Size of In Vitro Plantlets Affects Subsequent Tuber Production of Acclimated Calla Lily

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Abstract. Tuber production of calla lily (Zantedeschia eülliotiana Spreng cv. Super Gold) was investigated using three size ranges (7–10, 4–7, and <4 mm shoot diameter) of in vitro plantlets acclimated in either pots or soil beds in a protected house. The shoots and tubers of large plantlets exhibited higher rates of dry-matter accumulation than did those of small plantlets. The diameter of tubers harvested from pots ranged from 0.67 to 4.1 cm with median values of 2.7, 2.1, and 1.9 cm for the plants derived from large, medium, and small plantlets, respectively. Plants grown in soil beds, regardless of size, produced larger tubers than did those grown in pots. Tubers >3 cm in diameter developed on 25% and 52% of plants grown in pots and soil beds, respectively. Our results suggest that improved calla lily production could be realized by using larger in vitro plantlets as the source material and growing them in soil beds in a protected house.

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LA appeared to be independent of size. The mean maximum LAs attained by large, medium, and small plantlets were 81, 73, and 55 cm$^2$ per plant, respectively (Fig. 1A). The LA started to decrease after 14 weeks of cultivation when leaves began to senesce. The decrease in LA was presumably due to the onset of leaf abscission, as indicated by the decrease in leaf number per plant (Fig. 1B). The pattern of change in leaf number during the culture period resembled that of change in leaf area (Fig. 1B). Leaf number increased rapidly during the first 11 weeks and reached a plateau ≈11–14 weeks after planting. The maximum leaf numbers attained by plants derived from large, medium, and small plantlets were 8.1, 7.2, and 7.6 per plant, respectively, at 14 weeks after planting. The change in leaf number after week 11 was similar for all treatments.

Dry-matter accumulation of shoots, regardless of plantlet size, changed little during the first 3 weeks of culture (Fig. 2A). Thereafter, it increased to a maximum at 14 weeks after planting, with a growth rate ranging from 27 to 40 mg·week$^{-1}$ per shoot (Table 1).

Tuber dry weight began to increase when LAs approached the maximum and continued to increase linearly until harvest (Fig. 2B). Tuber growth occurred only after leaf area had reached its maximum when small tubers were used for propagation (Clemens and Welsh, 1993). This was also the case in the present study with in vitro plantlets. Clemens and Welsh (1993) reported that the initiation and subsequent rate of tuber growth was primarily related to the availability of assimilates in excess of the demands of shoot development. This tendency is probably due to limitation of assimilate supply during the early stage of growth (Koble and Stephan-Beckmann, 1997). Our data showed little change in tuber dry weight until the shoots attained 75% to 80% of their maximum weight (Fig. 2A). Tuber growth rate (TGR), estimated by linear regression between 11 and 20 weeks after planting, ranged from 81 to 168 mg/tuber per week (Table 1). The rate and duration of tuber growth was positively related to the original size of mother plantlets (Fig. 2B). About 95% of the final dry weight was accumulated by week 24, 22, and 20 for plants derived from large, medium, and small plantlets, respectively.

The difference in rate of tuber dry-matter accumulation was reflected in the size of tubers (Fig. 3A). For plants grown in pots, tuber size ranged from 0.7 to 4.1 cm in diameter, with median values of 2.7, 2.1, and 1.9 cm in diameter for the plants derived from large, medium, and small plantlets, respectively (Fig. 3A). For the small plantlets, 79% of the tubers were <2.5 cm and only 0.4% were >3 cm in diameter, whereas all tubers produced from large plantlets were >2 cm, and ≈25% were >3 cm in diameter (Fig. 3A).

Growth in soil beds. Tubers grown in soil beds showed a size trend similar to that of grown in pots. However, the pattern of tuber size distribution differed significantly from that of tubers grown in pots (Fig. 3B). Tuber size in soil beds ranged from 0.9 to 4.3 cm in diameter, with median values of 3.3, 2.8, and...
Table 1. Shoot and tuber growth rate of Zantedeschia produced from in vitro plantlets of three sizes.

<table>
<thead>
<tr>
<th>Size of plantlets</th>
<th>Shoot growth rate $^{b}$ (mg week $^{-1}$)</th>
<th>Tuber growth rate $^{c}$ (mg week $^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>40</td>
<td>168</td>
</tr>
<tr>
<td>Medium</td>
<td>33</td>
<td>132</td>
</tr>
<tr>
<td>Small</td>
<td>27</td>
<td>81</td>
</tr>
<tr>
<td>LSD$_{	ext{P}0.05}$</td>
<td>4</td>
<td>19</td>
</tr>
</tbody>
</table>

$^{a}$Size of plantlets was graded by measuring diameter at basal part of shoot. The shoot diameter for the large, medium, and small plantlets was 7–10 mm, 4–7 mm, and <4 mm, respectively.

$^{b}$Shoot growth rate was estimated by fitting a linear regression to the data for dry weight between 3 and 11 weeks after planting.

$^{c}$Tuber growth rate was estimated by fitting a linear regression to the data for dry weight between 11 and 20 weeks after planting.

$^{d}$Mean separation within columns by LSD, $P \leq 0.05$.

2.5 cm for the plants derived from large, medium, and small plantlets, respectively (Fig. 3B). Plants grown in soil beds, regardless of plantlet size, tended to produce larger tubers than did those grown in pots. For the large plantlets, especially, the proportion of tubers that produced flowers was 25% in pots vs. 52% in soil.

Discussion

For calla lily growers, production requires a high proportion of flowering tubers (Corr and Widmer, 1988; Welsh and Clemens, 1992), and production of plantlets in vitro has become an alternative method (Cohen, 1981). Generally, tissue culture plantlets require two growing cycles ex vitro to reach sufficient diameters (3–6 cm) for flowering. Welsh and Clemens (1992) reported that micropropagated plants produced small tubers in their first growing season and reached flowering size in their second season. In the present study, however, we found that the variation of tuber size distribution depended on both the size of mother plantlets and the culture method. About half of the tubers produced by the larger in vitro plantlets grown in soil beds reached flowering size in only one growth cycle, whereas only 0.4% of tubers produced from small plantlets grown in pots reached flowering size within one season (Fig. 3).

The variation in size of in vitro plantlets is typical, and growers do not select for size for tuber production. Many researchers have suggested that the multiplication rates in vitro can be controlled by adjusting the form and/or concentration of plant growth regulators in the medium (Pierik, 1991). However, the conditions that favor adventitious bud formation (i.e., high multiplication rate) would usually limit plantlet development (i.e., plantlet size) during in vitro culture. Therefore, balancing the rate of multiplication and the size of plantlets in a tissue culture system is important for establishing a highly efficient system of tuber production that uses in vitro plantlets as mother stock.

Literature Cited


