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Developmental response of hybrid lilies to bulb removal date

Asker H. M.

Floriculture Unit, University of Baghdad, Iraq.

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The effect of different bulb removal date on the development of underground organs particularly bulblets of four lily hybrids was investigated. Three treatments were used included the bulbs were not removed (control) or removed 6 and 8 weeks after planting .The test hybrids were "Royal show" (LA hybrids), "White heaven" (L. longiflorum hybrid), "Sorbonne" and "Premium blond" (Oriental hybrids).The results indicated that the development of underground organs of plant was greatly influenced by bulb removal. However, both 6, 8 weeks treatments significantly increased the bulblet production compared to control treatment, but 8 weeks treatment recorded the highest production. The six weeks treatment had stronger induced effect on the emerged shoots from bulblets. The hybrid lilies differed significantly for all observed traits. However, the "Royal show" cultivar recorded the highest values of bulblets number and weight. The "White heaven" cultivar showed the best capability of the shoots emergence from the bulblets and from the daughters which grown inside the mother bulbs. Both "Sorbonne" and "Premium blond" cultivars had more growth of stem roots, less bulblets, no emerged shoots, compared to other cultivars. All these observations suggest that the technique of bulb removal have a potential use to stimulate the plant to produce more bulblets and the tested hybrids of lilies showed significant differences in their capability for bulblets formation and in their response to bulb removal.

Key words: Hybrid lilies, underground organs, bulb removal date, bulblets.

INTRODUCTION

Lilies produce very attractive flowers with a wide range of colors, shapes therefore they make excellent cut flowers, and wonderful flowering potted plants and a great ornamental value for landscape purposes. However, the important groups of hybrid lilies for cut flower production are Asiatic hybrids, LA hybrids (they are a cross between *L. longiflorum* and Asiatic lily), oriental hybrids and longiflorium hybrids (*L. longiflorum*). These groups have many things in common but there are some differences between them; some related to their morphological, anatomical structures and developmental patterns, while others related to their growing and environmental conditions (Roh, 2011; Grassotti and Gimelli, 2011; van Tuyl et al., 2011).

Considerable studies related to geophytes were carried out to investigate the relationship between the bulb and plant development, and to understand the main changes in this relationship during different stages of plant development, these studies indicated that the bulb is important source which provide carbohydrate reserves for growth and development of the plant particularly in early stages, and the flowers are considered as major organ utilizes and consumes the carbohydrates which received from current photosynthesis and bulb scales (Addai and Scott, 2011a, b; Wu et al., 2012b). The recent study (Wu et al., 2012a) confirmed that the bulb is considered as a source, a combination of sink and source and finally as a sink dependently on the stages of plant development.

E-mail: hassan.asker2@gmail.com

Table 1. Effect of bulb removal date on the weight (g) of bulblets in hybrid lilies.

Time of bulb removal	Wt. of bulblets (g)		Cultivars		
Weeks after planting	**White heaven**	**Royal show**	**Sorbonne**	**Premium blond**	**Mean**
Control	7.42	15.56	4.09	0.00	6.77
Six	24.67	27.53	7.40	2.55	15.54
Eight	20.52	38.83	7.31	1.6	17.07
Mean	17.54	27.31	6.27	1.38	
	Times		2.32		
LSD	Cultivars		2.68		
	Interaction		4.65		

Multiple studies focused on bulblets (little bulbs) which were produce by most lilies around the bulb and on the stem just above the bulb during development, and nearly most parts of the lily plant have ability to produce bulblets during vegetative propagation such as bulb scales, leaves, and stem. Bulblets can be produced by micro-propagation technique (Ruffoni et al., 2011; Xiao et al., 2012), scaling technique (Park, 1996), and it can be increased by stimulating the plant during growing to produce more bulblets via carbohydrate remobilization by application of chemicals (Zheng et al., 2012) or by organ removal from plant (Asker, 2012; Leclerc et al., 2005). It is very useful to promote the plants to produce more bulblets for next growth season instead of producing one big bulb. The main objective of present study is to determine the optimum time to remove the bulb from plant during the development to stimulate the plant to produce more bulblets, and to determine the capability of four hybrid lilies for bulblets formation and to assess their response to bulb removal.

MATERIALS AND METHODS

This experiment was conducted in the nursery of Floriculture Unit, Baghdad University, Iraq in October 2012 to March 2013. Vernalized bulbs of four lily hybrids including "Royal show" represents LA hybrids group, "White heaven", represents L. longiflorum hybrid group , "Sorbonne" and "Premium blond" represent oriental hybrids group (10 to 14 cm in circumference) were imported from the Netherlands. The bulbs were planted inside the plastic house of the nursery in cultivation beds containing peat-moss (peat-moss was obtained from Estonia; type H2-4,) and contains N: P: K- 14:16:18 fertilizer, lime, with pH value of (5.9). Planting was at 7 cm depth with 20 (cm) apart to promote development of stem roots, and the irrigation was manually. To remove the bulb from the plant, the stem was cut off carefully above the nose of the bulb without any effect to stem roots. The plant was re-planted again immediately after the bulb was removed. The dates of bulb removal were 6 weeks and 8 weeks after planting. The control treatment consisted of plants whose bulbs were not removed. And the averages of stem lengths (cm) of plants were 34.8, 19.4, 36.3 and 38.3 (cm) after six weeks of planting and were 75.6, 44.8, 64.6 and 66.3 (cm) after eight weeks of planting for "Royal show", "White heaven", 'Premium blond " and "sorbonne" cultivars respectively.

After 18 weeks from planting, data of number and weight (g) of bulblets per plant, weight (g) of shoot of bulblet, shoot of daughter and stem roots per plant were collected. Data of bulb weight per plant after 0, 6, 8 and 18 weeks of planting were collected. This experiment was arranged in a completely randomized block design (CR-BD). The treatment consisted of three replicates, and each replication consisted of 8 bulbs. Data were subjected to analysis of variance using Statistical analysis system (SAS) program and the mean separation was performed using Duncan's multiple range test at the5% level of significance.

RESULTS

Bulblet

The results in Tables 1 and 2 and Figure 1 showed that the number and weight (g) of bulblets per plant were different as dependent on removal treatments and cultivars. It varied from 0.00 to 38.83 (g) (weight) and from 0.00 to 9.83 (number). However, they were significantly higher in removal treatments and lower in control treatment in all cultivars**,** but 8 weeks treatment recorded the highest production. Four hybrids of lilies showed significant differences in term of bulblets formation. However, the highest number and weight of bulblets were recorded in "Royal show" cultivar and the lowest were observed in "premium blond" cultivar.

Emerged bulblet shoot

The results in Table 3 and Figure 1 showed that the weight (g) of shoots emerged from bulblets per plant were different as dependent on removal treatments and cultivars. It varied from 0.00 to 4.29 (g). However, they were significantly higher in six weeks treatment compare to other treatments. The tested hybrids of lilies showed significant differences in the shoots emergence of bulblets and that the "White heaven" cultivar had significantly more emerged shoots compared to other cultivars.

Table 2. Effect of bulb removal date on the number of bulblets in hybrid lilies.

Time of bulb removal	No. of bulblets		Cultivars		
Weeks after planting	**White heaven**	**Royal show**	**Sorbonne**	**Premium blond**	**Mean**
Control	1.5	3.79	2.07	0.00	1.84
Six	5.75	5.75	5.33	2.33	4.79
Eight	6.37	9.83	6.75	1.91	6.22
Mean	4.54	6.46	4.72	1.41	
	Times	0.74			
LSD	Cultivars	0.86			
	Interaction	1.49			

- 1 - - 2 -

White heaven cultivar: 1. Control treatment 2. Bulb removal treatment

- 1 - - 2 - - 3 -

Royal show cultivar: 1. Control treatment 2, 3. Bulb removal treatments

- 1 - - 2 - - 3 -

Sorbonne cultivar: 1. Control treatment 2, 3. Bulb removal treatment

Figure 1. Different response of hybrid lilies to bulb removal treatments in related to the development of underground organs.

Table 3. Effect of bulb removal date on the weight (g) of emerged shoots from bulblets per plant in hybrid lilies.

Time of bulb removal	Wt. (g) of bulblets shoots		Cultivars		
Weeks after planting	**White heaven**	**Royal show**	**Sorbonne**	**Premium blond**	**Mean**
Control	1.29	0.00	0.00	0.00	0.32
Six	4.29	0.00	0.00	0.00	1.07
Eight	0.65	0.00	0.00	0.00	0.16
Mean	2.08	0.00	0.00	0.00	
	Times	0.60			
LSD	Cultivars	0.69			
	Interaction	1.20			

Table 4. The weight (g) of emerged shoots from daughters per plant of four hybrid lilies.

Cultivars	Wt. (g) of daughter shoots
White heaven	16.12
Royal show	0.00
Sorbonne	0.00
Premium blond	0.00
LSD	2.19

Emerged daughter shoot

The weight (g) of the emerged shoot from daughter per plant was different as dependent on cultivars (Table 4 and Figure 1). It varied from 0.00 to 16.12 (g). However; the "White heaven" cultivar showed the highest value of shoots weight which emerged from daughters of bulbs compared to other cultivars.

Stem roots

The weight of stem roots (g) per plant was different as dependent on removal treatments and cultivars (Table 5 and Figure 1). It varied from 0.00 to 26.37 (g) among the treatments. However, the plants of control treatment showed more stem roots compared to the plants of removal treatments. The weight of stem roots differed significantly among the tested hybrids of lilies. It was significantly higher in "Sorbonne" cultivar and lower in "White heaven" cultivar compared to other cultivars.

Bulb

The weight (g) of bulb per plant was different as dependent on growth stage and cultivars (Table 6). It varied from 18.26 to 83.74 g. However, it was significantly higher after 18 weeks of planting and lower after 6 and 8 weeks of planting compared to bulb weight before planting in all cultivars. Four hybrids of lilies showed significant differences in bulb weight after 18 weeks of planting and that the "Sorbonne" cultivar had larger bulb compare to others.

DISCUSSION

The results indicated that the development of underground organs of plant were greatly affected by bulb removal treatments and that probably due to removal of bulb resulting in loss of the major sink for carbohydrate and that caused the carbohydrates to remobilize and to accumulate into other underground organs, both 6, 8 weeks treatments significantly increased the bulblet production compared to control treatment, but 8 weeks treatment recorded the highest production, and that probably due to the plants of 6 weeks treatment and the plants of 8 weeks treatment were in different development stages when the bulbs were removed and it means that, they had different relationship of source – sink, because this relationship change during plant development (Addai and Scott, 2011a, b; Wu et al., 2012a, b). Six weeks treatment produced significantly more emerged shoots from bulblets compared to other treatments. The weight of bulb was lower after 6 and 8 weeks of planting but it was higher after 18 weeks of planting compared to bulb weight before planting and that probably due to the plants after 6, 8 weeks of planting were in stage (before

Table 5. Effect of bulb removal date on the weight (g) of stem roots in hybrid lilies.

Time of bulb removal	Wt. of stem roots (g)		Cultivars		
Weeks after planting	**White heaven**	**Royal show**	**Sorbonne**	**Premium blond**	**Mean**
Control	2.17	12.65	26.37	21.45	15.66
Six	0.43	1.62	0.00	0.75	0.70
Eight	0.59	3.78	9.65	5.60	4.91
Mean	1.06	6.02	12.01	9.27	
	Times	1.44			
LSD	Cultivars	1.67			
	Interaction	2.89			

Table 6. Effect of the period (weeks) after planting on the weight (g) of bulb in hybrid lilies.

Time of bulb removal	Wt. (g) of bulb		Cultivars		
Weeks after planting	**White heaven**	**Royal show**	**Sorbonne**	**Premium blond**	**Mean**
0	24.92	51.84	71.02	50.88	49.67
6	20.31	33.81	56.72	34.10	36.24
8	18.26	24.19	46.43	26.14	28.76
18	83.74	65.45	80.17	67.05	74.10
Mean	36.81	43.82	63.59	44.54	
	Times		3.73		
LSD	Cultivars		3.73		
	Interaction		7.47		

The mean separation was performed using Duncan's multiple range tests at the 5% level of significance.

anthesis) therefore the bulbs still provided carbohydrate reserves for development process while the plants after 18 weeks of planting were in stage (after anthesis) therefore the bulbs were a main sink to store the carbohydrate which received it from other organs (Wu et al., 2012a).

The results also indicated that the tested cultivars behaved differently in term of the development of underground organs and marked variations were observed among them in case of their response to removal treatments. However, the "Royal show" cultivar had more bulblets but with no shoots. The "White heaven" cultivar showed more emerged shoots from bulb daughter and from bulblets. The "sorbonne" and "premium blond " cultivars had less bulblets with no shoots, but more stem roots with larger bulbs which contain large daughters compared to other cultivars and that probably due to the plants of "sorbonne" and "premium blond " stored their carbohydrate reserves mainly into the bulb daughters and stem roots rather than into bulblets while the plants of "White heaven" and "Royal show" cultivars were greatly allocated their energy into the bulblets and shoots. It can be concluded that the development of underground organs of plant were greatly affected by bulb removal treatments, and bulb removal was effective method to induce the plant to produce more bulblets. The "royal show" cultivar showed better results in term of bulblets formation and the "white heaven" cultivar had significantly more emerged shoots from bulblets and from daughters, and both cultivars showed better response to bulb removal treatment in term of bulblets formation compared to other cultivars.

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