Research Article

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Bulb preservation influenced by various temperature and media on flower and bulb production in Lilium (*Lilium* spp.)

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ABSTRACT

The experiment was conducted with three levels each of storage temperature (2.1-2.5^{0}c, 6.5-7.5^{0}c and 8.0-10°c) and preservation media (sawdust, cocodust and combination of both in equal quantities) from June 2019 to May 2020 at Floriculture Division, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh, to find out the optimum storage temperature and suitable media for Lilium (*Lilium* spp.) bulb preservation and also to see their effect on flower and bulb production in the next flowering season. The bulbs under cool temperature (2.1-2.5^{0}c) with sawdust produced minimum sprout (22.0%), shorter root (3.25cm) and shoot (0.55cm) and gained the minimum weight 30, 60, 90 and 120 days after storage (1.42, 2.35, 3.07 and 3.20%, respectively) which ultimately protected bulbs from deterioration during storage period. The two other temperature (6.5-7.5^{0}c and 8.0-10.0^{0}c) including all media produced 100% sprouting and poor performance in other parameters. Though non-significant variations were recorded in flower, bulb and bulblet production from bulbs kept in storage in relation to combination of temperature and media but bulbs preserved in various media at cool temperature (2.1^{0}c-2.5^{0}c) showed better performances on growth, flowering, bulb and bulblet production in next flowering season.

Key words: Bulb preservation, Temperature, Media, Flower, and Bulb production

Lilium *(Lilium* spp.*)* is a high demanded cut flower in world flower market (Lucidos *et al*., 2013). To meet its local demand, its flowers are imported (Khan and Ambia, 2018). Considering its market demand, farmers in Bangladesh are very much interested in its cultivation. Bulb preservation is an important issue for commercial cultivation. Shin *et al*. (2002) showed that low temperature is necessary for sprouting of bulbs after harvesting. Vernalization is affected by combination of temperature and duration of storing period (Le Nard and De Hertogh, 1993). According to Boontjes (1983) and Beattie and White (1993), bulbs of Asiatic hybrids, Oriental hybrids and *L. longiflorum* are stored in moist peat at -2 °C for year-round forcing. Maddah *et al*. (2012) showed that after 10 weeks of vernalization most of bulbs were stimulated. But in Bangladesh climatic condition, 10 weeks are not sufficient to keep its bulbs in storage. Besides, a certain level of postharvest rots of lilium bulbs occurred due to its perishable nature. Moist cocodust is being used widely for lilium bulb preservation (Malik, 2017). Therefore, an experiment was conducted to standardize optimum storage temperature and suitable preservation media for its bulb preservation and also to see effect of storage temperature and preservation media on flower and bulb production in the next flowering season.

MATERIALS AND METHODS

The experiment was conducted at Bangladesh Agricultural Development Corporation (BADC) cold storage of Kashimpur, Postharvest Division's cool room of Bangladesh Agricultural Research Institute (BARI) and Constant temperature and humidity chamber of Horticulture Research Centre (HRC), BARI, Gazipur, during June 2019 to October 2019 to see the behaviour of bulbs in storage. Later on, experiment was continued at Floriculture Research Field, HRC, BARI during November 2019 to May 2020 to observe its flowers, bulbs and bulblet production from stored bulbs. The bulbs of BARI Lilium-1 (Asiatic group and flower creamy white in colour) were used.

There were two factors, viz. storage temperature @ 2.1-2.5^{0}c, 6.5-7.5^{0}c and 8.0-10°c considered as one factor and preservation media like sawdust (100%),

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cocodust (100%), and sawdust+cocodust (50:50) were considered as another factor. The bulbs were kept in plastic crate at cold storage at per treatments in June 2019. Various growth parameters of lilium bulbs during storage period were recorded. After completion of storage period, bulbs were planted in November 2019 under shade net. In field, unit plot size was 1.2 m × 1.50 m and spacing was maintained at 15cm × 15cm. No chemical fertilizer up to 3 weeks of bulb planting was applied.

After 3 weeks of bulb planting, NPK@30:20:20g/m^2 was applied. Urea and MoP @ 100kg/ha were topdressed before spike initiation stage and bulb lifting, respectively. Cultural practices, weeding and watering were done as per the requirement. Mulching with straw was done when temperature got high. Netting (GI wire and nylon thread) was given to support the plants. The plants were protected from birds and other harmful animals using net made of nylon threads. Carbendazim (Autostin) was sprayed @ 1g/L of water at 15 days interval starting from 20 days after planting to protect the plants from botrytis blight disease. Simultaneously, neem oil and Biomax (1 ml/L) were used to protect from aphids and beetles. The flower spikes were harvested when lower most buds showed colour.

During flower harvesting, plants were kept leaving 25-30cm stem in field for bulb development. When leaves were brown and more or less damaged bulbs were lifted carefully and stored at 2.1-2.5^{0}c temperature for next planting. Various quantitative data regarding flower, bulb and bulblet production were recorded from ten randomly selected plants from each unit plot. The CRD factorial was followed for storage experiment and RCB factorial design was followed for field experiment. The data were analyzed statistically by using R software to find out the variation among different treatments. Treatment means were compared by LSD (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of temperature and media on growth

During storage period bulbs growth was significantly influenced by various storage temperature and media (Table 1). Cool temperature (2.1-2.5^{0}c) showed significantly less sprout initiation

Table 1: Effect of storage temperature and media on growth of bulbs during storage

Treatment	Sprout initiation (%)	Root number/bulb	Average root length (cm)	Average shoot length (cm)
	Temperature			
2.1-2.5^{0}c (T_1)	65.0 b (51.83)	9.55 c	4.0 c	0.58 c
6.5-7.5^{0}c (T_2)	100.0 a (86.04)	12.98 b	11.75 b	10.20 b
8.0-10.0^{0}c (T_3)	100.0 a (86.04)	15.0 a	16.45 a	13.10 a
Level of significance	**	*	**	**
	Media			
Sawdust (M_1)	72.0 c (56.0)	12.83 a	7.75 c	5.78 c
Cocodust (M_2)	98.50 a (80.04)	11.52 b	13.83 a	10.24 a
50% sawdust+50% cocodust (M_3)	90.0 b (69.04)	12.12 ab	10.38 b	7.80 b
Level of significance	**	*	**	**
CV(%)	4.48	6.20	13.0	11.12

Figures in parentheses are transformed value

Means with the same letter(s) are not significantly different

** significant at 1%; * significant at 5%

(65.0%), minimum number of roots/bulb (9.55) and shortest root and shoot (4.0 and 0.58cm, respectively). The higher temperature (8.0-10.0^{0}c) showed poor performances. As per Yu-Fang and Qiu-Rong (2016), low temperature storage can keep the activity of related enzymes to delay senescence and browning thus sprouting will be less. The starch contents decreased continuously in interior and exterior scales, while contents of total soluble carbohydrates and reducing sugar increased at low temperature. But due to low respiration rate, there was a minimal consumption of carbohydrates.

Considering preservation media, sawdust showed lower number of sprout initiation (72.0%), shorter root (7.75cm) and shoot (5.78cm). Though sawdust produced maximum number of roots/bulb (12.83), followed by mixture of sawdust and cocodust (12.12) but overall good performances was shown by sawdust. Finley (2021) showed that bulbs should be stored in container with peat moss, sawdust or vermiculite which supported our study. Beattie and White (1993) used moist cocodust as preservation media for bulbs storing at -2 °C for year-round forcing.

Combined effect of temperature and media

Combined effect of temperature and media showed significant variations on all the parameters during storage period except roots/bulb (Table 2). The cool temperature (2.1-2.5^{0}c) with sawdust produced minimum sprouts (22.0%), shorter root (3.25cm) and shoot (0.55cm). At temperature (6.5-7.5^{0}c and 8.0-10.0^{0}c) including all media produced 100% sprouting. The bulbs under high temperature (8.0-10.0^{0}c) with cocodust produced longest root (21.0) and shoot (16.85cm).

Effect of temperature and media on weight of bulbs

Changes in bulb weight (%) at various days after

Table 2: Combined effect of temperature and media on growth of bulbs during storage

Treatment	Sprout initiation (%)	Roots number/bulb	Average root length (cm)	Average shoot length (cm)
T_1 M_1	22.0 c (26.98)	10.12 cd	3.25 c	0.55 d
T_1 M_2	96.20. a (75.98)	9.47 d	5.43 c	0.77 d
T_1 M_3	78.0 b (59.84)	9.65 d	3.67 c	0.58 d
T_2 M_1	100.0 a (86.04)	13.0 b	6.40 c	7.48 c
T_2 M_2	100.0 a (86.04)	12.15bc	15.45 b	12.67 b
T_2 M_3	100.0 a (86.04)	12.80 b	12.45 b	9.68 c
T_3 M_1	100.0 a (86.04)	15.75 a	13.65 b	9.60 c
T_3 M_2	100.0 a (86.04)	13.51 ab	21.0 a	16.85 a
T_3 M_3	100.0 a (86.04)	14.18 ab	15.21 b	13.0 b
Level of significance	**	NS	**	**
CV(%)	4.48	6.20	13.0	11.12

Figures in parentheses are transformed value

Means with the same letter(s) are not significantly different

** significant at 1%; NS, non-significant

Where, T_1, 2.1-2.5^{0}c M_1, sawdust (100%)

T_2, 6.5-7.5^{0}c M_2, cocodust (100%)

T_3, 8.0-10.0^{0}c M_3, sawdust+cocodust (50:50)

storage were significantly influenced by various temperatures (Fig. 1). At 30 Days after storage (DAS), the minimum weight (3.02%) was gained at 2.1-2.5^{0}c which gradually increased 8.89% up to 120 DAS. Whereas, high temperature (8.0-10.0^{0}c) showed 10.25% increase in bulb weight at initial stage (30 DAS) which turned 23.80% at storage ending period (120 DAS). The sawdust significantly showed less increase in bulb weight at 30, 60, 90 and 120 DAS (3.45%, 4.78%, 6.31% & 9.32%, respectively) (Fig. 2). In contrast, the bulbs preserved by cocodust gained significantly higher weight at various storage periods (9.37%, 12.36%, 17.33% & 26.81%, respectively).

Combined effect of temperature and media

Changes in bulb weight (%) at various storage dates were significantly influenced due to combined effect of temperature and media (Table 3). The bulbs with sawdust preserved at low temperature (2.1-2.5^{0}c) gained minimum weight during storage period (1.42%, 2.35%, 3.07% and 3.20%, respectively) which ultimately protected bulbs from deterioration. Maddah *et al*. (2012) reported that vernalization temperature of 3°C has preferred to 9°C for *Lilium ledebourii's* bulb preservation because at 9°C starch hydrolyzed and soluble sugar consumption were decreased. The consumption rate of sugar stored in plant storage organs slows down by lowering their respiration (Salisbury and Ross 1992). Whereas bulbs at high temperature (8.0-10.0^{0}c) with cocodust gained maximum weight 30, 60, 90, and 120 DAS (17.58, 22.73, 26.06 and 36.07%, respectively) which may be due to higher sprout initiation, longer root and shoot produced during entire storage period.

Effect of temperature and media on growth and flower from stored bulbs

The growth and flower production showed significant variation at various temperatures except emergence (%) (Table 4). Significantly longer plant (62.50 cm), spike (82.10cm) and rachis (29.35cm), maximum number of florets (6.75) and also larger floret (16.45cm) were recorded from bulbs kept at 2.1-2.5 °c during storage.

The bulbs preserved with various media did not show significant differences on growth and flower production except spike length (Table 4). The longest spike (67.90 cm) was produced by bulbs preserved in sawdust media followed by 50%sawdust+50%cocodust (65.50cm).

Combined effect of temperature and media

Non-significant variations were recorded in flower production from bulbs kept in storage in relation to combination of temperature and media (Table 5). But bulbs preserved in various media at cool temperature (2.1^{0}c-2.5^{0}c) showed better performance for growth and flowering parameters.

Effect of temperature and media on bulb and bulblet production from stored bulbs

All the parameters of bulb and bulblet production were significantly influenced by bulbs preserved at various temperatures during storage (Table 6). Bulbs preserved in cold storage (2.1-2.5^{0}c) produced significantly higher number of bulbs/plant

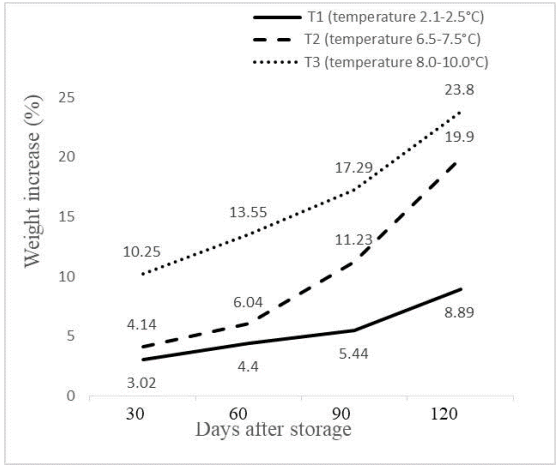

Fig.1. Increase in bulb weight (%) influenced by various temperature during storage period where, T_1, 2.1-2.5^{0}c T_2, 6.5-7.5^{0}c, T_3, 8.0-10.0^{0}c

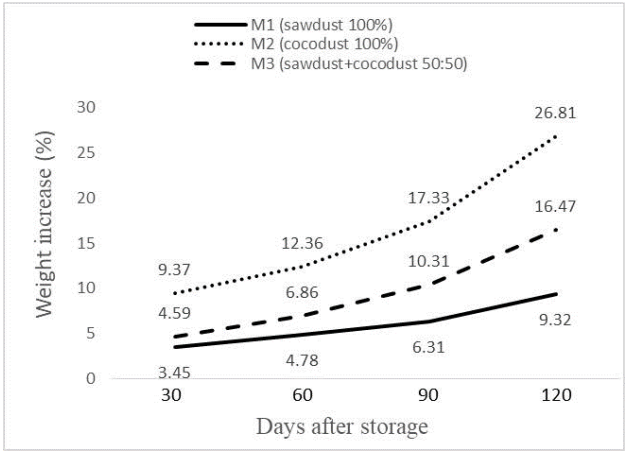

Fig. 2. Increase in weight of bulb (%) influenced by various media during storage period where, M1, sawdust (100%) M, cocodust (100%) M, sawdust+cocodust (50:50)

Table 3: Combined effect of temperature and media on changes of weight of lilium bulbs during storage period

Treatment	Changes of weight (%)			
	30 DAS	60 DAS	90 DAS	120 DAS
$T_1 M_1$	1.42 d	2.35 e	3.07 e	3.20 f
	(1.12)	(1.53)	(1.73)	(9.81)
$T_1 M_2$	4.99 bc	6.65 bcd	8.31 cd	14.07 cd
	(2.23)	(2.58)	(2.88)	(21.25)
$T_1 M_3$	2.65 cd	4.21cde	4.94 de	9.41e
	(1.62)	(2.04)	(2.2)	(17.22)
$T_2 M_1$	3.10 bcd	4.14 de	5.07 de	11.92 de
	(1.73)	(2.02)	(2.24)	(19.47)
$T_2 M_2$	5.53 bc	7.71bcd	17.61 ab	30.30 a
	(2.34)	(2.76)	(4.18)	(32.18)
$T_2 M_3$	3.79 bcd	6.29 bcd	10.99 bc	17.48 bc
	(1.92)	(2.50)	(3.31)	(23.82)
$T_3 M_1$	5.85 bc	7.85 bc	10.79 bc	12.83 cde
	(2.40)	(2.80)	(3.28)	(20.23)
$T_3 M_2$	17.58 a	22.73 a	26.06 a	36.07 a
	(4.18)	(4.75)	(5.09)	(35.59)
$T_3 M_3$	7.33 b	10.08 b	15.0 b	22.51b
	(2.69)	(3.17)	(3.87)	(27.32)
Level of significance	*	**	*	*
CV(%)	14.96	9.90	10.56	5.79

Figures in parentheses are transformed value

Means with the same letter(s) are not significantly different

**, significant at 1%; *, significant at 5%

where, T1, 2.1-2.50c M1, sawdust (100%)

T2, 6.5-7.50c M2, cocodust (100%)

T3, 8.0-10.00c M3, sawdust+cocodust (50:50)

Table 4: Performance of flower production of lilium from bulbs kept in storage in relation to the temperature and media

Treatment	Emergence (%)	Plant height (cm)	Spike length (cm)	Rachis length (cm)	Florets/ spike	Floret diameter (cm)
			Temperature			
2.1-2.5^{0}c (T_1)	100.0 (9.99)	62.50 a	82.10 a	29.35 a	6.75 a	16.45 a
6.5-7.5^{0}c (T_2)	96.66 (9.89)	53.75 b	58.25 b	18.29 b	2.42 b	16.10 ab
8.0-10.0^{0}c (T_3)	98.32 (9.83)	51.30 b	55.0 b	18.10 b	2.37 b	15.77 b
Level of significance	NS	**	**	**	**	*
			Media			
Sawdust (M_1)	99.43 (9.97)	58.0	67.90 a	23.66	4.50	16.33
Cocodust (M_2)	96.66 (9.83)	54.56	63.830b	21.89	3.46	15.86
50% Sawdust+50% Cocodust (M_3)	98.32 (9.91)	56.30	65.50 ab	22.68	3.86	15.98
Level of significance	NS	NS	*	NS	NS	NS
CV(%)	1.44	5.88	4.50	7.57	24.50	2.96

Figures in parentheses are transformed value

Means with the same letter(s) are not significantly different

**, significant at 1%; *, significant at 5% ; NS, non-significant

Table 5: Performance of flower production of bulbs kept in storage in relation to combination of temperature and media

Treatment	Emergence (%)	Plant height (cm)	Spike length (cm)	Rachis length (cm)	Florets/ spike	Floret diameter (cm)
T_1 M_1	100.0 (9.99)	63.50	84.0	30.73	7.20	16.84
T_1 M_2	100.0 (9.99)	60.0	79.77	28.67	5.95	16.21
T_1 M_3	100.0 (9.99)	62.68	82.53	29.50	6.87	16.35
T_2 M_1	100.0 (9.99)	56.33	61.0	18.90	2.75	16.15
T_2 M_2	94.99 (9.74)	52.58	55.52	17.80	2.36	15.88
T_2 M_3	98.32 (9.91)	53.60	57.31	18.43	2.49	16.13
T_3 M_1	98.32 (9.91)	52.67	55.57	18.69	2.61	15.97
T_3 M_2	94.99 (9.74)	48.45	54.31	17.87	2.24	15.55
T_3 M_3	96.66 (9.83)	51.33	54.65	18.50	2.41	15.62
Level of significant	NS	NS	NS	NS	NS	NS
CV(%)	1.44	5.88	4.50	7.57	24.50	2.96

Figures in parentheses are transformed value

Means with the same letter(s) are not significantly different

NS, non-significant

Where, T_1, 2.1-2.50c M_1, sawdust (100%)

T_2, 6.5-7.50c M_2, cocodust (100%)

T_3, 8.0-10.00c M_3, sawdust+cocodust (50:50)

(1.98), heaviest and largest bulbs (29.94g and 4.93cm, respectively) and maximum number and weight of bulblets/plant (2.45 and 2.79g, respectively). Tang *et al*. (2021) showed that soluble sugar content of bulblets at 2 and 5^0c was significantly more than that of the control and 10^0c -treated bulblets. The lower the temperature, the faster the conversion of soluble sugars, and greater the soluble sugar content. Very minimum percentage of botrytis blight disease (only 1.0%) occurred in plants produced by bulbs preserved at 2.1-2.5^{0}c, while 26.45% and 78.95% disease occurred in plants from bulbs preserved in storage temperature of 6.5-7.5^{0}c and 8.0-10.0^{0}c, respectively.

Bulbs preserved in various media showed significant influence on single bulb weight and bulblet weight/plant (Table 6). Bulbs preserved in sawdust produced heaviest bulbs and bulblets/plant (29.0g and 2.69g, respectively)

Combined effect of temperature and media on bulb and bulblet production

Non-significant variations were recorded by the combination of temperature and media during bulb preservation at storage on bulbs and bulblet production in the next season (Table 7). But bulbs preserved at cool temperature (2.1-2.5^{0}c) with various storing showed better performances on all parameters of bulb and bulblet production.

CONCLUSION

The cool temperature (2.1-2.5^{0}c) with sawdust media showed better performances for bulbs preservation. For producing flower, bulb and bulblet production in next flowering season from bulbs kept at storage, cool temperature (2.1-2.5^{0}c) performed very well. As preservative media did not show any

Table 6: Performance of bulb production of flowers from stored bulb in relation to temperature and media

Treatment	Bulbs/ plant	Single bulb weight (g)	Bulb diameter (cm)	Bulblet number/ plant	Bulblet weight/ plant	Disease incidence (%)
Temperature						
2.1-2.5^{0}c (T_1)	1.98 a	29.94 a	4.93 a	2.45 a	2.79 a	1.0 c (4.86)
6.5-7.5^{0}c (T_2)	0.96 b	26.30 b	4.48 b	1.96 b	2.14 b	26.45 b (29.82)
8.0-10.0^{0}c (T_3)	0.92 b	23.83 c	4.27 b	1.85 b	2.09 b	78.95 a (60.97)
Level of significance	**	**	**	**	**	**
Media						
Sawdust (M_1)	1.38	28.56 a	4.71	2.22	2.59 a	32.82 (29.85)
Cocodust (M_2)	1.22	25.19 b	4.27	1.84	2.04 b	38.82 (34.60)
50% sawdust+50% cocodust (M_3)	1.28	26.15 b	4.50	2.10	2.26 ab	34.77 (31.20)
Level of significance	NS	**	NS	NS	*	NS
CV(%)	15.07	5.5	8.0	14.50	16.21	12.53

Figures in parentheses are transformed value
Means with the same letter(s) are not significantly different
**, significant at 1%; *, significant at 5%
NS, Non-significant

Table 7: Performance of bulb production of lilium flower from bulb kept in storage in relation to the combination of temperature and media

Treatment	Bulbs/ plant	Bulb weight (g)	Bulb diameter (cm)	Bulblet number/ plant	Bulblet weight/ plant	Disease incidence (%)
T_1 M_1	2.09	33.69	5.19	2.52	3.04	0.0 (3.91)
T_1 M_2	1.87	27.71	4.71	2.33	2.50	2.0 (6.76)
T_1 M_3	1.97	28.33	4.81	2.40	2.74	0.0 (3.91)
T_2 M_1	1.05	26.82	4.43	2.03	2.23	25.74 (29.37)
T_2 M_2	0.90	25.07	4.22	1.80	1.93	27.78 (30.62)
T_2 M_3	0.97	26.72	4.37	1.98	2.08	25.83 (29.46)
T_3 M_1	1.0	25.17	4.52	2.10	2.50	72.22 (56.26)
T_3 M_2	0.88	22.78	3.87	1.39	1.70	86.67 (66.42)
T_3 M_3	0.92	23.41	4.32	1.94	1.95	77.96 (60.24)
Level of significance	NS	NS	NS	NS	NS	NS
CV(%)	15.07	5.5	8.0	14.50	16.21	12.53

Figures in parentheses are transformed value
NS, non-significant
where, T1, 2.1-2.50c M1, sawdust (100%)
T2, 6.5-7.50c M2, cocodust (100%)
T3, 8.0-10.00c M3, sawdust+cocodust (50:50)

significant differences on various growth, flowering, bulb and bulblet production in next flowering season from stored bulbs without few exceptions. So, lilium bulbs can be successfully preserved at cool temperature (2.1-2.5^{0}c) with any media like sawdust (100%), cocodust (100%) and mixture (50:50) of sawdust and cocodust for producing quality flowers, bulbs and bulblet.

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