Localization of Reserve Remobilization During Scalet Formation on Lilium longiflorum Scales

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ABSTRACT

When Lilium longiflorum bulb scales are removed and placed in a moist environment, new bulbs ("scalets") arise from the base of the original scale, providing a practical means of clonal propagation. To determine which region of the scale is responsible for the early development of the new scalet, investigations were conducted on the localization of starch hydrolysis and accumulation of soluble sugars in basal, distal, and central regions. Over a six week period, starch concentration decreases initially in the distal regions, followed by the central region. Soluble sugars increased in distal areas over this same time period. These findings indicate the distal regions of a lily scale are important in the early development of the new scalet, in contrast to the adjacent, basal region.

INTRODUCTION

The lily bulb production industry is worth more than $10 million annually in the United States. To maintain clonal characteristics, all bulbs are propagated through vegetative means. The most common method is "scaling," where scales are removed from the parent bulb then planted in fields. The new scalets that form on the base of the scale are then field grown for three years to produce saleable bulbs. Thus, this process forms the basis of propagation of millions of bulbs annually for the United States and foreign lily industries.

Since the new scalet does not have leaves, it initially is entirely dependent on the mother scale for its expansion growth and dry weight increase. Bulb scales contain as much as 65% starch on a dry weight basis, and utilization of this starch certainly is important to nourish the developing scalet. Scales also contain glucomannan, a polysaccharide composed of mannose and glucose residues. The function, if any, of glucomannan during scalet formation is unclear.

The purpose of this study was to identify the regions of a lily scale that are most active in supplying initial assimilate to the developing scalet.

MATERIALS AND METHODS

On 8 February 1988, 120 mother bulb scales were collected from 10 'Nellie White' Easter lily bulbs. For an initial sample, 20 scales were cut into 3 equal length cross sections and designated "basal", "middle", and "distal or apical". Fresh weight was recorded, then scales were frozen in liquid nitrogen, and freeze dried. Dry weight was recorded for each replication of 5 scales, and tissues ground in a mortar and pestle.

The other replications were placed in polyethylene bags with approximately 200 cc of moist vermiculite per replication. Bags were stored in darkness at 20°C for periods of 2, 4, or 6 weeks. At the end of each storage period, scales were destructively harvested and as described above.

Soluble carbohydrates were extracted from freeze dried tissues, and quantitated by high performance liquid chromatography (HPLC). Starch concentration of each section was determined by estimating the glucose liberated (via glucose oxidase) from the tissue residue as a result of amyloglucosidase digestion.

RESULTS

The dry weight of the mother scale, and of the mother scale plus any initiated organs did not significantly change during the six week experiment (Table 1). Organ initiation was visually apparent within two weeks, as evidenced by extremely small swellings at the scale base, although the mass of these swellings was small (Table 1). Growth of the initiated scalets was rapid, however, and by six weeks averaged 90 milligrams dry weight (Table 1). The dry weight of the three scale regions did not change significantly during the experiment, with the exception of a significant weight decrease in the apical region at week six (Table 2).

Starch concentration decreased significantly (11.9%) within four weeks in apical regions. In contrast, middle regions required six weeks for a (barely) significant decrease, and basal regions showed no significant decrease (Table 2). These changes were also visually apparent by the lack of iodine staining in apical regions, and progressively greater staining in basal areas.

Differences in soluble carbohydrate profiles were seen by two weeks, where fructose and glucose increased in both apical and middle sections (Table 2). By week four, however, only apical sections were exhibiting significant increases in soluble sugar concentration (sucrose, glucose and fructose). By six weeks, mannose began to accumulate in the apical region.

Metabolic changes associated with Lilium bulb reserve hydrolysis and sucrose export have been previously described elsewhere by the author. The decrease in starch concentration indicates that the apical region of a lily scale is the major source of carbohydrate for the growth of the developing scalet. This finding is unusual in that partitioning of carbohydrate is generally related to proximity of source and sink: sources adjacent to a sink are more important to a sink then more distal sources.

The increases in soluble carbohydrate (sucrose and its components glucose and fructose) indicates the rate of sucrose synthesis and export is relatively slower than starch breakdown. Further, we may infer that starch is the main reserve carbohydrate used during scalet initiation since mannose does not increase in concentration until substantial starch hydrolysis had occurred (Table 2).

Table 1. Changes in dry weight of entire scales and initiated scalets during the experiment.

Time (weeks)	Total dry weight[z]	Remaining scale dry weight	Initiated scalet dry weight (mg)
0	3.27	3.27	0
2	3.26	3.25	2.7
4	3.23	3.19	36.2
6	3.06	2.97	90.2
LSD[1], 0.05	0.49	0.21	17.4

[1]LSD = least significant difference at the 0.05 level.

Table 2. Dry weight and carbohydrate profiles of Easter lily scale regions as influenced by scalet formation.

Scale region	Time (weeks)	Dry wt. (gms)	Carbohydrate Concentration (mg/gm)						
			Sucrose	Glucose	Fructose	Mannose	TSC[z]	Starch	TC[y]
Apical	0	0.91	29.0	2.0	4.2	0.3	35.6	693.1	728.7
	2	1.11	32.1	7.9	7.0	0.3	47.3	659.0	706.3
	4	1.06	37.6	10.3	10.4	0.5	58.8	644.2	703.0
	6	0.76	43.8	20.5	22.2	1.9	88.5	553.5	642.0
Middle	0	1.36	34.8	2.0	2.3	0.4	39.5	721.2	760.7
	2	1.30	35.4	9.5	6.5	0.4	51.8	716.1	767.9
	4	1.29	33.4	6.6	5.8	0.2	45.9	688.3	734.2
	6	1.31	40.7	8.5	8.1	0.4	57.6	681.3	738.9
Basal	0	0.99	41.4	1.5	2.6	0.2	45.7	688.0	733.7
	2	0.85	31.9	4.4	3.4	0.4	40.1	683.6	723.7
	4	0.84	32.0	2.1	2.6	0.1	36.8	682.7	719.5
	6	0.90	35.1	1.3	2.3	0.4	39.0	669.2	708.2
LSD, 0.05		0.21	8.3	4.8	4.1	0.6	13.5	40.0	36.1

[z]TSC is total soluble carbohydrate, the sum of sucrose, glucose, fructose, and mannose.
[y]TC is total carbohydrate, the sum of TSC and starch.