Terminology for the Description of Developmental Stages of Horticultural Crops

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Terms describing or identifying developmental stages of horticultural crops are not used consistently, thus the meaning of each term becomes ambiguous. The cause for this discrepancy is speculative; however, the discrepancy could be minimized if a set of widely applicable definitions were available as guides in selecting the appropriate terms. Lott (2) recommended definitions for the terms "mature" and "ripening" and their derivatives. However, his definitions of the term "mature" and its derivatives were restricted to fruit while it is still attached to the plant, and the definitions of the term "ripe" and its derivatives were restricted to physiological changes and conditions which occur in fruit following harvest, which limit the use of terms only to specific fruits and exclude any of those ripening prior to harvest.

Gortner et al. (1) proposed definitions for the terms "development," "prematuration," "maturation," "ripening," and "senescence," which were based mainly on physical and biochemical changes in a given fruit. Definitions based on physical and biochemical parameters of a given fruit accurately describe the physiological state of that fruit, but they limit the applicability of the terms only to those fruit that are similar to the specified fruit. "Development" as described by Gortner et al. (1) is restricted to period during which new tissue is formed and brought to morphological completion. As now understood, developmental processes continue to the death of the plant. These and other terms are used to describe stages of development not only of fruit, but also those of nonfruit vegetables and floral and nursery crops; therefore, the definitions should be phrased so that the terms are applicable to a wide range of horticultural crops. The definitions should be brief but explicit to avoid the synonymous use of different, but closely related terms. Terms such as "maturation" and "maturity" unfortunately have dual usages: they can refer to a physiological stage and to the time of harvest. Since these 2 terms generally represent different stages of development, the definitions must indicate the context of application. The following definitions have been derived to fulfill these needs:

Development: The series of processes from the initiation of growth to death of a plant or plant part.

Growth: The irreversible increase in physical attributes (characteristics) of a developing plant or plant part.

Maturation: The stage of development leading to the attainment of physiological or horticultural maturity.

Physiological maturity: The stage of development when a plant or plant part will continue ontogeny even if detached.

Horticultural maturity: The stage of development when a plant or plant part possesses the prerequisites for utilization by consumers for a particular purpose.

Ripening: The composite of the processes that occur from the latter stages of growth and development through the early stages of senescence and that results in characteristic aesthetic and/or food quality, as evidenced by changes in composition, color, texture, or other sensory attributes.

Climacteric period: The period in the development of some plant parts that involves a series of biochemical changes associated with the natural respiratory rise and autocatalytic production of ethylene. The climacteric period consists of the preclimacteric, preclimacteric minimum, climacteric rise, climacteric peak, and postclimacteric phases (Fig. 1).

Aging: Any increment of time which may (or may not) be accompanied by physiological change.

Senescence: Those processes that follow physiological maturity or horticultural maturity and lead to death of tissue.

The stages of development can overlap, as indicated by broken lines at the ends of the solid lines in Fig. 2. For example, growth of most fruit ceases by the early stages of maturation but growth of some fruits, such as apples and pears, continues through maturation and into the initial part of ripening. The term "growth" is restricted to irreversible increases in physical characteristics and excludes the reversible, temporary increases that results from uptake of water or other substances. "Physiological maturity" and "ripening" are phenomena generally observed with many fruits and some flowers but generally not with other organs such as roots, foliage, stems, and tubers. The well-known term "climacteric" is included here to emphasize that the term applies to the respiratory rise which occurs naturally and not induced by external stress. The various phases of the climacteric period are identified differently by people, thus they are identified appropriately in Fig. 1. "Aging" is included because its connotation in a scientific context can differ from that of common usage where aging is equated with senescence (4). In science, the term "aging" is used when materials such as tissue slices, extracts, organelles, and even some mature but unharvested fruit (e.g., avocados) may age without necessarily undergoing changes associated with physiological senescence.

The term "horticultural maturity" is defined on a relative scheme as suggested by Ryall and Lipton (3), because the term can refer to any stage of development. For example, sprouts or seedlings are horticulturally mature in the early stage of development, whereas most vegetative tissues, inflorenscences, flowers, fruits, and underground storage organs become horticulturally mature in the midstage, and seeds and nuts in the late stage of development (Fig. 2). The stages depicted for a specific type of morphological tissue also need to be considered on a relative scheme. For example, among the underground storage organs, the potato tuber is harvested after the plants have bloomed, whereas carrots and onions are harvested be-

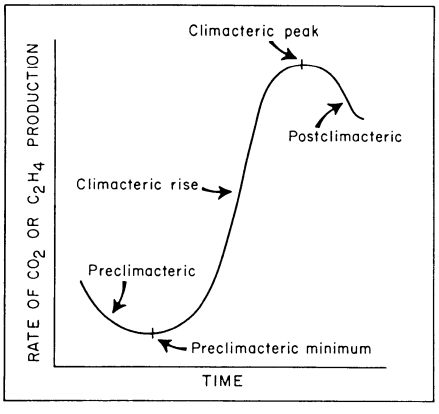

Fig. 1. Phases of the climacteric period.

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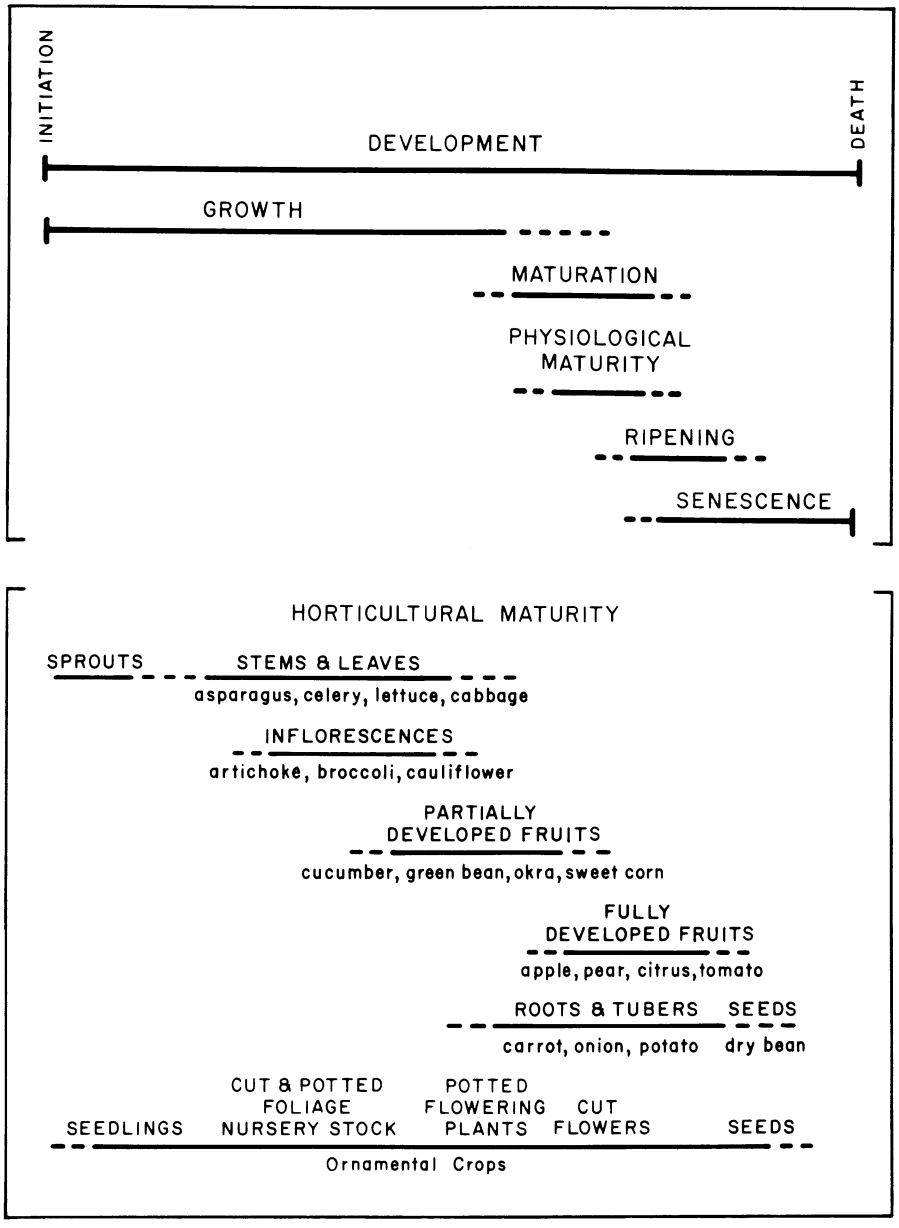

Fig. 2. Stages of development and senescence based on physiological processes and usage of horticultural crops.

fore the plants have bloomed. Fruits have been separated into 2 groups: those harvested when partially developed and physiologically immature, and those harvested when fully developed and physiologically mature, or even ripe.

These definitions are based on detailed discussions held at several ASHS Postharvest Working Group meetings and at the 1982 Gordon Research Conference on Postharvest Physiology. Progress reports have appeared in newsletters of the Working Group. The definitions should serve as a point of reference to minimize ambiguities and encourage appropriate use of these terms by postharvest biologists and others in describing the developmental stages of horticultural crops.

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