Influence of Storage Temperature, Storage Duration and Disbudding on Bulb Production in Asiatic Lilium cv. 'Royal Trinity'

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The main focus in lily cultivation has been on flowering attributes and bulb programming has not got a due attention Thus the experiment was carried out to investigate the effects of different storage temperatures and durations along with the two stages of disbudding on bulb development of Asiatic lilium at AICRP floriculture research unit Regional research station Wadura. (SKUAST-K). Freshly harvested bulbs were subjected to four storage temperatures (Ambient, 4^{0}C, 0^{0}C,-4^{0}C) three durations (2, 4 and 6 weeks) and plants were disbudded at first bud appearance and third bud appearance. Results of this Investigation revealed that bulbs stored under ambient conditions sprouted earliest (8.18days) with maximum height (57.60cm) and more leaves plant^{-1}(55.89) whereas earlier flower bud appearance (52.59 days) maximum number of bulbs(3.37), heaviest bulb(97.32g),maximum diameter(4.59cm),increased number of daughter bulbs(3.12) maximum diameter of daughter bulbs (1.36), maximum scale size(1.30cm) and efficient propagation coefficient(3.37) were observed at4^{0}C but number of scales per bulb was highest at -4^{0}C(14.82). Storage duration on other hand played a pivotal role in bulb production in lilium. Among three storage durations (2, 4 and 6 weeks).Earliest sprouting (8.03days) was observed under six week duration. Maximum plant height (67.84cm) with increased leaf number (72.74) was observed at two week duration. Similarly maximum number of bulbs(4.88),number of daughter bulbs(4.15),number of scales(15.97) and propagation coefficient(4.88) was observed at two week duration and heaviest bulb(102.83g),maximum diameter of bulb (4.89cm) and number of daughter bulb(1.58) along with scale size(1.46cm) were observed for six weeks. On the other hand stage of disbudding had a negative impact on plant height. Plant height was reduced in plants disbudded at first bud appearance (49.65cm) compared to non disbudded plants (62.42cm). Plants disbudded at first bud stage had least number of leaves (44.86) as compared to non disbudded plants (48.68). Plants disbudded after three bud appearance produced increased number of bulbs(3.46) with maximum bulb weight(120.13g) and diameter(5.87cm) as well as increased number of daughter bulbs (3.20 plant^{-1}). Disbudding after three bud appearance also significantly increased diameter of daughter bulbs (1.99cm) Scale size (1.92cm) and propagation coefficient (3.46) were also higher in plants disbudded after three bud appearances. However number of scales per bulb (18.93) was more in non disbudded plants.

Keywords: Lilium, Bulb production, storage temperature, storage duration and disbudding.

Lilium is one of the most handsome and popular ornamental bulbous plant belonging to the family Liliaceae. It is an herbaceous perennial having scaly bulb. Stems are unbranched, smooth or pubescent, usually bright green, sometimes tinged purple or brown and generally clothed with leaves. Lily bulbs have a solid basal plate that produces roots from its bottom and a concentric series of tight-to-loose, fleshy, overlapping scales

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of varying width from its top. In Kashmir valley, culture of Asiatic lilies for cut flower production has become popular among the flower growers during last 4–5 years. Most of the bulbs are imported from The Netherlands and planted in open field or under shade net during the summer and in unheated polyethylene houses for the September crop. Demand for lily bulbs is increasing every year (Wani et al., 2016) Cut flowers which are available during the normal season are plentiful, thus fetching a low price. Sometimes the farmers have to sell their produce even at a loss. In some cases, flowers which could not be sold are either left on the plants or are spoiled after being harvested. Thus, it would be beneficial for farmers to go for bulb programming to ensure sale of bulbs at any time of demand without any apprehension of loss even if bulbs remain unmarketable Many bulbs require a minimal period of low temperatures to enable root and shoot development (Le Nard and De Hertogh, 1983). If this period of cold is applied too early or for longer duration, aberrations like bud abortion in many bulbous plants are reported viz, lilium and tulip which occur after planting (DeMunk and Hoogeterp, 1975). The applied temperatures during the phase of enlargement affect the physiological state of the bulb at harvest. However, the temperatures in this period can hardly be controlled since it usually occurs outside on the field. The applied low temperatures are usually necessary to break the rest period or the so-called dormancy of flower bulbs, which is defined as the state of a healthy bulb, characterized by little or no external growth of the shoot and roots. On the other hand by getting plants disbudded more and more food material is translocated to the bulbs which improve the growth and development of bulbs.

MATERIAL AND METHODS

The present investigation was conducted during 2012 and 2013 at AICRP floriculture research unit Regional research station Wadura. (SKUAST-K) to study the effects of low temperature storage, duration and disbudding on flower and bulb production in Asiatic Lilium. The bulbs were lifted from experimental field of division of FLA SKUAST-K Shalimar Srinagar during December 2012.The bulbs were weighted individually at the beginning of storage, and were selected within the range of 30-35 g during 2012 and 2013 respectively. All the selected bulbs after proper cleaning were dusted with Bavistin 50% WP before storage. The 12 bulbs for each treatment were selected and put in to the punched polythene bags of one kg capacity containing partially moisten coco peat.

Storage chambers and freezers with temperature and humidity controlled automatically were employed for storage of bulbs at desirable temperatures and durations except for the lots of natural storage at room temperature. The relative humidity of the storage chambers were adjusted to the range between 70-80% throughout the storage period. The bulbs were stored according to storage durations. The 8 week duration lot was stored first in the month of February, 2012 followed by other lots according to storage period .Hence 1 week storage lots were stored at last. All the treatment lots were taken out at one time and were kept at room temperature for one week. The whole experimental material was then shifted to RRS Wadura and planted at the same date i.e. 14th of April 2012.The same procedure was repeated for the next year's experimental trial in 2013.

RESULTS AND DISCUSSION

Effects of storage temperature

The data on influence on low temperature storage, duration and disbudding on bulb production in Asiatic Lilium cv Royal Trinity is presented in the **Table** 1-7

It is generally assumed that storing bulbs at cold temperature (usually above 4 °C) triggers the increase of the promoters and/ or the decrease of inhibitors that result in rapid shoot emergence (Wang and Roberts, 1970).

The ability of plants to sprout was highly influenced by the storage temperature. In general the time required for sprouting decreased as the temperature regimes were increased. Earliest sprouting in days (8.18) was observed under ambient conditions where as highest number of days taken to sprouting was observed in -4^{0}C (10.33). The data presented here revealed that with the increase in the temperature regime the time taken by bulbs to sprout decreased and vice versa. . The results are in conformity with the findings of Dhiman (2005 who also reported that with the increase in temperature regimes, the time

Table 1. Effect of storage temperature on vegetative, floral and bulb characteristics in Asiatic Lilium cv Royal Trinity

Storage Temp (^{0}c)	Plant height (cm)	Number of leaves plant^{-1}	No of days to floral bud appearance	Number of bulbs/m^2	Weight bulb^{-1} (g)	Diameter of the bulb (cm)	No of daughter bulbs bulb^{-1}	Diameter of the daughter bulbs(cm)	No of scales bulb^{-1}	Scale size (cm)	Propagation coefficient
T_1 Ambient	57.60	55.89	54.58	3.25	93.77	4.40	3.02	1.27	14.48	1.25	3.25
T_2 -4	54.38	39.65	57.65	2.68	91.32	4.24	2.59	1.20	14.82	1.11	2.68
T_3 0	55.43	43.89	55.65	2.96	95.79	4.46	2.80	1.30	13.97	1.21	2.96
T_4 4	56.28	50.23	52.59	3.37	97.63	4.59	3.12	1.36	13.59	1.30	3.37
C.D ($p<0.05$)	0.163	0.408	0.176	0.076	0.272	0.048	0.068	0.047	0.086	0.053	0.076

Table 2. Effect of storage duration on vegetative, floral and bulb characteristics in Asiatic Lilium cv Royal Trinity

Storage Duration (weeks)	Plant height (cm)	Number of leaves plant^{-1}	No of days to floral bud appearance	Number of bulbs/m^2	Weight bulb^{-1} (g)	Diameter of the bulb (cm)	No of daughte r bulbs bulb^{-1}	Diameter of daughter bulbs(cm)	No of scales bulb^{-1}	Scale size (cm)	Propagation coefficient
2	67.84	72.74	61.06	4.88	86.72	3.98	4.15	1.03	15.97	0.99	4.88
4	51.95	42.00	54.36	2.90	94.33	4.40	2.91	1.24	14.14	1.20	2.90
6	47.97	27.51	49.92	1.42	102.83	4.89	1.59	1.58	12.52	1.46	1.42
C.D ($p<0.05$)	0.141	0.353	0.153	0.066	0.235	0.041	0.059	0.041	0.075	0.045	0.066

Table 3. Effect of disbudding on vegetative and bulb characteristics in Asiatic Lilium cv Royal Trinity

Treatment code	Plant height (cm)	Number of leaves $plant^{-1}$	Number of bulbs $/m^2$	Weight $bulb^{-1}$ (g)	Diameter of the bulb (cm)	No of daughter bulbs $bulb^{-1}$	Diameter of daughter bulbs(cm)	No of scales $bulb^{-1}$	Scale size (cm)	Propagation coefficient
D_0	62.42	48.67	2.53	64.80	3.15	2.43	0.59	18.93	0.55	2.53
D_1	49.64	44.86	3.46	120.13	5.87	3.19	1.99	9.40	1.92	3.46
D_2	55.70	47.50	3.21	98.95	4.25	3.02	1.23	14.31	1.18	3.21
C.D ($p<0.05$)	0.141	0.353	0.066	0.235	0.041	0.059	0.041	0.075	0.045	0.066

D_0= No disbudding $D_{1=}$ Disbudding at first bud appearance $D_{2=}$ Disbudding at third bud appearance

Table 4. Interactive effects of storage temperature and duration on vegetative and bulb characteristics in Asiatic Lilium cv. Royal Trinity

Treatment code	Days taken to bulb sprouting	Plant height (cm)	Number of leaves $plant^{-1}$	Days to appearance floral buds	Number of bulbs $/m^2$	Weight $bulb^{-1}$ (g)	Diameter of the bulb (cm)	No of daughter bulbs $bulb^{-1}$	Diameter of daughter bulbs(cm)	No of scales $bulb^{-1}$	Scale size (cm)	Propagation coefficient
T_1xS_1	10.16	69.54	89.08	60.20	5.10	85.72	4.01	4.27	1.03	16.31	1.09	5.10
T_1xS_2	8.80	53.46	48.38	53.50	3.11	93.69	4.35	3.04	1.24	14.38	1.18	3.11
T_1xS_3	5.60	49.80	30.21	50.06	1.56	101.91	4.86	1.75	1.56	12.76	1.48	1.56
T_2xS_1	13.50	66.22	53.87	64.90	4.46	83.34	3.79	3.89	0.94	16.71	0.88	4.46
T_2xS_2	10.41	50.51	40.16	57.46	2.38	91.85	4.24	2.65	1.13	14.74	1.08	2.38
T_2xS_3	7.10	46.42	24.92	50.60	1.20	98.77	4.70	1.24	1.54	13.01	1.39	1.20
T_3xS_1	12.41	67.34	67.60	61.86	4.78	87.95	4.02	4.05	1.07	15.58	0.93	4.78
T_3xS_2	9.83	51.44	37.40	55.00	2.80	95.27	4.45	2.82	1.27	13.92	1.25	2.80
T_3xS_3	6.30	47.53	26.69	50.09	1.32	104.17	4.93	1.53	1.57	12.41	1.45	1.32
T_4xS_1	10.30	68.28	80.40	57.31	5.19	89.88	4.13	4.39	1.08	15.30	1.08	5.19
T_4xS_3	8.90	52.41	42.08	51.50	3.33	96.52	4.57	3.13	1.33	13.55	1.29	3.33
T_4xS_3	6.23	48.16	28.22	48.96	1.60	106.49	5.07	1.85	1.67	11.93	1.55	1.60
$C.D_{(p<0.05)}$	0.248	0.283	0.707	0.306	0.132	0.471	0.083	0.118	NS	0.150	NS	0.132

Table 5. Interactive effects of storage temperature and disbudding on vegetative and bulb characteristics in Asiatic Lilium cv Royal Trinity

Treatment code	Plant height (cm)	Number of leaves $plant^{-1}$	Number of bulbs $/m^2$	Weight $bulb^{-1}$ (g)	Diameter of the bulb (cm)	No of daughter bulbs $bulb^{-1}$	Diameter of daughter bulbs(cm)	No of scales $bulb^{-1}$	Scale size (cm)	Propagation coefficient
T_1xD_0	64.44	58.44	2.64	64.74	3.14	2.51	0.62	19.33	0.63	2.64
T_2xD_0	60.18	39.93	2.39	60.33	3.02	2.27	0.49	19.68	0.43	2.39
T_3xD_0	61.52	45.00	2.51	66.24	3.16	2.38	0.61	18.58	0.53	2.51
T_4xD_0	63.56	51.33	2.60	67.90	3.29	2.60	0.66	18.15	0.62	2.60
T_1xD_1	51.10	53.40	3.72	119.22	5.81	3.39	1.99	9.59	1.92	3.72
T_2xD_1	48.40	36.38	2.91	118.59	5.62	2.81	1.86	9.94	1.79	2.91
T_3xD_1	49.74	41.63	3.30	120.52	5.95	3.08	2.03	9.20	1.94	3.30
T_4xD_1	49.36	48.05	3.92	122.21	6.09	3.52	2.11	8.87	2.04	3.92
T_1xD_2	57.26	55.84	3.40	97.37	4.26	3.16	1.22	14.53	1.21	3.40
T_2xD_2	54.57	37.78	2.78	95.03	4.09	2.71	1.15	14.83	1.13	2.78
T_3xD_2	55.06	45.07	3.09	100.63	4.28	2.95	1.27	14.13	1.15	3.09
T_4xD_2	55.93	51.33	3.60	102.79	4.39	3.25	1.30	13.76	1.26	3.60
$C.D_{(p<0.05)}$	NS	0.707	0.132	0.471	NS	NS	NS	0.150	0.091	0.132

Table 6. Interactive effects of storage duration and disbudding on vegetative and bulb characteristics in Asiatic Lilium cv Royal Trinity

Treatment code	Plant height (cm)	Number of leaves $plant^{-1}$	Number of bulbs $/m^2$	Weight $bulb^{-1}$ (g)	Diameter of the bulb (cm)	No of daughter bulbs $bulb^{-1}$	Diameter of daughter bulbs(cm)	No of scales $bulb^{-1}$	Scale size (cm)	Propagation coefficient
S_1xD_0	71.38	75.03	4.26	55.83	2.72	3.74	0.32	21.10	0.36	4.26
S_2xD_0	60.17	42.52	2.20	63.36	3.14	2.52	0.58	18.67	0.53	2.20
S_3xD_0	55.72	28.48	1.14	75.22	3.61	1.05	0.89	17.03	0.77	1.14
S_1xD_1	63.87	68.80	5.32	116.63	5.33	4.46	1.65	11.03	1.57	5.32
S_2xD_1	44.76	39.38	3.40	119.46	5.87	3.20	1.97	9.37	1.90	3.40
S_3xD_1	40.31	26.41	1.67	124.31	6.41	1.93	2.36	7.80	2.30	1.67
S_1xD_2	68.28	74.39	5.06	87.71	3.91	4.25	1.11	15.79	1.05	5.06
S_2xD_2	50.94	40.48	3.11	100.19	4.21	3.02	1.17	14.39	1.17	3.11
S_3xD_2	47.89	27.64	1.48	108.97	4.65	1.79	1.42	12.75	1.34	1.48
$C.D_{(p<0.05)}$	0.245	0.612	0.115	0.408	0.072	0.102	0.071	0.130	0.079	0.115

taken by lilium bulbs to sprout was significantly decreased. Ambient conditions recorded maximum plant height (57.60 cm) and number of leaves (55.89) which are once again in conformity with the findings of Dhiman (2005) and Lee & Roh (2001) who also reported maximum plant height and highest number of leaves under higher storage temperature regimes. Our observations suggest that plants with maximum height have depicted maximum foliage. The significant variation in this regard on days taken to appearance of first floral bud was recorded. The minimum days (52.59) to appearance of first floral bud was found on 4^0C which was lesser than other temperature regimes whereas maximum days (57.65) for appearance of first floral bud were found on -4^0C required

Table 7. Interactive effects of storage temperature, duration and disbudding on vegetative and bulb characteristics in Asiatic Lilium cv Royal Trinity

Treatment code	Plant height (cm)	Number of leaves plant^{-1}	Number of bulbs /m^2	Weight bulb^{-1} (g)	Diameter of the bulb (cm)	No of daughter bulbs bulb^{-1}	Diameter of daughter bulbs(cm)	No of scales bulb^{-1}	Scale size (cm)	Propagation coefficient
$T_1xS_1xD_o$	74.10	91.76	4.40	55.50	2.70	3.78	0.33	21.93	0.46	4.40
$T_1xS_2xD_0$	61.58	52.26	2.33	63.58	3.06	2.61	0.55	18.96	0.58	2.33
$T_1xS_3xD_0$	57.65	31.30	1.21	75.15	3.68	1.15	1.00	17.10	0.85	1.21
$T_2xS_1xD_o$	69.21	56.01	4.16	51.91	2.60	3.61	0.23	22.20	0.23	4.16
$T_2xS_2xD_o$	58.08	37.53	2.00	60.50	2.96	2.36	0.50	19.46	0.43	2.00
$T_2xS_3xD_o$	53.26	26.33	1.01	68.58	3.50	0.85	0.75	17.40	0.65	1.01
$T_3xS_1xD_o$	69.53	69.76	4.20	56.91	2.73	3.70	0.33	20.20	0.30	4.20
$T_3xS_2xD_o$	59.98	37.81	2.20	64.16	3.21	2.48	0.65	18.53	0.56	2.20
$T_3xS_3xD_o$	55.06	27.43	1.15	77.65	3.55	0.96	0.85	17.03	0.75	1.15
$T_4xS_1xD_o$	72.71	82.61	4.30	59.00	2.85	3.90	0.41	20.10	0.45	4.30
$T_4xS_2xD_o$	61.05	42.51	2.30	65.20	3.33	2.65	0.63	17.76	0.56	2.30
$T_4xS_3xD_o$	56.93	28.88	1.20	79.50	3.71	1.26	0.96	16.60	0.86	1.20
$T_1S_1xD_1$	65.03	87.00	5.60	115.91	5.35	4.63	1.70	11.20	1.65	5.60
$T_1S_2xD_1$	46.10	45.03	3.70	118.75	5.80	3.40	1.93	9.59	1.86	3.70
$T_1S_3xD_1$	42.18	28.18	1.88	123.0	6.30	2.15	2.35	8.00	2.25	1.88
$T_2S_1xD_1$	62.38	50.21	4.63	11496	5.03	4.08	1.55	11.53	1.46	4.63
$T_2S_2xD_1$	43.78	35.10	2.70	119.53	5.70	2.88	1.85	9.90	1.76	2.70
$T_2S_3xD_1$	39.05	23.83	1.40	121.30	6.15	1.48	2.18	8.40	2.16	1.40
$T_3S_1xD_1$	64.60	61.30	5.20	116.91	5.38	4.31	1.65	11.00	1.53	5.20
$T_3S_2xD_1$	44.51	37.76	3.20	119.61	5.96	3.05	2.01	9.10	1.96	3.20
$T_3S_3xD_1$	40.11	25.83	1.50	125.06	6.53	1.88	2.43	7.50	2.35	1.50
$T_4S_1xD_1$	63.50	76.70	5.88	118.76	5.56	4.85	1.73	10.40	1.65	5.88
$T_4S_2xD_1$	44.65	39.66	4.00	119.96	6.05	3.48	2.11	8.90	2.03	4.00
$T_4S_3xD_1$	39.93	27.80	1.90	127.91	6.66	2.23	2.50	7.31	2.45	1.90
$T_1S_1xD_2$	69.51	88.50	5.30	85.76	3.98	4.41	1.06	15.80	1.16	5.30
$T_1S_2xD_2$	52.70	47.86	3.30	98.76	4.21	3.13	1.25	14.60	1.11	3.30
$T_1S_3xD_2$	49.58	31.16	1.60	107.6	4.61	1.96	1.35	13.20	1.36	1.60
$T_2S_1D_2$	67.08	55.40	4.60	83.15	3.75	4.00	1.05	16.40	0.95	4.60
$T_2S_2D_2$	49.68	33.36	2.46	95.53	4.08	2.73	1.06	14.86	1.06	2.46
$T_2S_3D_2$	46.95	24.60	1.30	106.43	4.45	1.40	1.35	13.23	1.38	1.30
$T_3S_1D_2$	67.91	71.76	4.96	90.05	3.95	4.16	1.23	15.56	0.96	4.96
$T_3S_2D_2$	49.85	36.63	3.00	102.06	4.20	2.95	1.15	14.13	1.25	3.00
$T_3S_3D_2$	47.43	26.83	1.33	109.80	4.71	1.75	1.45	12.70	1.26	1.33
$T_4S_1D_2$	68.63	81.90	5.40	91.88	3.98	4.43	1.11	15.40	1.16	5.40
$T_4S_2D_2$	51.55	44.09	3.70	104.41	4.35	3.28	1.25	14.00	1.28	3.70
$T_4S_3D_2$	47.63	28.00	1.70	112.08	4.85	2.06	1.55	11.90	1.36	1.70
$C.D_{(p<0.05)}$	0.490	1.225	NS	0.816	NS	NS	NS	NS	NS	NS

for late appearance of floral bud. All the bulb characteristics clearly reflected the same influence of the storage temperatures except number of scales per bulb (Table 1) but there was no significant difference in the number of bulbs and propagation coefficient. All the bulb characteristics attained maximum value at 4^0C except number of scales per bulb which were maximum at-4^0C this is because of the fact that bigger is the bulb lesser number of scales are produced in it and vice versa. It should be understood that the action of the storage temperatures is similar one on every bulb characteristic.

Effects of storage duration

Bulbous crops can develop dormancy to survive long periods of unfavorable conditions during the life cycle. Growth and development are temporarily suspended during the dormant period (Lang *et al*., 1985). Environmental conditions during the dormancy period trigger the developmental processes leading to dormancy breaking (Bewley, 1997). Growth is resumed when the conditions become favorable (Rees, 1992). The physical environment exerts a marked influence on dormancy, which is usually broken by a period of cold treatment, depending on plant species. Not only storage at low temperatures but also long storage durations at low temperatures can lead to successful flower regulation. Abscisic acid concentration in the scales of *Lilium* bulbs decreased as storage duration extended, and it declined to a constant low level after bulbs had been stored for 10 weeks at 4°C. This result indicates that the decrease in the endogenous ABA concentration during bulb storage is related to dormancy release of *Lilium bulbs* (Rong-Yan Xu, 2007) .

In general, the time required for bulb sprouting decreased as the duration of storage increased. Earliest sprouting (8.03) was recorded when bulbs were stored for six weeks duration. Similar results have been reported by several workers *viz.,* Dhiman (2005) and Lee *et al.* (1996) who also reported that time, required for bulb sprouting decreased as the storage duration was increased. However, the bulb sprouting percentage was hundred percent among all the storage durations.

Increasing the periods of storage duration decreased the plant height and leaf count. John *et al.* (1994), Dhiman (2005) also reported similar results and reported that with the increase in storage duration the plant height and number of leaves per plant significantly decreased. ln various bulbous crops like tulip and Lilium.

The physiological and biochemical processes causing viability loss during storage are rather unknown for lily bulbs. Therefore, loss of carbohydrates is not likely to be a limiting factor during storage of lily bulbs under conditions of minimal growth. In this experiment the number of bulbs per plant, number of daughter bulbs per bulb, number of scales per bulb and propagation coefficient showed a decreasing trend with increase in storage duration and were maximum at two week duration against six week duration whereas weight of bulbs, diameter of bulb and daughter bulb along with scale size were maximum at six week duration. This may be because of fact that Ion leakage of outer scales increased with storage duration and it was accompanied by a decrease in the ability of scales to form new bulblets. With inner and middle scales, the increase in ion leakage and the loss of the regeneration percent was limited. Since the effects of storage duration was most significant with outer scales. The faster decline of viability of outer scales compared to inner and middle scales was also found by Matsuo and Arisumi (1978) after storage of *L. longiflorum* bulbs. There may be several causes for this effect. First, outer scales are formed prior to the middle and inner scales and are therefore older. Second, outer scales are more exposed to environmental conditions and microorganisms. Our results are in conformity with the results of Matsuo and Arisumi (1978) and Bonnier *et al.* (2000).

Effects of disbudding

Disbudding has been employed as an effective tool for improvement in bulb production in many ornamentals including lilies (Wang and Breen, 1986; Hemphill *et al*., 1987; Dantuluri and Mishra, 2002)

In bulbous plants like lily the development of flowers and the later part of the stem growth is more dependent on current photosynthesis than on bulb reserves. The later are mainly utilized for initial growth, root and leaf formation. This means there are two competing sinks for photosynthesis i.e, the reproductive structures and growing bulbs. Elimination of floral sink potentially increases translocation of photosnthetes to growing daughter bulbs. But all this would be in vain if stage of disbudding is not ascertained to translocate these photosnthetes to daughter bulbs at proper stage for timely action. Therefore a part of this experiment was to study the effect of disbudding at first bud appearance and three bud appearances respectively.

Data revealed a significant decrease in mean plant height of disbudded plants with respect to stage of disbudding as compared to non-disbudded plants. Minimum plant height (49.65 cm) was observed in plants which were disbudded after first bud appearance followed by plants disbudded at three bud appearance(55.70) compared to plants which were not disbudded(62.44).There was a significant reduction in mean number of leaves after disbudding in comparison to non-disbudding. Same results were obtained by Masoodi and sidiquee (2001) where reduction in plant height and leaf count was recorded in plants which were disbudded. The present investigation are in agreement with various workers viz. Kruijer(1982a), Tungwang and Patrick(1986) who reported shorter crop after disbudding and inhibition of stem elongation respectively.

There was a significant and positive effect of not only disbudding but also stage of disbudding on the growth and development of underground bulb structures. Mean number of bulbs plant^{-1} (3.46) in plants disbudded at first bud appearance was significantly higher than plants disbudded at third bud appearance (3.21) and non-disbudded plants (2.53). Similarly weight(120.13g) and diameter of bulbs(5.87cm), number of daughter bulbs(3.19) diameter of daughter bulbs(1.99cm), size of scales(1.92cm**)** and propagation coefficient(3.46) were maximum in plants disbudded at first bud appearance as compared to plants which were disbudded at third bud appearance and plants which were allowed to grow without getting disbudded. The increase in weight and diameter of bulbs, number and diameter of daughter bulbs, size of scales is obviously a result of more resource allocation to the underground sinks which could have otherwise been used by developing flowers (Wang, 1984). On the other hand the number of scales per bulb had different results and maximum number of scales (18.93) was found in non-disbudded plants than plants disbudded at first and three bud appearance. This is because of the fact that smaller is the bulb more and small scales are produced in it.

The results are in agreement with those obtained in Asiatic hybrid cultivars (Hemphill *et al*., 1987; Dantuluri and Mishra, 2002) who reported a significant improvement in bulb size, bulb weight and number of daughter bulbs produced as a result of disbudding irrespective of stage of disbudding in cultivars like campfire, Debutante, Impact, Monn fire, Snowcap and Carrida .Increase in bulb size as a result of flower bud removal was also reported in tulip by John and Khan (2003) and in Asiatic lilium hybrids by Wani *et al.,* 2015.

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