.26	-6.85	0.81	6.57	2.82	-0.15	-0.19	0.17	1.47	-0.44	1.02	0.40	7.19	-0.05	0.62	1.11
Shiraj	40.61	-6.50	0.95	0.81	1.97	-1.00	0.42	-0.02	1.60	-0.31	0.68	0.16	6.83	-0.41	1.12	0.08
Brunello	48.29	1.18	0.65	64.85	3.70	0.73	1.80	1.16	2.07	0.16	-0.05	0.20	7.45	0.21	1.76	0.45
Pollyana	42.81	-4.30	0.64	10.27	1.53	-1.45	0.08	0.09	1.86	-0.05	2.18	0.40	7.10	-0.14	1.10	-0.06
Elite	49.19	2.08	1.23	1.53	1.99	-0.98	0.34	-0.03	1.57	-0.34	1.42	0.18	7.24	0.00	0.73	0.00
Eyeliner	64.05	16.94	1.15	3.17	7.20	4.23	2.69	0.04	3.26	1.35	1.02	0.07	10.28	3.04	0.62	0.68
Ercolano	44.48	-2.63	0.75	5.71	2.60	-0.37	0.71	0.17	1.70	-0.21	0.13	0.00	6.22	-1.02	1.02	0.00
Ceb Dazzle	58.26	11.15	1.75	24.42	5.27	2.30	2.84	0.02	1.78	-0.13	0.19	0.11	6.27	-0.97	1.14	0.25
Best Seller	45.58	-1.53	0.98	28.21	2.84	-0.13	1.19	-0.01	1.78	-0.13	0.72	0.75	6.36	-0.88	0.95	0.04
Pavia	46.27	-0.84	1.13	75.24	4.73	1.76	2.57	0.11	2.02	0.11	0.75	0.21	6.81	-0.43	0.73	0.14
Salmon Classic	58.11	11.00	1.82	49.49	3.05	0.08	1.51	-0.02	2.62	0.71	2.56	1.63	7.93	0.69	2.41	0.61
Yelloween	45.23	-1.88	0.97	62.97	1.83	-1.15	0.28	0.26	1.51	-0.40	0.47	0.09	6.94	-0.30	0.49	0.07
Celesta	45.91	-1.20	0.45	16.28	3.14	0.17	1.31	0.05	2.15	0.24	1.52	0.14	8.42	1.18	-0.04	0.50
Montego Bay	61.34	14.23	1.64	46.86	2.17	-0.80	0.52	0.07	2.76	0.85	0.90	6.01	7.15	-0.09	1.43	-0.06
Viviana	24.18	-22.93	0.04	19.20	1.73	-1.24	0.23	0.23	0.67	-1.24	0.03	-0.03	6.73	-0.51	0.32	0.32
Sapporo	22.15	-24.96	0.13	22.21	1.83	-1.14	0.19	0.04	1.80	-0.11	1.03	0.20	7.54	0.30	1.01	0.60
Overall mean	47.11	SE (m) = 3.27 SE (b) = 0.17			3.00	SE (m) = 0.26 SE (b) = 0.18			1.91	SE (m) = 0.46 SE (b) = 1.32			7.24	SE (m) = 0.38 SE (b) = 0.42		

Table 6. Parameter wise stable genotype of *Lilium*

Parameters	Genotypes	Conclusion
Days taken for bulb sprout emergence	Navona, Prato, Shiraj, Pollyana, Best Seller, Cilesta, Salmon Classic	Early genotypes
	Eyeliner	Stable genotype
Plant height (cm)	Brunello	Rich environments
		Stable genotypes : None
Number of leaves/plant	Salmon Classic	Stable genotype
Leaf length (cm)	Yelloween	Stable genotype
Leaf width (cm)	Brunello, Pavia and Viviana	Stable genotypes
Stem length (cm)	Salmon Classic	Rich environments
Days to flower bud formation	Navona, Prato, Shiraj, Pollyana, Best Seller, Cilesta, Salmon Classic, Elite	Early genotypes
	Pollyana	Stable genotype
Bud length (cm)	Pollyana, Eyeliner, Yelloween	Stable genotype
Days to first flower	Best Seller, Cilesta	Early varieties
	Yelloween, Sapporo	Stable genotypes
Stem diameter (cm)	Pavia, Best Seller, Salmon Classic	Stable genotype
Size of the flower (cm)	Yelloween, Brunello	Stable genotype
	Sapporo	Low sensitivity to environments
Number of flower/stem	Eyeliner, Salmon Classic	Stable genotype
Tepal length (cm)	Viviana	Stable genotype
	Prato, Yelloween, Sapporo	Poor environments
Tepal width (cm)	Brunello, Montego Bay	Stable genotype
	Sapporo	Poor environments
Duration of flowering (days)	Salmon Classic	Stable genotype
	Eyeliner	Rich environments
	Prato	Poor environments
Bulb diameter(cm)	Navona, Brunello, Elite, Eyeliner	Stable genotype
Weight of bulb (g)	Eyeliner, Elite	Rich environments
	Stable genotype	None
Number of bulblets/stem	Salmon Classic, Celesta	Rich environments
	Eyeliner	Average environments
Weight of bulblet (g)	Eyeliner, Pavia	Stable genotype
Vase life (days)	Eyeliner	Stable genotype

In *Lilium*, bulblets can be used as a future planting material source. A significant maximum number of bulblets per plant was recorded in 'Eyeliner' (7.20), with a phenotypic index greater than zero, a high value of regression coefficient (2.69) and a low value of deviation from linearity (0.04) indicating average performer over the different environment. However, genotypes 'Salmon Classic' and 'Cilesta' were also stable performers. Kirtiman *et al.* (2011) and Khar *et al.* (2005) reported varied responses for yield of cormels in gladiolus in different environments.

'Eyeliner' and 'Pavia' were found to be the most stable genotype for the weight of the bulblet. Genotypes such as 'Brunello' (2.07 g), 'Salmon Classic' (2.62 g), 'Cilesta' (2.15 g) and 'Montego Bay' (2.76 g) recorded higher mean value than the overall mean (1.91 g) but were unpredictable over environments.

Comprehensive knowledge of genotype × environment interaction is necessary to develop improved and stable genotypes. Selecting a stable genotype that interacts less with the environments is important to realize yield uniformity. With regards to the stability of different genotypes, 'Eyeliner' exhibited stability for most of the economic parameters like days taken to bulb sprout emergence, bud length, number of flowers/stem, weight of bulblets, number of bulblets and vase life though showed unpredictable performance for flower size, tepal length, tepal width and stem thickness. Yet, it exhibited a great promise for hybridization with a consistently higher number

of flowers/stems, bulb size and bulblet yield. Moreover, genotype 'Yelloween' exhibited stability for aesthetic parameters such as leaf length, bud length and size of flower.

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