Changes in Carbohydrate Levels and Associated Enzyme Activities During Flower Development in Easter Lilies

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Introduction

Flower growth, development, and senescence are very important processes in floricultural crops, both in cut flowers and pot plants. The pattern and the rate of growth and senescence are usually determined by the genetics of the plant as well as external environmental factors. Studies on fundamental physiological processes involved in flower growth are valuable for several reasons. Information on the enzymes and genes involved in regulating these growth processes will facilitate breeding programs for the selection of better flower qualities and other desirable traits. On the other hand, this information will be helpful to manipulate environmental factors to adjust flower growth and development according to growers needs.

Carbohydrates are necessary for the growth of any plant part as carbohydrates provide energy and the building blocks for growth processes. Flowers usually do not have chlorophyll, and therefore cannot carry out photosynthesis to produce carbohydrates for their needs. In addition, flowers have very rapid growth rates that require large amounts of carbohydrates. For these reasons, flowers are dependent upon other parts, especially leaves, for their carbohydrate supply. Therefore, the ability of flower buds to import carbohydrates is vital in flower development.

Usually, sucrose (i.e. table sugar) is the form of sugar translocated from leaves to flowers. Once sucrose enters the flower, it has to be broken down to glucose and fructose before it can be used for growth. The ability to break down sucrose is determined by the activity of sucrose-degrading enzymes present in flower tissues. One enzyme, invertase has been suggested as the major sucrose-hydrolyzing enzyme active in flower tissues.

Here we report the results of several experiments conducted to investigate carbohydrate changes during the flower development of Easter lilies (*Lilium longiflorum*). Since flower buds contain various organs that have various growth patterns, individual organs were studied. The changes in carbohydrates, and its relationship to invertase activity were studied throughout flower development, from young buds to flowering.

Materials and Methods

Easter lily (*Lilium longiflorum* cv Nellie White) plants were grown in greenhouses at Clemson University under standard conditions. Flower buds were harvested at five different stages of development (3-4 cm in length, 6-7 cm, 9-10 cm, 13-14 cm (mature bud), and open flower). Flower buds were dissected into tepal, anther, filament, stigma, style, and ovary, and fresh weights of individual organs were recorded. Soluble carbohydrates were extracted from freeze-dried tissue with water at 70 C, and extractable sugars were separated and quantified by liquid chromatography. The proteins were extracted under appropriate conditions to stabilize enzyme activities, and invertase activity was assayed in the extracts.

Results and Discussion

The growth of individual flower organs varied depending on the organ. Most of the total weight increase came from expansion and growth of the tepals. Tepal fresh and dry weights increased at very high rate throughout the development until the mature bud stage. Filament, style, stigma, and ovary fresh and dry weight also increased gradually until the flower opened. However, anther fresh weight was highest in 6-7 cm long flower buds and then declined during later flower bud maturation. Glucose, and fructose levels of tepal, style, stigma, and filaments increased dramatically during the growth (Figure 1). However, sucrose levels didn't show this rapid increase, and either remained constant or decreased during development. In anther, glucose and fructose levels increased up to 6-7 cm long buds and then decreased in mature buds, whereas sucrose levels fluctuated.

Invertase activity increased throughout bud development in tepal, style, filament, stigma, and ovary (Figure 2). In anther, invertase activity increased from 3-4 cm to 6-7 cm long bud and then decreased in the mature bud. This results shows that glucose and fructose are high in periods of rapid growth, and that invertase activity has a positive correlation with these sugar levels. Invertase seems to play an important role in supplying carbohydrates for flower growth. We have conducted further experiments and isolated three different types of invertases contributing to this activity. Also, the genes of these enzymes are being investigated to gain a better understanding of this process.

Acknowledgments

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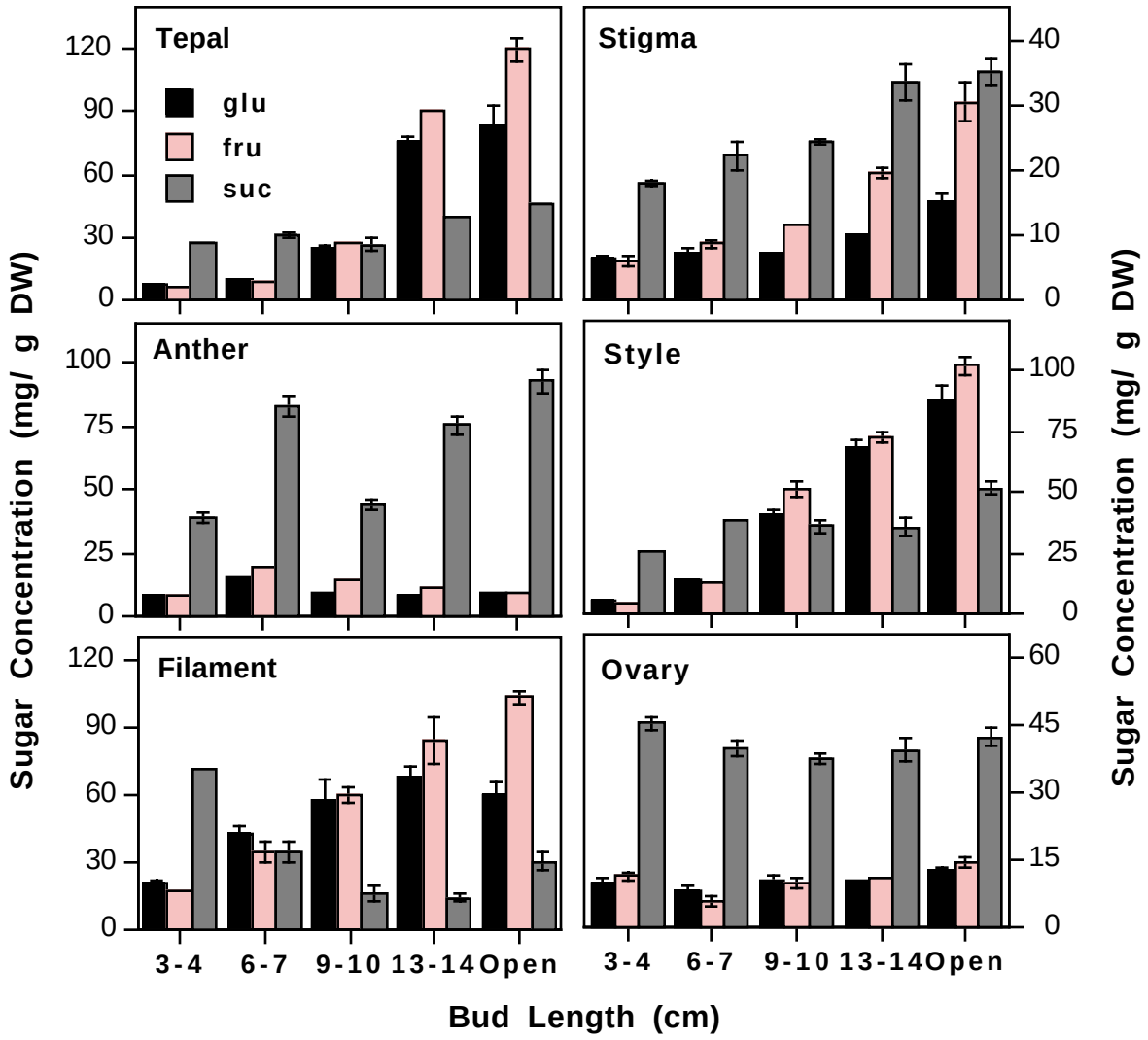

Figure 1. Soluble sugar concentrations of Easter lily flower organs during flower bud development

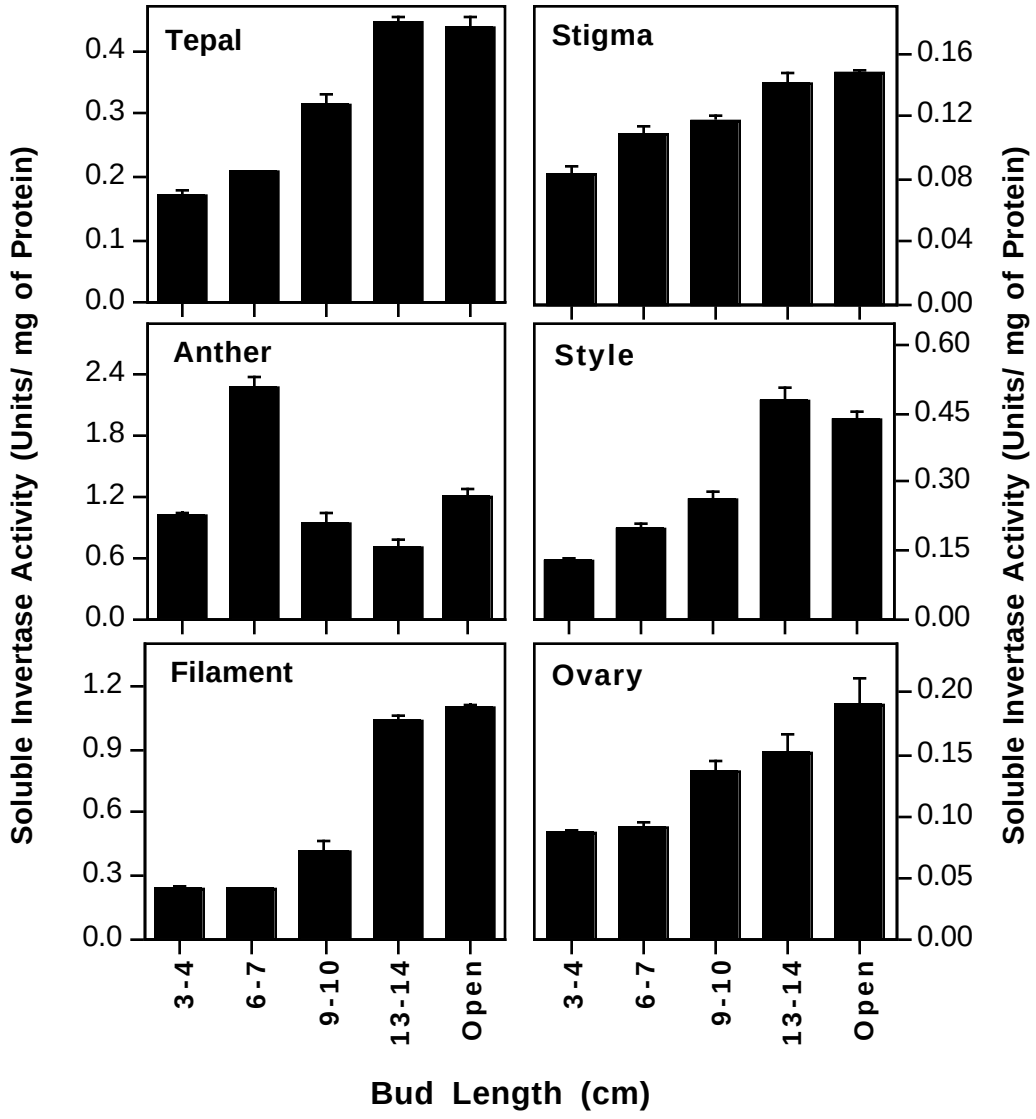

Figure 2. Changes in invertase activity of Easter lily flower organs during flower bud development