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RESPONSES OF LILY TYPES IN DIFFERENT VERNALIZATION PERIODS ON VEGETATIVE AND GENERATIVE GROWTH PERFORMANCES OF LILY

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ABSTRACT. *Lilium spp. is one of important ornamental plant commodities in Indonesia, however development of the plant commercially is constrained by availability of qualified-planting materials. Objective of the study was to test responses of lily types in different vernalization periods on vegetative and generative growth performances under plastic house. Materials used in the research were Lilium bulbs of Lilium longiflorum, L. 'Renata', L. 'Delina', L. 'Liana', Asiatic and local Cipanas lily in 3.5-4.5 cm in diameter. These bulbs were vernalized in 4ºC from 6, 7, 8 and 9 weeks, respectively. The experiment was arranged in a split plot design with three replications, where lily types were as main plot and vernalization periods as subplot. Results of the study revealed that each type of lily exhibited different performances compared to others. More uniform performances with 8.3 and 5.7 plants flowered per replication, 71.8 and 84.3 days initial flower buds opened and 4.5 and 4.9 cm bulb diameter, respectively were noted on L. 'Renata' and L. 'Delina'. The 4ºC for 6 weeks was the optimal vernalization period in producing 6.3 plants flowered per replication with 2.9 flower buds per plant and 4.5 cm bulb diameter. Results of the study implicated that each lily types need different specific conditions for optimal growth performances*

KEYWORDS*: Lily, bulbs, growth, morphology, and vernalization.*

INTRODUCTION

Lilies (*Lilium spp*.), belong to family *Liliaceae*, are one of important cut flower in Indonesia. Total lily cultivation area is only 131,628 m^2 in 2016 and widespread in Cianjur, Cisarua, Cihideung-West Java; Batu-East Java, Berastagi-West Sumatra, Tabanan-Bali, and Tomohon-South Sulawesi (Statistics Indonesia 2016). The lily cut flower has high selling value compared to other cut flowers. The flowers are sold between US$ 22.06 to 66.17 per bunch (@ 5 stems) and consumer demand for the flower increases continually year by year up to 10% (Statistics Indonesia 2016). Though the cut flower has high selling value and consumer demand, development of it commercially in Indonesia was constrained by availability of qualified production bulbs in establishing high quality cut flowers. Traditionally, lilies are usually propagated using seeds generatively and bulbils from the stem, bulblets around the stem base and scales vegetatively (Hartmann et al. 1997; Thomson 2007). In Indonesia, commercial cultivation of lilies is carried out by rich and poor farmers. The rich farmers generally use imported bulbs ready planted. To obtain the materials, they have to spend high production cost from US $ 2.57 - 3.53 per bulb. The cost, in fact, can not be covered by poor farmers. Its impact, the farmers used un-qualified bulbs in varied-sizes and seeds to reduce the production cost. The condition lead to resulting in low quality and productivity of their products and less profit obtained by them in every cultivation period (Herlina & Winarto 2018). To overcome these problems and help the poor farmers in improving their lily products and profit, enlargement bulbs derived from *in vitro* culture works and producing high quality bulbs was significantly addressed. High quality bulbs that result in the best performances phenotypically of lilies are generally produced under bulb enlargement processes. The processes were significantly affected by several factors i.e. genotype (Panda 2015; Herlina & Winarto 2018), cultivation area, media and fertilization (Podwyszyńska & Nowak 2004; Treder 2005; Burchi et al. 2011; Khodorova & Boitel-Conti 2013; Bhandari et al. 2017); environmental conditions (temperature, light conditions, relative humidity, watering/irrigation, biotic and abiotic stress) (Hiramatsu et al. 2006; Burchi et al. 2011; Ndhlala et al. 2012; Lucidos et al. 2013; Ucar & Kazaz 2015; Islam et al. 2017), vernalization of bulbs and bulb size selection (Ahmad et al. 2009; Addai & Scott 2011; Kapczyńska 2014; Brito de Almeida et al. 2017). Optimal synergism effects of all factors will lead to

enlarging bulbs occurred maximally. Vernalization is the physiological event through which flowering is induced by exposure of the seeds and asexual structures and/or plants to cold temperatures (Tombolato et al. 2010; Taiz & Zeiger 2013), optimally from 6-10ºC to induce differentiation of vegetative stage into reproductive buds (Brito de Almeida et al. 2017). The vernalization of bulbs can also break the bulb dormancy (Maddah et al. 2012), shorten and induce plant flowering (Streck & Schuh 2005) and each type of bulb need specific temperature and period of it. In *L. longiflorum,* vernalization of bulbs in 4ºC for 9 weeks successfully induced stem elongation and blooming synchronously (Ben-Hamo et al. 2015); 4ºC for 35-49 days was used on oriental hybrid lily 'Sorbonne' to investigate molecular changes of endogenous abscisic acid (ABA), soluble sugars concentrations and gene their controlling (Liu et al. 2014). While in Indonesia, study that reveals responses of different types of lily and vernalization of bulbs in different periods on growth performances of lilies is not established yet. In the recent study, different responses of lily types and vernalization periods on vegetative and generative growth performances of lilies under plastic house was successfully revealed. The new findings expected can be used to support farmers having alternative choices of lily types that can produce high quality and productivity cut flowers optimally under best vernalization treatment.

MATERIALS AND METHODS

Plant materials

The experiment was conducted at Segunung Experimental Garden of Indonesian Ornamental Crop Research Institute (IOCRI) 1100 meter above see level (m asl). Planting materials used in the experiment were lilium bulbs of *Lilium longiflorum*, *L.* 'Renata' or Renata cultivar (hybrid of Trumpet × Asiatic), *L.* 'Delina' or Delina cultivar (hybrid of Longiflorum × Asiatic), *L.* 'Liana' or Liana cultivar (hybrid of Trumpet × Oriental), Asiatic and local *Cipanas* lilium in 3.5-4.5 cm in diameter.

Preparation of cultivation beds

Cultivation beds were prepared by hoing the land areas conventionally using hoe in ± 30 cm in depth. The cultivation areas were then added by 5 kg/m^2 carbonized-rice husk and 10 kg/m^2 bamboo moss and fumigated using 98% dazomet for 14 days. After the fumigation, the cultivation areas were made into beds. Size of beds were 1 × 1 m^2 (length and width) with 50 cm distance between each bed and

watered sufficiently. Before bulb planting, adding 20 g/m^2 gliocompost was carried out to improve quality of media for bulb growth.

Planting of bulbs

Vernalized-bulbs after prepared were then planted in the cultivation beds with 20 × 20 cm planting distance. The bulbs were planted by making holes in the beds in ± 7 cm in diameter and depth, putting the bulbs in the hole with one bulb for one hole, covering the bulb with media and watering beds with water sufficiently.

Maintaining of plants

After bulb planting, the bulb growth was maintained by watering, weed handing and pest-disease controlling. Watering of lily sufficiently was carried out by spraying water manually using a plastic hose in every morning. Weed handling was done when the growth of weeds inhibited the growth of lily plants. The weed handling was carried out manually by hand. While pest and disease controlling was conducted by spraying pesticide in suggested dosage depending on targets of pests and diseases using difekonazole, hexaconazole and propamocarb hydrochloride. The frequency of pesticide application was depended on pest and disease intensity.

Effect of lily types and vernalization periods of lily bulbs on vegetative and generative growth performances of lilies

In the experiment, 3.5-4.5 cm in bulb diameters of *L. longiflorum*, *L.* 'Renata', *L.* 'Delina', *L.* 'Liana', Asiatic and local *Cipanas* lilium (as control) were used as the main plot. Vernalization of bulbs was carried out by storing the bulbs in 4ºC at different times of 6 (as control), 7, 8 and 9 weeks as a subplot. The experiment was arranged in a split plot design with 3 replications. Each treatment consisted of 10 bulbs planted.

Variables

Variables observed in the study were (1) plant height (cm), measured from base part of stem till tip of shoots using ruler; (2) number of leaves per plant; (3) initial flower buds opened (days), counted started from initial planting till early flower buds produced opened, (4) number of plants flowered per replication, (5) number of flower buds per plant, (6) flower bud diameter (cm) and (7) bulb diameter (cm), measured on the widest part of its using digital caliper. A periodical observation was carried out to follow bulb growth response till flower harvesting. All variables were measured in different flower harvesting time from 3.5 to 4.5 months after bulb planting.

Data analysis

All data collected from the experiments were analyzed by analysis of variance

(Anova) using SAS program Release Windows 9.12. Significant differences between means were assessed by Tukey test at $p = 0.05$ (Mattjik & Sumertajaya, 2006).

RESULTS

Based on periodical observation, vernalized-different *Lilium* bulbs produced initial shoots 10-15 days after culture. The initial shoots grew continually and increased gradually in height of shoots and number of leaves. After 68-175 days of culture, initial flower buds opened were noted. All plants generally flowered. The range of plant height could reach 35-210 cm with 48-175 leaves per plant, 4-9 plants flowered per replication, 2-4 flower buds per plant and 9-21 cm in diameter. Each lily type had different growth performances. *L*. 'Delina' generally had more uniform (Figure 1I, 1J, 1K, and 1L), while higher number of plants flowered was recorded on *L*. 'Renata' (Figure 1E). In the study, six lilium types and treated under different vernalization periods gave significant effects in all variables observed statistically ($p=0.05$). *L*. 'Delina' had the optimal and more uniform growth in all vernalization periods, however the *Lilium* produced lower number of plants flowered per replication and number of flower buds per plant compared to *L*. 'Renata', almost similar to Asiatic and local *Cipanas lilium* as control and higher than others in 85 days after culture. The height of plants of the *Lilium* could reach 61.1 cm with 62.9 leaves per plant, 5.7 plants flowered per replication, 84.3 days in initial flower buds opened, 2.2 flower buds per plant, 18.4 cm flower bud diameter and 4.5 cm in bulb diameter (Table 1). A high number of plants flowered up to 8.3 plants per replication was established in *L*. 'Renata'. While high flower bud productivity up to 3.7 flower buds per plant with wider flower diameter up to 19.3 cm was noted on the Asiatic lilium. Furthermore, though *L.* 'Liana' and *L. longiflorum* had higher plant height compared to others, the two lilies need longer time to flower. The study was also revealed that each lilium had different plant conditions under different vernalization periods (Figure 1A to 1X). In vernalization treatments, longer vernalization periods lower variable values gradually, except the number of flower buds per plant and flower bud diameter. Though 6 weeks of vernalization as control had higher variable values than others, the treatment kept better plant growth with the high number of flower buds per plant and number of plants flowered per replication, especially in *L.* 'Renata' and *L*. 'Delina'. In the treatment, the


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Figure 1. Growth performances of lily types on different vernalization periods. Asiatic lily performances on A. 6 weeks, B. 7 weeks, C. 8 weeks and D. 9 weeks of vernalization; *L.* 'Renata' performances on E. 6 weeks, F. 7 weeks, G. 8 weeks and H. 9 weeks of vernalization; *L*. 'Delina' performances on I. 6 weeks, J. 7 weeks, K. 8 weeks and L. 9 weeks of vernalization; *L*. 'Liana' performances on M. 6 weeks, N. 7 weeks, O. 8 weeks and P. 9 weeks of vernalization; Introduction of *L. longiflorum* performances on Q. 6 weeks, R. 7 weeks, S. 8 weeks and T. 9 weeks of vernalization and Cipanas local lilium perormnces on U. 6 weeks, V. 7 weeks, W. 8 weeks and X. 9 weeks of vernalization.

Table1. Effect of lilium types on vegetative and generative growth performances of lilies.

Response of lilium type	Plant height (cm)	Number of leaves per plant	Initial flower buds opened (days)	Number of plants flowered	Number of flower buds per plant	Flower bud diameter (cm)	Bulb diameter (cm)
Asiatic lilium	64.7 c	59.8 c	80.1 d	4.7 b	3.7 a	19.3 a	4.0 b
L. 'Renata'	39.2 e	60.5 c	71.8 e	8.3 a	2.7 b	13.3 c	4.5 ab
L. 'Delina'	61.1 d	62.9 c	84.3 cd	5.7 b	2.2 b	18.4 b	4.9 a
L. 'Liana'	136.0 b	114.1 b	137.2 b	5.3 b	3.4 a	11.6 e	4.5 ab
L. longiflorum	207.7 a	146.0 a	170.2 a	5.0 b	2.7 b	10.3 f	4.6 a
Local *Cipanas* lilium	39.2 e	51.9 d	87.4 c	5.3 b	2.2 b	12.2 d	4.1 b
CV (%)	2.68	4.15	3.39	19.6	22.2	3.5	12.4

Means followed by the same latter in the same column are not significant differences based on Tukey test, *p=0.05*.

height of plants could reach 95.4 cm with 89.7 leaves per plant, 6.3 plants flowered per replication, 113.6 days for initial flower buds opened, 2.9 flower buds per plant, 13.9 cm in flower bud diameter and 4.5 cm in bulb diameter (Table 2). Seven days of vernalization gave second best results, while the lowest results were recorded on 9 weeks of vernalization with un-uniform plant growth. In the study, there was an interaction effect between lily types and different vernalization periods on plant height, the number of leaves per plant and initial flower buds opened. Based on the variables, optimal results with higher number of flowered plants up to 8.3 plants per replication was noted on *L.* 'Renata' bulbs vernalized for 6 weeks, but the

Table 2. Effect of vernalization periods on vegetative and generative growth performances of lilies.

Period of vernalization (weeks)	Plant height (cm)	Number of leaves per plant	Initial flower buds opened (days)	Number of plants flowered	Number of flower buds per plant	Flower bud diameter (cm)	Bulb diameter (cm)
6	95.4 a	89.7 a	113.6 a	6.3 a	2.9 a	13.9 b	4.5 a
7	90.3 bc	81.2 b	105.7 b	6.0 ab	2.9 a	14.3 ab	4.5 a
8	91.9 b	82.2 b	101.6 c	5.7 ab	2.7 a	14.2 ab	4.4 a
9	88.7 c	77.9 c	99.8 c	5.3 b	2.8 a	14.4 a	4.3 a
CV (%)	2.68	4.15	3.39	20.1	23.8	4.7	11.0

Means followed by the same latter in the same column are not significant differences based on Tukey test, *p=0.05*.

combination only induced 46.2 cm height of plant, 73.1 leaves per plant and 76.5 days of initial flower buds opened (Table 3, 4 and 5). Second best combination treatment was recorded *L*. 'Delina' and 6 weeks of vernalization period. While other combination treatments, though they stimulated higher plant height and number of leaves per plant, they generally needed longer time to produce flower buds with less uniformity, except local *Cipanas lilium* that had lower results in all combinations. The vernalization treatments of lilium bulbs in the study successfully broke bulb dormancy, followed by inducing bulb sprouting, increasing and developing plant growth of lilies in all vegetative and generative variables. All these processes were responded differently by each type of Lilium tested. This condition has high corelation to genotype dependent effect. Results of the study opened chances for farmers to solve their problems in obtaining best alternative lilium by applying optimal vernalization period suitable to their preferences.

DISCUSSION

In the study, it was successfully revealed that different types of lilies performed different plant growth condition under different vernalization treatments. According to Langens-Gerrits et al. (2003) during storage of lilium bulbs at low temperature, starch was hydrolyzed in the bulb scales and sugars accumulated. During this period mobilization of carbohydrate

Table 3. Interaction effect of lilium types and vernalization period on plant height (cm).

Vernalization period (weeks)	Response of lilium types					
	Asiatic lilium	*L.* 'Renata'	*L.* 'Delina'	*L.* 'Liana'	*L. longiflorum*	Local Cipanas lilium
6	64.3 b	46.2 a	62.9 a	146.1 a	217.0 a	36.0 c
7	75.1 a	41.4 a	57.9 a	112.5 c	207.6 b	47.6 a
8	66.4 b	44.0 a	62.2 a	138.2 b	202.9 b	37.7 bc
9	52.9 c	25.1 b	61.4 a	147.3 a	203.2 b	42.2 b
CV (%)	3.74	6.97	4.28	1.54	1.30	4.71

Means followed by the same latter in the same column are not significant differences based on Tukey test, *p=0.05*.

Table 4. Interaction effect of lilium types and vernalization period on number of leaves per plant.

Vernalization period (weeks)	Response of lilium types					
	Asiatic lilium	*L.* 'Renata'	*L.* 'Delina'	*L.* 'Liana'	*L. longiflorum*	Local Cipanas lilium
6	60.3 b	73.1 a	64.3 a	124.8 a	150.0 a	60.2 a
7	67.9 a	72.3 a	55.2 b	94.2 c	143.0 a	54.6 b
8	67.4 b	60.4 b	66.0 a	112.7 b	141.8 a	44.9 c
9	43.5 c	35.9 c	66.0 a	124.9 a	149.0 a	47.8 c
CV (%)	3.77	4.87	4.16	3.99	3.30	3.73

Means followed by the same latter in the same column are not significant differences based on Tukey test, *p=0.05*

Table 5. Interaction effect of lilium types and vernalization period on initial flower buds opened (days).

Vernalization period (weeks)	Response of lilium types					
	Asiatic lilium	*L.* 'Renata'	*L.* 'Delina'	*L.* 'Liana'	*L. longiflorum*	Local Cipanas lilium
6	97.2 a	76.5 a	91.1 a	139.8 a	174.5 a	102.8 a
7	78.5 b	76.5 a	84.8 ab	132.3 a	170.7 ab	91.1 b
8	75.1 b	66.6 b	81.1 ab	135.2 a	172.5 ab	78.9 c
9	69.5 b	67.7 b	80.4 b	141.3 a	163.0 b	76.7 c
CV (%)	4.74	2.68	4.75	3.06	2.16	3.96

Means followed by the same latter in the same column are not significant differences based on Tukey test, *p=0.05*.

reserves which play a role in leaf growth and development of the photosynthetic apparatus, was occurred. In the next step, bulb sprouting and further growth of lilies vegetative till generative stage were taken place. Based on uniformity and the number of plants flowered per replication, *L*. 'Delina' and *L.* 'Renata' were better than others, but for the height of plant and number of leaves, *L*. 'Liana' and *L. longiflorum* gave better results than others. In the previous study, better plant growth were established on *L*. 'Liana' than Asiatic lilium, *L*. 'Delina', *L. longiflorum*, and *L*. Renata; but for uniformity, number of plants flowered per replication and initial flower buds opened in shorter period, *L*. 'Renata' and *L*. 'Delina' kept better results than others (Herlina & Winarto 2018). In other studies, Cebdazzle was better than Bernini in fresh and dry weight of leaves, leaf area, stem diameter, number of leaves, stem dry weight and root length (Nikrazm et al. 2011), *L*. 'Cavalese' better than *L*. 'Fingo' in vase life, stem height and diameter (Burchi et al. 2011), *L*. 'Pavia' better than *L*. 'Bach' in number flower buds per plant up to 5.99 buds, bulb diameter till 46.34 mm, 10.1 stem root length and 18.64 cm basal root length (Bhandari et al. 2017), These results revealed that there were different growth ability and performances of lilies, it was also reported on *L. longiflorum* (Fisher & Lieth 2000). The differences were significantly affected by genotypes (Panda 2015; Burchi et al. 2011; Bhandari et al. 2017) that was also revealed in the study and in the previous study (Herlina & Winarto 2018), growing media (Bhandari et al. 2017), fertilization (Treder 2005; Mirkalaei et al. 2013; Satpute et al. 2014), bio-stimulant and biochar application (De Lucia & Vecchietti 2012; Guo 2014); irrigation (Ucar & Kazaz 2015); and environmental factors (temperatures, biotic and abiotic stress) (Hiramatsu et al. 2006; Lucidos et al. 2013; Islam et al. 2017). Vernalization of bulbs in low temperature for certain periods that have highly significant effects on vegetative and generative growth of *Lilium* was successfully revealed in the study. Six weeks of bulb vernalization under 4ºC were the best vernalization period in obtaining more uniform growth and flowering in shorter period with high number of flower buds per plant (Table 1 and 2; Figure 1E and 1I). The similar results were also reported on *L. longiflorum* 'Nellie White' (Dole & Wilkins 1994), while for *L. longiflorum* 'Snow Queen', the 4ºC temperature for vernalization was optimal for growth performances when applied for 41,6 days (Streck & Schuh 2005). Castelo Asiatic hybrid bulbs successfully produced earlier ripening plants that bore less unopened flowers, super buds and a higher percentage of extra quality flowers with longer vase life

when they vernalized at 3°C for 8 weeks (Auzaque-Rodríguez et al. 2009). Malik (2014) recorded that 4ºC for 6 weeks of *Lilium x elegans* bulb vernalization induced the earliest appearance of a flower bud, the maximum number of bulbs, the weight of bulbs, heaviest bulbs, bulb diameter, number of daughter bulbs and scale size. In the study, increasing vernalization periods reduced all variable values observed both vegetative and generatively. The same results were also noted by Brito de Almeida et al. (2017). In the experiment, longer vernalization periods decreased plant height, the diameter of the planted bulbs, number, the fresh and dry weights of the produced buds. Though there were interaction effects of lily types in different vernalization periods on plant height, the number of leaves per plant and initial flower buds opened, plant growth of lilies was more affected by lily types or vernalization periods individually. Optimal growth of plants was determined on *L*. 'Delina' and *L.* 'Renata'. The treatments induced more uniform performances, the higher number of flower buds, initiated and flowered in a shorter period less than 85 days after culture. The two lilies can be best alternative choices cultivated for poor farmers in increasing their lilium cut flower products instead of local Cipanas lilium using 6 weeks vernalization period of bulbs.

CONCLUSION

From the study it can be concluded that optimal growth performances of lilium were affected by types of lilium or genotype dependent and vernalization period. *L*. 'Delina' and *L.* 'Renata' and 6 weeks of vernalization under 4ºC were optimal types of lilium and vernalization period in producing optimal plant growth of it. The results were recommended to be applied by poor farmers in obtaining high quality and productivity products as best alternative choices compared to the previous lilium usually cultivated.

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