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# Respiration and Weight Changes of Easter Lily Flowers during Development

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*Additional index words.* *Lilium longiflorum*, fresh and dry weight

***Abstract.*** **To simulate the developmental sequence of the Easter lily flower (*Lilium longiflorum* Thunb. 'Nellie White'), flower buds from 4.5 cm to 16 cm (anthesis) were cut from field-grown plants on a single date. Fresh weight increased with bud length and was highest at anthesis, whereas dry matter reached a maximum of 1.6 g when buds were 14 cm long. The percentage of dry matter declined from 16% in the smallest bud to only 9% at anthesis. Respiration rates, both per bud and per unit dry weight, increased with bud size, reaching peak values of 3.0 mg $CO_2$ · $bud^{-1}$ · $hr^{-1}$ and 1.8 mg $CO_2$ · $g^{-1}$ dry wt · $hr^{-1}$ at anthesis before declining to a markedly lower rate. From these data, the total dry matter needs of flowers on field-grown plants were estimated.**

Large lily bulbs sell for a high price because they have the potential to produce a forced plant with more flowers than those grown from small bulbs (2, 3). During bulb production, flowers might reduce bulb size through competition for available assimilates (7, 10, 12). Removal of small flower buds reportedly increased total bulb yield by 30% (4). Manual removal of small flower buds is difficult, and the common commercial practice in Oregon and California is to remove flowers just before anthesis to prevent *Botrytis elliptica* from entering the leaves through senescing flowers (6). Dry weight and respiration rate of Easter lily flowers should be maximal near anthesis, based on data from other flower crops (1, 9). The period from visible buds to anthesis in Easter lily takes about 6–7 weeks under field conditions, and the formation of several large flowers on a plant could constitute a considerable sink prior to their removal. The assimilate demands of developing lily flowers are unknown, since the carbon requirement for their growth and respiration has not been determined. Therefore, the purpose of this research was to measure fresh and dry weights and respiration rates of Easter lily flower buds of various sizes as an attempt to describe developmental sequence of the flower.

Flower buds were cut from 'Nellie White' plants grown at Harbor, Oregon, placed in punctured polyethylene bags, transported to Corvallis, and stored overnight in darkness at 10°C. The buds then were separated into groups differing by one cm increments in length, from 4.5 to 15.5 cm. In addition, partially open and fully opened flower groups were included. Field measurements indicate that it takes about 25 days for a flower bud 4.5 cm in length to reach anthesis. Five uniformly sized buds or flowers were weighed, sealed in a 4-liter glass jar through which air was passed at 3 liters · $hr^{-1}$, and placed in the dark at 21°. The proximal end of each bud or flower was placed in 5 ml of a 10% sucrose solution. After 12 hr the $CO_2$ concentration in supply and exhaust air streams was determined with a Beckman 865 Infrared Gas Analyzer. Buds or flowers were weighed after drying at 65° for 48 hr.

The fresh weight of flower buds increased linearly over the range between the 4.5 cm size and opening flowers, reaching a peak at full bloom (Fig. 1). This pattern also has been observed in carnation, chyrsanthemum, and grape blossoms (7, 9, 12). Dry weight increased from 0.45 g per bud at 4.5 cm to a maximum of 1.62 g for an opening flower, then decreased (Fig. 1).

The percentage of dry weight decreased from 15.5% when a flower bud was 4.5 cm in length to 8.4% after the flower opened

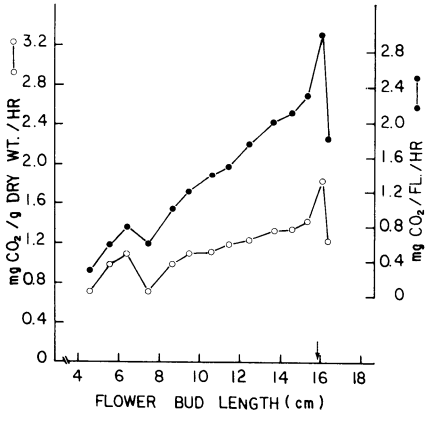


Fig. 1. Changes in fresh weight (FW), dry weight (DW) and percentage of dry weight (%DW) during the development of the Easter lily flower. The arrow indicates the length at which the flower bud opened.

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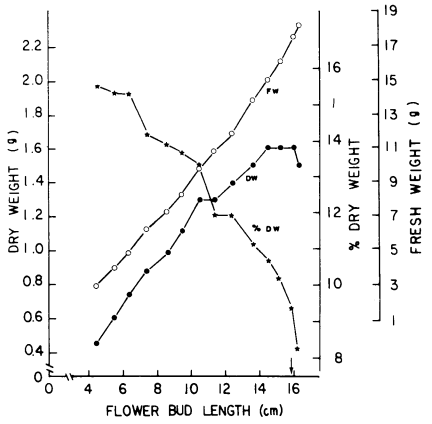


Fig. 2. Respiration of Easter lily flower [per flower/bud (●) and per g dry weight (○)]. The arrow indicates the length at which the flower bud opened.

(Fig. 1). This change likely reflects the increased need for water during expansion of the lily flower bud. The percentage of dry weight of carnation and chyrsanthemum flowers also declined as their size increased, but falling only to 14% to 20% when fully mature (7).

Respiration rate, whether expressed on a unit weight or per organ basis, generally increased with size until bud opening, then rapidly declined (Fig. 2). For example, respiration rate per bud or flower was 0.9 mg $CO_2$ · $hr^{-1}$ for a 4.5 cm bud, 3.0 mg $CO_2$ · $hr^{-1}$ at anthesis, and 1.8 mg $CO_2$ · $hr^{-1}$ for fully opened flowers. In rose flower petals, chyrsanthemum, tulip, and carnation flowers, a high respiration rate was associated with actively dividing and expanding cells (5, 9, 13, 14), and respiration declined after full petal expansion (9, 14). Tulip flowers cut freshly from the field at successive developmental stages showed the same respiratory pattern observed in this study (9). When cut flowers are placed in water only, the respiration rate usually declines sharply after one day (5, 9, 11, 15). Roses (5) and zinnia (15) placed in a sucrose solution maintained respiration at high rates. Dipping lily flower buds or flowers in a 10% sucrose solution may have allowed respiration to continue at rates comparable to those of freshly cut flowers.

An Easter lily plant of the size required to produce a commercial bulb has an average of 4 flowers with a combined dry weight of 6.4 g (1.6 × 4) at anthesis (Fig. 1). By adjusting ($Q_{10}$ = 2) the respiration rates in Fig. 2 to an average field temperature of 14°C, it was estimated that over a 25-day developmental period, 4 flowers would consume approximately 1.4 g of dry matter in respiration. Thus, plants would use about 8 g of dry matter in flower growth. Deblossoming studies show that lily flowers divert a large fraction of current photosynthate away from the bulb (16). If the bulb received an additional 8 g of dry matter upon flower bud removal, it would result in a 24 g increase in fresh weight (bulbs are about 33% dry matter) and about a 2 cm increase in circum-

ference (2). Lily bulbs are marketed by circumference, and such an increase, if realized, would be of appreciable economic importance. The occasional failure of bulb size to increase in reponse to hand deflowering (8) or application of the flower aborting agent CIPC (isopropyl-*m*-chlorocarbanilate) (17) suggests that other factors, such as alternate sinks or hormonal regulation may affect bulb growth after removal of flowers.

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# *In Vitro* Propagation of African Marigold

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*Additional index words.* African marigold, adventitious shoot buds, plant regeneration, negatively geotropic green roots

***Abstract.*** **Leaf segments of *Tagetes erecta* L. (African marigold) were cultured on Murashige and Skoog (MS) basal medium supplemented with 6-benzyl-aminopurine (BA), kinetin, 3-indoleacetic acid (IAA), 3-indolebutyric acid (IBA), and naphthaleneacetic acid (NAA). Regeneration of a large number of adventitious shoot buds was observed on a medium with BA (3 to 5 mg/liter) + IAA (1 mg/liter). When shoot buds plus some callus were subcultured on the same medium, additional buds differentiated for up to 2 years. The shoot buds elongated when subcultured on a medium with BA (2 mg/liter) + 0.5 mg/liter gibberellic acid ($GA_3$). Shoots with sufficiently developed internodes were rooted on filter paper bridges in culture tubes on MS liquid medium with IBA (0.5 mg/liter) + $GA_3$ (0.5 mg/liter) to obtain complete plantlets with well-developed root and shoot systems. Abnormal negatively geotropic green roots formed on a medium with kinetin (1 to 4 mg/liter) + IBA (1 to 4 mg/liter).**

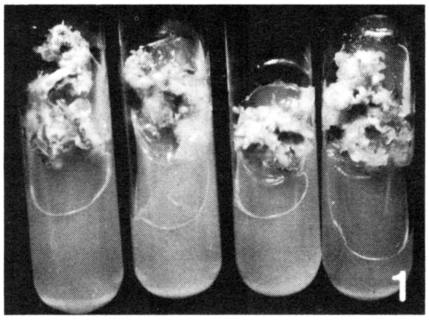

Fig. 1. Formation of shoot buds from callus from leaf explants on MS + BA (5 mg/liter) + IAA (1 mg/liter) after 20 days of culture.

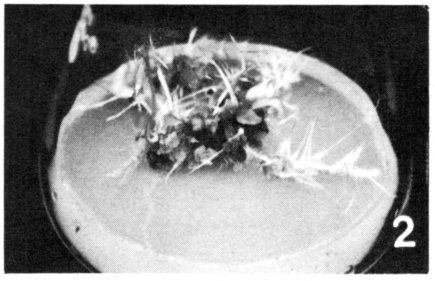

Fig. 2. Shoot and root formation from leaf segments on MS + BA (3 mg/liter) + IAA (5 mg/liter).

Plant tissue and organ culture as a technique for the mass propagation of selected plants is now established for many plant species (1, 5, 6, 7, 9), but only a few species in the Asteraceae family have been propagated using tissue culture (2, 3, 10, 12). *In vitro* multiplication of ornamental plants through tissue culture is advantageous since the plants produced may be genetically identical and disease free (6). The present report describes regeneration of plants of *Tagetes erecta*, an important ornamental plant, through leaf culture. Organogenesis in *Tagetes* from hypocotyl and cotyledons has been reported (8).

Leaves taken from plants growing in the botanic garden of the Univ. of Rajasthan, Jaipur campus, India, were surface sterilized for 5 min in a 0.1% $HgCl_2$ solution and washed 3 times in sterile distilled water. Leaf segments (1.5 × 0.6 cm) were cultured aseptically on 0.8% agar (Difco Bacto) solidified MS basal medium (11) supplemented with various concentrations of auxins and cytokinins. The pH of the medium was adjusted to 5.8 before autoclaving at 1.06 kg/cm$^2$. All cultures were incubated at 28°C under 24 hr illumination from cool-white fluorescent tubes and incandescent bulbs (1000 lx). Wide neck 100 ml Erlenmeyer flasks and test tubes (25 × 150 mm and 25 × 200 mm) were used as culture vessels. A 40 ml medium was dispensed in each flask and 20 ml in a tube. Throughout this paper, basal medium is denoted as MS followed by hormonal levels in mg/liter in brackets. All experiments were repeated 3 times.

The responses of leaf segments to different concentrations and combinations of BA, kinetin, IAA, IBA, and NAA are given in Table 1. The formation of complete plantlets

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