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Flower Bud Initiation in Strawberry Cultivars

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The strawberry is a perennial plant and thus requires a physiological mechanism for balancing flowering and vegetative growth. When the daylength shortens and temperature drops, vegetative growth of the strawberry plant decreases and flower bud initiation starts. Thus the process of flower bud initiation must be related to photoperiod and/or temperature.

Darrow and Waldo (6) and Darrow (4) were the first to note the response of strawberry plants to photoperiod. They classified June bearers as short day plants and everbearing as long day plants on the basis of their flowering responses. With light interruption studies, Vince-Prue and Guttridge (18) indicated that the regulation of flowering in strawberry is through long day inhibition rather than short day stimulation. Therefore, it is the length of the night which is the controlling factor of flower initiation in strawberry.

Photoperiodic Effects

The single-cropping or June-bearing octoploid cultivars of temperate climates are facultative short day plants; they will only flower when the length of the night period is greater than 14 hours (10). Thus these cultivars will initiate flower buds in the fall (September to October) leading to a summer crop (in May to July) (Fig. 1). However, both species and cultivars vary in their sensitivity to photoperiod. For example, *Fragaria vesca* is relatively insensitive (2) whereas *F. virginiana* is quite sensitive to photoperiod (6). In many cultivars, flower initiation can usually be induced under long days if other growing conditions are unfavorable (low growing temperature, drought and mineral starvation) (9).

The everbearing or double-cropping octoploid cultivars flower more freely under long day than short day conditions (7, 8). Thus, in these cultivars flowers appearing from late April to early June are derived from primordia formed in late summer or early autumn of the previous year. Flowers borne from mid- or late-July onwards are derived from primordia initiated a few weeks before emergence (Fig. 1). Therefore, flower initiation seems to be independent of photoperiod in the sense that long daylengths fail to inhibit flower bud initiation. In the June-bearing cultivars, late summer and autumn fruiting can also occur if the temperature in summer is relatively cool leading to a failure of photoperiodic regulation (9).

The term 'day-neutral' has been used synonymously with 'everbearing' to designate cultivars which have two

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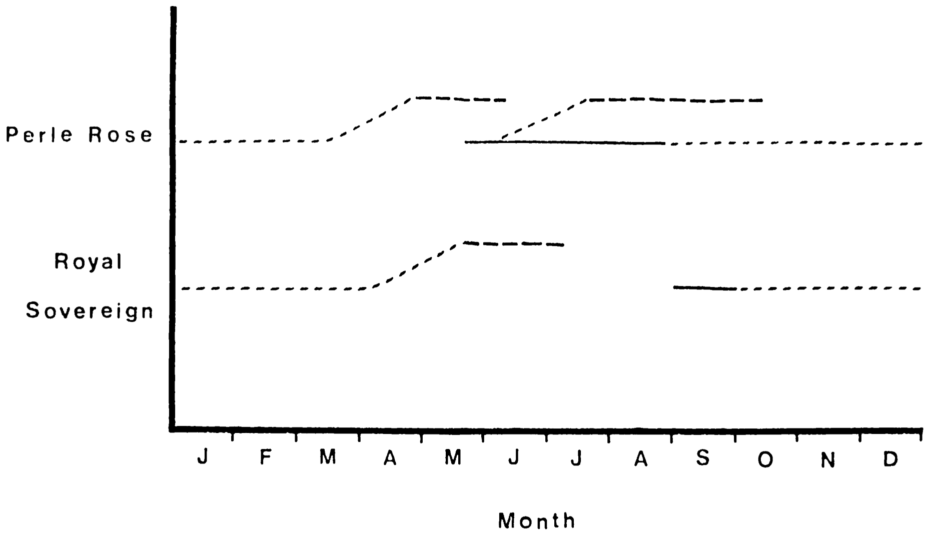

Figure 1. Comparative periods of flower initiation, inflorescence development and flowering in strawberry cultivars 'Perle Rose' (everbearing) and 'Royal Sovereign' (single-cropping) —— initiation of flower primordia; - - - development of inflorescences; — — flowering period (adapted from Robertson, 1955).

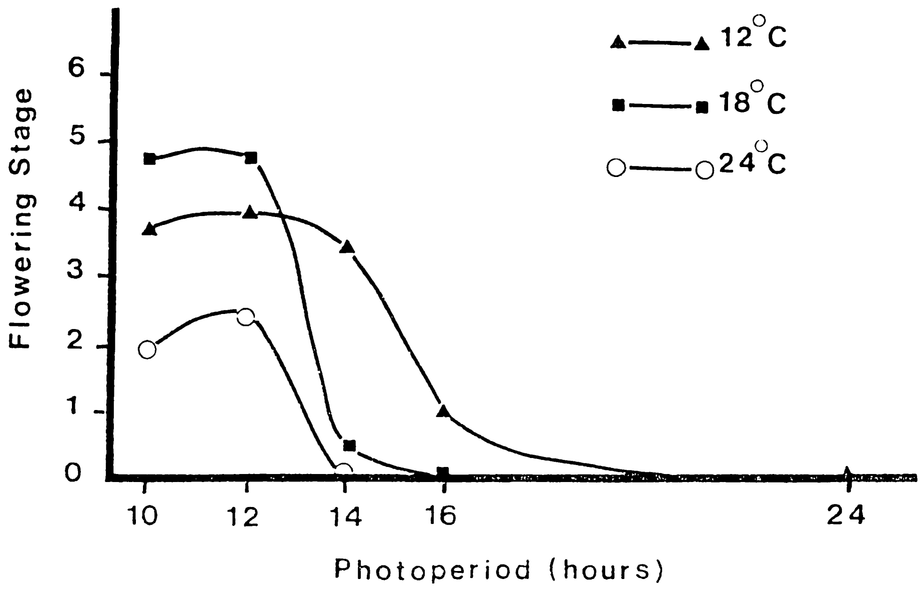

Figure 2. Flowering stages of strawberry cultivar 'Senga Sengana' after 5 weeks of cultivation at various photoperiods and temperatures as indicated. Stage 0—vegetative apex, stage 1—broadened apex with first bract primordium, stage 2—sepal primordia visible in terminal flower, stage 3—petal primordia visible, stage 4—stamen primordia visible, stage 5—first carpel primordia visible, stage 6—all flower parts differentiated (Heide, 1977).

crops a year. The yield of the combined crops usually does not exceed the single crop of the June-bearers and thus everbearers have not been of great commercial importance. However, new cultivars are currently being developed which are truly day-neutral and are showing great potential for commercial production (12). In these cultivars (i.e. 'Hecker,' 'Aptos' and 'Fern') flower buds can be initiated in short or long days and initiation tends to occur in six-week cycles under most conditions. Thus a crop is produced continuously from the spring until the fall; several cropping peaks do occur, however, and Himelrick (12) suggests these cultivars be considered as triple-cropping. The day-neutral cultivars will flower, produce fruit and runner simultaneously. This allows them to be easily distinguished from the June-bearers which produce flowers, fruit and runners in sequence and from the everbearers which produce few runners.

Temperature Effects

Some everbearing cultivars exhibit a clearly defined post-chilling phase in spring in which flower initiation fails leading to a break in fruit production in summer (20). Smeets (17) found that chilling the plants delayed flower bud initiation in the everbearing cultivars 'Rabunda' and 'Ostara.' This seems to suggest that the chilling and photoperiodic responses may be genetically distinguishable in the octoploids (9).

The interaction of temperature with photoperiod has been extensively studied (11, 14, 17) and low temperatures have been reported to stimulate flowering at the expense of runner development (1) (Fig. 2). Darrow and Waldo (6) found that at temperatures above 15.5°C, short daylengths (10 hours or less) were necessary to initiate flower buds in June-bearers, but at low temperatures flower buds could form under longer light periods. The principles of this statement have been confirmed in later studies, for example, Hartmann (10) and Went (22), although greatly differing threshold temperatures (5-17°C) and photoperiods (11-16h) have been reported in the various studies. Brown and Wareing (2) showed that temperatures between 10° and 15°C were essential for flower bud initiation in *F. vesca* and that long photoperiods delayed but did not entirely suppress initiation in this temperature range.

In everbearing cultivars, the effects of temperature and photoperiod are also interrelated. However, the strength of this relationship varies between cultivars. In a number of everbearers, flower bud initiation takes place irregardless of the daylength (8, 9). However, in other cultivars, bud initiation (6). Smeets (16) found that in 'Revada' and 'Rabunda' flower bud initiation occurred irrespective of temperature and daylength. However, the rate of flowering was controlled by temperature as well as daylength and varied among cultivars.

In general, no flower bud formation will occur in any strawberry if day/night temperatures are greater than 26°/22°C. In day-neutral cultivars flower bud initiation is essentially independent of daylength if mean temperatures are about 21°C. However, if the day/night temperatures exceed 26°/22°C, the day-neutral cultivars will behave like long-day plants with regard to flowering. Thus the combination of long days and high temperatures may reduce flowering in these cultivars (12).

Regional Adaptation of Cultivars

The fact that cultivars differ in their critical photoperiodic and temperature requirements (11) leads to geographical variations in fruiting habit and the regional adaptation of the cultivars (4). The length of the cropping season may also differ between regions. Inadequate chilling leads to a prolonged fruiting season because flower initiation continues throughout the winter (if it is mild enough for growth) and spring until initiation is stopped by long daylengths and/or warm temperatures in summer. For example, some cultivars which are single-cropping in northerly regions of the U.S.A. or in Canada will fruit over a long season in Florida (5) and in some cases California (19) where the winters are mild.

Stage of Development

Flower bud initiation occurs irregardless of the age of the plant, but the stage of development of the runners does play a role. Webb and White (21) showed that earlier-rooted runners of 'Redgauntlet' and 'Cambridge Vigour' produced greater flower numbers the following season. Most likely, the amount of time available for growth between rooting and flower bud formation is the critical factor. Yield of 'Cambridge Favourite,' also studied by Webb and White (21), was not as dramatically affected by rooting date.

Growth Regulators

Cain, *et al.* (3) found a stimulation of fruit yield by a fall application of ethephon on the everbearer 'Centennial' and on a selection (107 M6) with two everbearing parents. June-bearing cultivars such as 'Redcoat' were not affected. The authors suggested that loss of apical dominance could have allowed for greater development of branch crowns on which inflorescences could have developed. Why the yield of June-bearers was not increased by fall application of ethephon is not yet known.

In some cultivars, flower initiation sometimes fails in the field leading to no fruit production the following year. This condition can be corrected by defoliation or mowing after harvest. Perhaps flowering inhibitors accumulate during late summer in these cultivars and the removal of the foliage in August stops this accumulation (9). Another possibility is that a flower promoting substance is formed when an inhibitor disappears or falls to a low level (13). This theory accounts for the evidence that control is mediated by the level of vegetative growth and perhaps by the supply of a promoter of vegetative growth which is formed in greater amounts in long days than short days. However, mowing appears to have no effect on the regular cycle of inflorescence production in the day-neutral cultivars (12).

The maximum number of fruits a plant produces is the outcome of two processes, the creation of a maximum fruiting potential at the time of flower initiation, followed by a reduction in the failure of flowers to produce fruit; each process is influenced by a different set of factors (21). The period prior to floral initiation could be a critical stage in which improvements in nutritional and cultural conditions lead to an increase in crop.

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Reviewed Research Paper

Potential Methods for Gene Exchange Between Rabbiteye and Highbush Blueberries[1]

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Cultivated blueberries (*Vaccinium* sp.) are mainly tetraploid ($4x = 2n = 48$) or hexaploid ($6x = 2n = 72$, and hybrids between these 2 groups are of considerable interest. The 2 species whose hybrids would probably be the most valuable are tetraploid highbush (*V. corymbosum* L.) and hexaploid rabbiteye (*V. ashei* Reade). Both rabbiteye and highbush have been improved by plant breeding, and each has strengths which could compliment the weaknesses of the other. Direct hybridizations between the 2 were once believed to produce almost sterile pentaploids (2, 3). More recent work has shown that hybrids are not only fertile but range in chromosome number between pentaploid ($5x = 60$) and tetraploid (6, 12, 13). However,

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