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ESTIMATION OF VARIABILITY ANALYSIS PARAMETERS FOR MAJOR GROWTH AND FLOWERING TRAITS OF *Lilium leichtlinii* var. *maximowiczii* GERMPLASM

Rameshwar Rai^{1,2} , Viet Yen Nguyen¹, Jong Hwa Kim^{1,2*}

¹College of Agriculture and Life Sciences, Department of Horticulture, Kangwon National University(KNU), Chuncheon 24341, Korea

²Oriental Bio-herb Research Institute, Kangwon National University, Chuncheon 24341, Korea

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ABSTRACT

This experiment was carried out to evaluate the *Lilium leichtlinii* var *maximowiczii* germplasm collected from the different natural habitats from all over Korea. In total 30 accessions were studied for nine traits viz. plant height, leaf length, leaf width, the numbers of flowers, flower diameter, length of outer tepal, width of outer tepal, the number of leaf burn, and days to flowering in randomized block design with three replications. The ANOVA revealed highly significant variability prevailing among the investigated genotypes for almost all studied traits (except leaf width). The higher estimated value of GCV, PCV, heritability (H^2), and genetic advance as percent of the mean was obtained for the number of flowers and leaf burn. The moderate to high GCV and PCV coupled with higher heritability estimates (H^2) and GAM were found for plant height and flower diameter. Progeny selection would be effective as the prevalence of additive gene effect for these traits. Besides, leaf width, leaf length, length of outer tepal, the width of outer tepal, and days to flowering traits were possessed moderate to low GCV and PCV value coupled with the moderate value of heritability estimate with the low level of GAM proved to be the prevalence of non-additive genetic effect thereby indicating the necessity of alternative breeding approach for these traits improvement and breeding scheme. For the former group of traits breeding hybridization and selection would be an effective method, and primarily mean performance of these traits would be very handy for the decision of selection.

* Corresponding author

E-mail: jonghwa@kangwon.ac.kr (Jong-Hwa Kim)

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1 Introduction

The genus *Lily* belongs to the family *Liliaceae* includes more than 110 species throughout the world, out of which 50-60 species are being cultivated in Asia, 24 species are being exploited in North America, and 12 species are exploiting in Europe (Dhiman et al., 2018). In the context of Asia, the East Asian region especially Japan, Korea, and China are thought to be the native of the many wild lily species (Mc Rae, 1998; Gao & Gao, 2016). The southwest and north parts of China are taken as natural habitats of more than 55 species of wild lily, and it is believed to be the center of the diversity of *Lilium* species (De Jong, 1974). Furthermore, Korea is thought to be another center of genetic diversity of *Lilium* in Asia due to the availability of diverse geographical and climatic characteristics, including temperate and warm climatic pockets, and to date total of 15 wild species have been exploited (Kim, 2008; Lucidos et al., 2013). Further, till now 15 wild lily species have been recorded so far in the East Asian region, and seven species belong to the *Sinomartagon* section i.e. *L. amabile*, *L. callosum*, *L. cernuum*, *L. concolor*, *L. lancifolium*, and *L. leichtlinii* var. *maximowiczii*. Based on morphological and cytological characteristics, *L. leichtlinii* var. *maximowiczii* is thought to be closely related to the origin of triploid *L. lancifolium* (Tiger-lily) (Nguyen et al., 2015). Its wide distribution comprised Japan, Korea, Manchuria, Northern China, and Ussuri in Russia (Nguyen et al., 2015), and it is an endemic lily in Korea. Earlier *L. leichtlinii* var. *maximowiczii* was thought to be diploid like *L. lancifolium* but later on, it has also proved to be diploid-triploid complex species (Kim et al., 2006; Nguyen et al., 2015; Nguyen et al., 2016). According to Wilson (1925), tiger lily (*L. lancifolium*) can be distinguished from *L. leichtlinii* var. *maximowiczii* which possesses a stoloniferous bulb-bearing underground stem and the complete absence of bulbils on the leaf-axils. Lighty (1968) had explored *Lilium* populations in South Korea and suggested limited distribution of *L. leichtlinii* var. *maximowiczii* and it was reported only from Gangwon do province. Jeong (1991) had collected *L. leichtlinii* var. *maximowiczii* specimens in Korea from Sokeumkang (Gangneung city), Goonbukmyun of Ockcheongun and Miryang of Kyangsangnam-do and other botanists had collected specimens from Kumo-do, the southernmost part of Korea to Gangwon do, the northernmost part of Korea, though some specimens were misidentified (KBIS, 2013). Kim et al. (2016) had reported that *L. leichtlinii* var. *maximowiczii* plants grow in very scattered populations and are distributed in steep mountain ranges of Chungcheongbuk do, Gyeonggi-do, and Gangwon-do provinces of South Korea. Noda (1966), Noda (1974), and Noda (1986), hypothesized that sterile triploids of *L. lancifolium* might have originated from *L. leichtlinii* var. *maximowiczii*. In this context, previous studies have been reported a favorable argument regarding the origin of triploid *L. lancifolium* that they had surveyed 30 Korean islands since 1997 but never identified

L. leichtlinii var. *maximowiczii* on these islands (Kim et al., 2004, 2005, 2006) where only diploids *Lilium lancifolium* are distributed. The triploids plants are more common than diploid plants in *L. leichtlinii* var. *maximowiczii* populations, but both triploids and diploids populations have possessed only one cytotype while analysis was carried out through conventional chromosome analysis (Kim et al., 2016). *L. leichtlinii* var. *maximowiczii* germplasm has been collected, and every accession has registered at the germplasm reservation center, gene bank at rural development administration (RDA). Germplasm evaluation deserves prime importance for any breeding scheme as previously introduced *L. leichtlinii* var. *maximowiczii* comprised of both diploid and tripod. These varieties can be distinguished based on morphology. This study's objective is to assess variability for major growth and flowering traits of 30 *L. leichtlinii* var. *maximowiczii*, thereby understanding the breeding potentiality of that germplasm for population improvement.

2 Materials and Methods

2.1 Plant material

The plant materials used for this study consisted of 30 genotypes of the *L. leichtlinii* var. *maximowiczii* (Table 1) received from the floricultural breeding lab under the department of horticulture, Kangwon National University (KNU). These genotypes were collected from the different habitats especially forest areas of different locations of South Korea and officially registered in the germplasm reservation center of Rural Development Administration (RDA), and other government organizations of the Gangwon Province, providing IT number and GWL number on the behalf of oriental bio herb research institute and was used continuously as germplasm for further breeding and research scheme.

2.2 Field layout and Experimental setup

The commercial bulbs of all 30 genotypes as standing crops were obtained at KNU main research farm. The whole field was laid out as a block consisting of 20 beds, and each bed measured 30m long and 1.2m wide. The space in between the bed was 0.6-0.75m for intercultural operation viz. weeding, herbicide, insecticide, fertilizer application, plowing, etc. The bulbs were transplanted plant to plant and row to row equidistance of 12.5cm. The bulbs were grown in the field as randomized block design (RBD) with three replications.

2.3 Morphological observation and sampling

The morphological observation of 9 important traits of 30 *L. leichtlinii* var. *maximowiczii* genotypes were measured and collected at the KNU main research farm growing site during the flowering season from the first week of June 2020 to the last week

of July 2020. Since the limited germplasm was collected and maintained in the farm with three replications, each replication represented three plants. For morphological observation, every single plant was taken as a sample, eliminating those with similar morphological appearances. The morphological measurements were taken by following the guidelines of lily register checklists given by Matthews (2007).

2.4 Statistical analysis

The raw data obtained by observing the morphology of all 30 genotypes for nine studied characteristics were first processed and prepared using MS-excel 2013 and analyzed the least significant difference, and further analysis of variability parameters was carried out using the TNAUSTAT statistical packages. The

Table 1 Lists of genotypes designation, its special characteristics and resource center of *L. leichtlinii* var. *maximowiczii* genotypes

S.N.	Genotypes Designation	Special remarks	Resource
1	IT 282830	Early flowering, Middle plant height, Botrytis infestation 10.1~ 20%.	Oriental bio-herb research Institute / Floricultural breeding lab., KNU
2	IT 283143	Intermediate flowering habit and plant height, Botrytis infestation 5.1~10%.	
3	GWL 1522	Tall, early flowering, Botrytis infestation 1.1~5%.	
4	IT 283142	Intermediate plant height and flowering, and botrytis infestation 1.1~5%.	
5	IT 283183	Early flowering and middle plant height, and botrytis infestation 1.1~5%.	
6	IT 283147	Tall and intermediate flowering habit, and botrytis infestation 5.1~10%.	
7	IT 283148	Intermediate flowering and plant height, and free of botrytis infestation.	
8	IT 283146	Tall and early flowering habit, and free of botrytis infestation.	
9	IT 283144	Early flowering and middle plant height, and free of botrytis infestation.	
10	IT 283151	Tall and middle plant height, and free of botrytis infestation.	
11	GWL 1300	Early flowering and middle plant height, and botrytis infestation 1.1~5%.	
12	IT 282927	Middle to tall and late flowering, and botrytis infestation 1.1~5%	
13	IT 283134	Middle-Tall, late flowering, and botrytis infestation 1.1~5%	
14	IT 283141	Tall and late flowering, and free of botrytis infestation.	
15	IT 283152	Very tall and intermediate flowering habit, and botrytis infestation 1.1~5%.	
16	GWL 1527 (214 Yanggu)	Short plant height but late flowering, and botrytis infestation 1.1~5%.	
17	IT 282827	Very tall and late flowering, and botrytis infestation < 1%.	
18	IT 283125	Short to middle and late flowering, and botrytis infestation < 1%.	
19	IT 283128	Very tall and late flowering, and free of botrytis infestation.	
20	IT 283129	Tall and late flowering, and botrytis infestation < 1%.	
21	IT 283140	Very tall but intermediate flowering habit, and botrytis infestation <3%	
22	IT 283134	Middle plant height but middle to late flowering habit, and botrytis infestation 5.1~10%.	
23	GWL 1426 (517 Sangnam)	Very tall but middle to late flowering, and botrytis infestation 1.1~5%.	
24	GWL 1477 (539 3 × Jungnali)	Middle to tall, early flowering, and botrytis infestation 1.1~5%.	
25	GWL 1477 (2013 533 2 × Jungnali)	Taller but early flowering, and botrytis infestation 5.1~10%.	
26	IT 283139	Middle-Tall, intermediate flowering habit, and botrytis infestation 5.1~10%.	
27	IT 283131	Very tall but early flowering, and botrytis infestation 10.1~20%.	
28	IT 283154	Tall and intermediate flowering habit, free of botrytis infestation.	
29	IT 283138	Shorter but late flowering, and botrytis infestation 10.1~20%.	
30	IT 283127	Intermediate plant height and flowering time, and botrytis infestation 1.1~ 5%.	

ANOVA analysis, F test, and other variance components viz. PCV, GCV, ECV, heritability (H^2), GA, and GAM were estimated by adopting the plant breeding general tools in a randomized block design (RBD); variability analysis of TNAUSTAT statistical package. Likewise, the DMRT (Duncan's multiple range test) was estimated at the 5% significance level for separating the estimated means of all the treatments following the DMRT comparison tools under the general designs head of the TNAUSTAT statistical package (Manivannan, 2014). The genotypic, phenotypic, environmental, and consecutive components variation were estimated using the formula and methods given by Burton & Devane (1953). In addition, heritability (H^2), genetic advance, and genetic advance as percentages of mean were estimated by adopting the formula and method given by Allard (1960).

3 Results and Discussion

3.1 Analysis of variance (ANOVA) and other variability parameters GCV, PCV, and ECV

The estimated value of analysis of variance (ANOVA) demonstrated that almost all investigated traits (besides leaf width) of *L. leichtlinii* var. *maximowiczii* were significantly different among the 30 studied genotypes at 1% level of significance (Table 2). This provides the validity of the experiment being conducted; the existence of variability's is the raw materials for the breeders, biologists, and geneticists which are the foundation for the execution of the future breeding scheme. Other coefficients of variance components GCV (genotypic coefficients of variation), PCV (phenotypic coefficients of variation), ECV (environmental coefficients of variation) with the addition of genetic advance and genetic advance as percent of the mean (GAM) were presented in table 2. There was a prevalence of environmental effect on the expression of the studied traits as observed higher phenotypic

coefficients variation value than genotypic coefficients of variation (Table 2). As observed in the current study, the estimated value of PCV and GCV for the investigated traits in this study was ranged between 5.32 and 4.71 for days to flowering and 82.08 and 59.41 for leaf burn, respectively, thereby indicating the prevalence of substantial broad-based genetic variability ability among the studied genotypes. Based on the classification provided by Deshmukh et al. (1986), higher GCV and PCV for the number of leaf burn and the number of flowers have been reported in this study; hereby indicating that these traits of the studied genotypes are performing outstanding, and there is a practical possibility for improvement through considering these traits during selection and hybridization. Likewise, the estimated GCV and PCV values demonstrated that plant height and flower diameter possessed a moderate value for this parameter, meaning acceptable improvement might be obtained through selecting these traits (Table 2). In addition, remaining traits including leaf length, leaf width, length of OT, and width of OT had demonstrated the combination of lower GCV value and moderate PCV value while for the days to flowering had possessed the combination of both GCV and PCV value low, thereby indicated for this traits that there was existing low level of magnitude of heritable genetic factor to the next generation, non-additive gene action was playing the vital role for these traits.

3.2 The mean performances of the investigated nine traits

The mean performance of all 30 genotypes for the studied traits viz. plant height, leaf length, leaf width, number of flowers, flower diameter, length of outer tepal (OT), the width of OT, number of leaf burn, and days to flowering are given in Table 3. The mean performance table demonstrated huge variability for the studied traits among the investigated genotypes. The tallest genotype goes for GWL 1426 (517 Sangnam) with 127.7cm average plant height,

Table 2 ANOVA and estimation of variability parameters for growth and flowering traits in *L. leichtlinii* var. *maximowiczii* genotypes

Traits / Parameter	G. Mean±SEM	LSD (5%)	CV (%)	F test	PCV (%)	GCV (%)	ECV (%)	H^2 (%)	GA	GAM (%)
Plant height(cm)	101.2±1.7	20.10	11.02	**	15.98	11.57	11.02	52.45	65.97	17.26
Leaf length	13.5±0.2	2.19	8.92	**	11.88	7.85	8.92	43.66	5.94	10.69
Leaf width	1.5±0.0	0.29	13.53	ns	14.26	4.50	13.53	9.96	0.22	2.93
No. of flowers	4.9±0.3	3.52	39.35	**	52.00	33.99	39.35	42.72	9.23	45.77
Flower diameter	39.0±0.9	11.70	16.31	**	21.99	14.75	16.31	44.98	32.26	20.38
Length of OT	8.3±0.1	0.93	6.24	**	8.24	5.37	6.24	42.53	2.47	7.22
Width of OT	1.9±0.0	0.30	8.84	**	11.05	6.63	8.84	35.98	0.69	8.19
Leaf burn (No.)	5.9±0.5	6.56	56.63	**	82.08	59.41	56.63	52.39	19.60	88.58
Days to flowering	97.1±0.6	7.40	2.46	**	5.32	4.71	2.46	78.54	21.19	8.60

Abbr. ANOVA=Analysis of variance, G.Mean=General Mean, SEM=standard error of mean, SD=Least significance difference, CV=Coefficient of variation, PCV=Phenotypic coefficient of variation, GCV=Genotypic coefficient of variation, ECV=Environmental coefficient of variation, H^2 =Heritability, GA=Genetic advance, GAM=Genetic advance as percentage of mean.

while the shortest genotype was recorded for GWL 1527 (214 Yanggu) with 71.0cm average plant height. Most extended leaves were measured for IT 283134 with an average leaf length of 16.4cm, while shortest leaves were recorded for the genotypes IT 282830 and GWL 1527 (214 Yanggu) jointly with the average leaf

length of 11.3cm. Likewise, the broadest and narrowest leaves were found for genotypes IT 283142 and IT 283125, with the average leaf width of 1.77cm and 1.20cm, respectively. The highest numbers of the flower were found for genotype IT 283151, with an average number of flowers of 11.3.

Table 3 The mean performance for major growth and flowering traits of *L. leichtlinii* var. *maximowiczii* genotypes

Traits /Genotypes	Plant height	Leaf length	Leaf width	No. of flowers	Flower diameter	Length of OT	Width of OT	Leaf burn (No.)	Days to flowering
IT 282830	89.3 ^{fg}	11.3 ^h	1.43 ^{ab}	4.3 ^{de}	34.88 ^{bc}	7.1 ^{eg}	1.73 ^{de}	3.3 ^{ef}	92.7 ^{kl}
IT 283143	102.3 ^{bc}	11.6 ^{fg}	1.37 ^{bc}	4.0 ^{de}	46.58 ^{ab}	8.6 ^{ab}	2.13 ^{ab}	2.3 ^{fg}	98.3 ^{ef}
GWL 1522	107.0 ^{ab}	13.6 ^{bc}	1.47 ^{ab}	4.0 ^{de}	34.64 ^{bc}	8.0 ^{cd}	1.83 ^{bc}	4.3 ^{ef}	88.0 ^p
IT 283142	106.3 ^{ab}	14.1 ^{ab}	1.77 ^a	5.0 ^{cd}	38.19 ^{ab}	8.5 ^{ab}	2.00 ^{ab}	12.3 ^{ab}	96.3 ^{fg}
IT 283183	95.67 ^{de}	12.6 ^{de}	1.43 ^{ab}	3.3 ^e	33.52 ^{cd}	8.1 ^{bc}	1.67 ^{ef}	9.3 ^{bc}	90.3 ^{no}
IT 283147	112 ^{ab}	14.1 ^{ab}	1.67 ^{ab}	5.0 ^{cd}	18.45 ^g	8.5 ^{ab}	2.13 ^{ab}	6.3 ^{cd}	93.0 ^{jk}
IT 283148	89.57 ^{fg}	12.5 ^{ef}	1.53 ^{ab}	3.0 ^e	40.73 ^{ab}	7.9 ^{ce}	1.80 ^{bc}	2.7 ^{fg}	92.0 ^{lm}
IT 283146	104.33 ^{bc}	13.8 ^{bc}	1.53 ^{ab}	6.0 ^{bc}	37.59 ^{ab}	8.0 ^{cd}	1.90 ^{ab}	3.3 ^{ef}	91.3 ^{mn}
IT 283144	98.33 ^{cd}	12.2 ^{ef}	1.53 ^{ab}	4.0 ^{de}	38.03 ^{ab}	8.0 ^{cd}	1.63 ^{fh}	2.7 ^{fg}	90.7 ^{no}
IT 283151	108.33 ^{ab}	15.8 ^{ab}	1.53 ^{ab}	11.3 ^a	48.33 ^a	8.3 ^{ab}	2.10 ^{ab}	1.3 ^{gh}	95.3 ^{gh}
GWL 1300	100.67 ^{bc}	13.1 ^{cd}	1.40 ^{ab}	3.0 ^e	21.80 ^{fg}	8.7 ^{ab}	1.93 ^{ab}	3.3 ^{ef}	89.7 ^{op}
IT 282927	98.33 ^{cd}	12.6 ^{de}	1.60 ^{ab}	3.3 ^e	41.83 ^{ab}	8.2 ^{ab}	1.93 ^{ab}	17.3 ^a	107.0 ^a
IT 283134	93.3 ^{de}	15.2 ^{ab}	1.63 ^{ab}	5.6 ^{bc}	39.67 ^{ab}	8.1 ^{bc}	2.07 ^{ab}	4.7 ^{de}	103.0 ^{ab}
IT 283141	106.0 ^{bc}	13.7 ^{bc}	1.40 ^{ab}	4.0 ^{de}	40.00 ^{ab}	8.5 ^{ab}	1.97 ^{ab}	3.3 ^{ef}	100.0 ^{cd}
IT 283152	114.7 ^{ab}	13.5 ^{bc}	1.40 ^{ab}	5.0 ^{cd}	41.67 ^{ab}	8.7 ^{ab}	2.00 ^{ab}	0.3 ^h	97.3 ^{fg}
GWL 1527 (214 Yanggu)	71.0 ⁱ	11.3 ^h	1.27 ^{cd}	3.7 ^{de}	31.67 ^{de}	6.7 ^h	1.77 ^{cd}	6.0 ^{de}	100.3 ^{cd}
IT 282827	122.7 ^{ab}	14.4 ^{ab}	1.33 ^{bc}	4.3 ^{de}	40.85 ^{ab}	8.5 ^{ab}	1.87 ^{bc}	4.3 ^{ef}	100.3 ^{cd}
IT 283125	79.3 ^{gh}	11.5 ^{gh}	1.20 ^e	2.7 ^e	31.50 ^{ef}	7.9 ^{cd}	1.73 ^{de}	9.7 ^{bc}	105.0 ^{ab}
IT 283128	118.7 ^{ab}	14.5 ^{ab}	1.23 ^{de}	9.0 ^{ab}	41.70 ^{ab}	8.7 ^{ab}	1.97 ^{ab}	8.3 ^{bc}	103.7 ^{ab}
IT 283129	100.3 ^{cd}	13.1 ^{cd}	1.33 ^{bc}	4.0 ^{de}	39.00 ^{ab}	8.0 ^{cd}	1.83 ^{bc}	2.0 ^{fg}	102.3 ^{bc}
IT 283140	113.7 ^{ab}	14.5 ^{ab}	1.43 ^{ab}	5.6 ^{bc}	36.33 ^{ab}	8.4 ^{ab}	1.97 ^{ab}	6.0 ^{de}	99.7 ^{cd}
IT 283134	90.0 ^{ef}	16.4 ^a	1.60 ^{ab}	6.0 ^{bc}	42.00 ^{ab}	8.7 ^{ab}	2.07 ^{ab}	6.0 ^{de}	99.0 ^{de}
GWL 1426 (517 Sangnam)	127.7 ^a	14.3 ^{ab}	1.50 ^{ab}	7.3 ^{bc}	43.07 ^{ab}	9.2 ^a	1.93 ^{ab}	3.7 ^{ef}	99.7 ^{cd}
GWL 1477 (539 3 × Jungnali)	95.0 ^{de}	13.8 ^{bc}	1.50 ^{ab}	5.7 ^{bc}	46.33 ^{ab}	8.7 ^{ab}	2.13 ^{ab}	5.7 ^{de}	94.3 ^{ij}
GWL 1477 (2013 533 2 × Jungnali)	106.0 ^{bc}	13.9 ^{bc}	1.63 ^{ab}	3.7 ^{de}	45.33 ^{ab}	8.6 ^{ab}	2.07 ^{ab}	6.3 ^{cd}	95.7 ^{fg}
IT 283139	105.0 ^{bc}	14.0 ^{bc}	1.40 ^{ab}	4.0 ^{de}	44.33 ^{ab}	7.5 ^{de}	1.60 ^h	6.0 ^{de}	97.3 ^{fg}
IT 283131	113.3 ^{ab}	13.3 ^{cd}	1.67 ^{ab}	5.0 ^{cd}	44.67 ^{ab}	8.4 ^{ab}	2.10 ^{ab}	11.0 ^{bc}	94.7 ^{hi}
IT 283154	105.0 ^{bc}	15.0 ^{ab}	1.50 ^{ab}	8.3 ^{ab}	47.67 ^a	9.1 ^{ab}	2.23 ^a	2.0 ^{fg}	97.0 ^{fg}
IT 283138	72.7 ^{hi}	12.9 ^{cd}	1.47 ^{ab}	2.3 ^e	36.73 ^{ab}	7.8 ^{cd}	2.00 ^{ab}	14.3 ^{ab}	100.3 ^{cd}
IT 283127	88.7 ^{fg}	12.9 ^{cd}	1.47 ^{ab}	3.3 ^e	42.00 ^{ab}	8.4 ^{ab}	1.97 ^{ab}	7.3 ^{cd}	98.3 ^{ef}
G Mean	101.17	13.5	1.47	4.9	38.97	8.3	1.94	5.86	97.1
SEM	1.70	0.2	0.00	0.3	0.89	0.10	0.00	0.50	0.60

In contrast, the fewest number of flowers were recorded for genotype IT 283138 with an average of 2.3 flowers. Furthermore, in the case of flower diameter, the biggest flower was found for genotypes IT 283151 and IT 283154 jointly, and the smallest flower diameters were recorded for genotype IT 283147 with an average of 18.45mm. The longest and shortest outer tepal were recorded for genotypes GWL 1426 (517 Sangnam) and GWL 1527 (214 Yanggu), with the average length of outer tepal 9.2cm and 6.7cm, respectively. Likewise, the broadest outer tepal was recorded for IT 283154 within an average width of outer tepal 2.23cm. In comparison, the narrowest outer tepal was found for IT 283139 with an average outer tepal width of 1.60cm. The number of leaves burns varied from 17.3 (highest) for genotype IT 282927 to 0.3 (lowest) for genotype IT 283152. At last, for the essential traits, days to flowering, most early flowering genotypes recorded for GWL 1522 with average days to flowering 88days while the most late-flowering genotype was IT 282927, with the average days of flowering for this genotype was recorded 107 days. The mean performance is insights that help for the selection of progeny having superior mean performance. In the line tester analysis of single crossed F^1 s. Similarly, Rai et al. (2018), has concluded that varied mean performance are possible due to the background of the genotypic variability of the studied materials.

3.3 Heritability estimates of the investigated traits

The details of the broad-sense heritability estimates are given in table 2. The highest heritability estimates were obtained for days to flowering with 78.54% and while the lowest heritability estimates were obtained for leaf width with 9.96%. Based on estimated heritability, it can understand that for a particular trait, there is the prevalence of strong or low levels of resemblances (Ranjan & Gautam, 2018). Out of nine studied traits, heritability estimates obtained pointed that days to flowering had possessed medium-high heritability. In contrast, plant height, leaf length, number of flowers, flower diameter, length of outer tepal (OT), and leaf burn had possessed medium heritability, and leaf width and width of outer tepal (OT) had shown low heritability (Singh, 2001). According to Johnson et al. (1955), higher heritability possessed a higher estimate of GCV and GAM more critical for predicting genetic gain to ensure effective selection for improvement of any traits in the populations. This experiment is due to the prevalence of non-additive gene action of almost all traits to the phenotypic expression of traits, limiting selective breeding effectiveness.

3.4 Genetic advance and Genetic advance as percent of the mean (GAM)

One of the parameters in variability analysis that deserved the most vital role in determining the underlying gene action of the traits under study is considered to be the genetic advance and genetic advance as percent of the mean. According to Johnson et al.

(1955), the combined estimates of higher heritability and higher genetic gain deserved more usefulness as heritability only does not indicate the amount of genetic improvement resulting from selecting the individual genotypes. The estimated genetic advance and genetic advance as percent of the mean (GAM) are given in Table 2. Higher GAM was obtained for the traits viz. number of leaves burn, number of flowers, and flower diameter, while moderate GAM was obtained for plant weight. Furthermore, remaining traits viz. leaf length, leaf width, length of OT, the width of OT, and days to flowering were possessed a low level of GAM. Based on the practical selection and the breeding principle of Johnson et al. (1955), in this study, higher value of GCV, heritability (in a broad sense, H^2), and GAM for the traits of the number of flowers and number of leaf burn was obtained which demonstrating that these traits were controlled by additive genetic effect and possessed heritable variability in the studied genotypes. The plant height and flower diameter are the traits that possessed a moderate value of estimated parameters, indicating the considerable improvement could be made through a compelling selection method for these traits. Furthermore, the lower combination of GCV, heritability, and GAM for the traits of leaf length, leaf width, length of outer tepal and width of outer tepal, and days to flowering proved to be the prevalence of non-additive genetic effect for these traits. There is a limitation for breeding through selection and improvement for these traits.

Conclusions

This study evaluated the variability of 30 genotypes of *L. leichtlinii* var. *maximowiczii* for the 10 phenotypic traits. Investigated genotypes showed a high significance value for almost all studied traits except for leaf width, thereby revealing the prevalence of a substantial amount of genetic variability among them, which provided the experiment's validity. The number of flowers, numbers of leaf burn, plant height, and flower diameter are the traits that had possessed high and medium GCV, PCV and coupled with higher heritability and GAM confirms the effectiveness of the progeny selection breeding for these traits. On other hand, leaf length, leaf width, length of outer tepal, the width of outer tepal, and days to flowering traits demonstrated non-additive genetic effect limiting the effectiveness of progeny selection after hybridization for these traits

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Conflict of Interest

The authors declare that there is no conflict of interest about the content of the article.

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