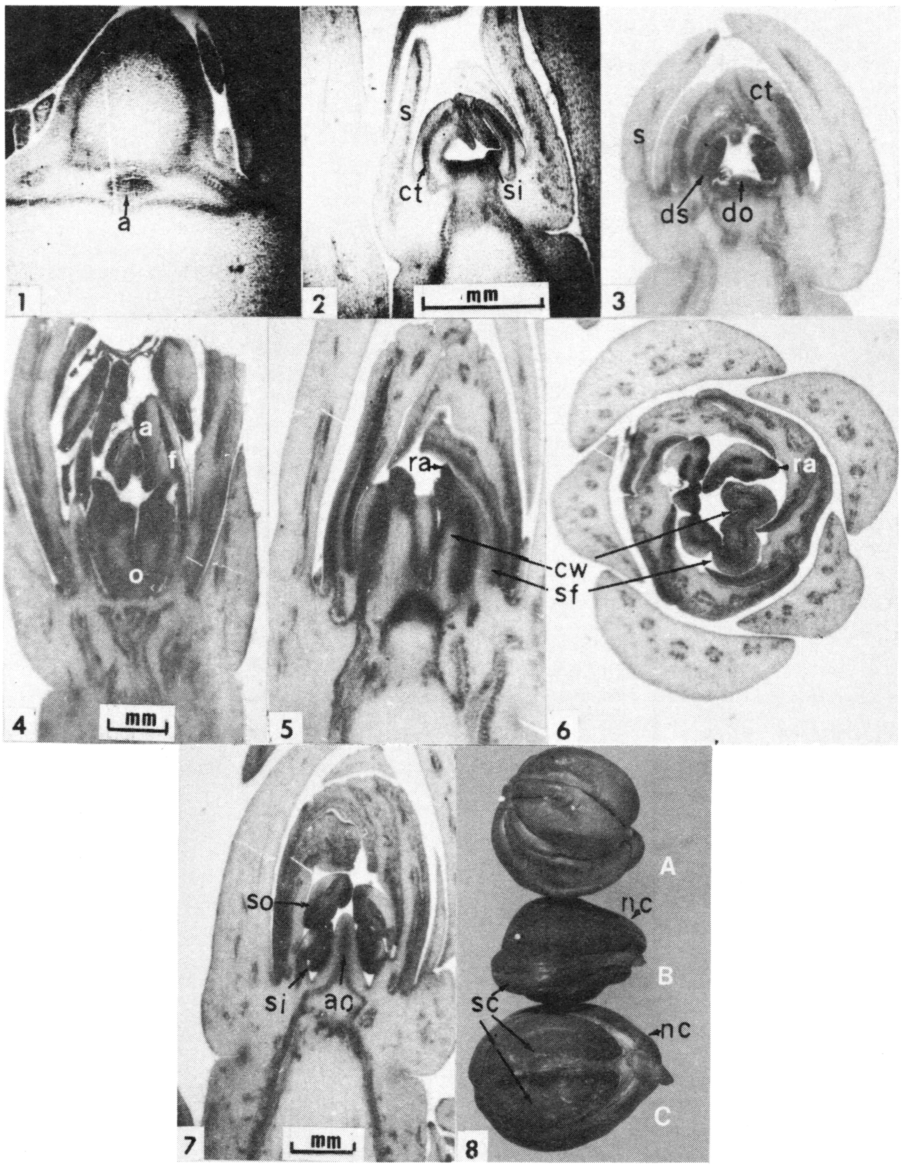

Figs 1–8. **1**) Tangential section of emerging flower bud (**a**) appearing at the axil of node No. 3 (scale as shown in Fig. 2). **2**) Longitudinal section of flower bud at about node No. 5; sepal (**s**), corolla tube (**ct**) are in an advanced stage of development; stamen initials (**si**) are becoming visible. **3**) Longitudinal view of a flower bud at about node 8 or 9 from a normal hermaphroditic plant. Sepals (**s**), corolla tube (**ct**), developing stamens (**ds**), and developing ovary (**do**) are identified (scale as shown in Fig. 2). **4**) Median longitudinal section of a normal hermaphroditic flower in its 5th week of development, showing filaments (**f**) and anthers (**a**) well-developed; carpels of the ovary (**o**) are still in the developmental stage. **5 and 6**) Median longitudinal and cross-sections, respectively, of moderately carpellodic flower at about the 5th week of development; reduced anther (**ra**), carpel wall (**cw**), and stamen filament (**sf**) expanding into carpel-like structure are shown. In Fig. 6, lateral adnation of carpels appear incomplete. (scale as shown in Fig. 4). **7**) Median longitudinal section of a female sterile flower at about the 5th week of development showing outer (**so**) and inner (**si**) whorls of stamens and the aborted ovary (**ao**). **8**) Carpellodic fruit showing various sizes of carpels and levels of lateral fusion, probably depending upon degree and time of occurrence of carpellody of the stamens.

12 to 13) is represented by the median longitudinal section in Fig. 7. Stamens of the inner and outer whorls and the aborted pistil are clearly discernible. Failure of the pistil to develop normally may be related to adverse conditions prevailing during the period of ovary differentiation, beginning about 3 weeks after the bud becomes visible to the naked eye.

An attempt was made to relate ontogenetic development of the sexual organs to time and relative sequence of events in the development of the flower from initiation to anthesis (Fig. 9). The flowers of the 'Solo' papaya took about 9 to 10 weeks from inception to anthesis. Flower buds became visible at about the 8th or 9th week from anthesis at approximately nodes 3 to 6 from the apex (Figs. 1, 9). Stamens were initiated around the 8th week before anthesis and completed their development about 5 weeks prior to anthesis (Figs. 2, 4, 7, 9). Ovaries were initiated about 7 weeks before anthesis (Figs. 3, 4, 9) and seemed to be complete about 4 weeks before anthesis at nodes 14 to 15.

Transformation of the stamens into carpel-like structures was discernible 5 weeks prior to anthesis (Figs. 5, 6). Stamen filaments expanded and seemed to be adnate to the ovary. The anther sac on the right side of Fig. 5 is no longer discernible, while a small knob representing arrested development of the anther on the left side is still visible. In cases of early stamen transformation into carpel-like structures, the change was complete with stigmatic rays taking the place of the anther sac. Since stamen differentiation begins 1 to 2 weeks earlier than ovary dif-

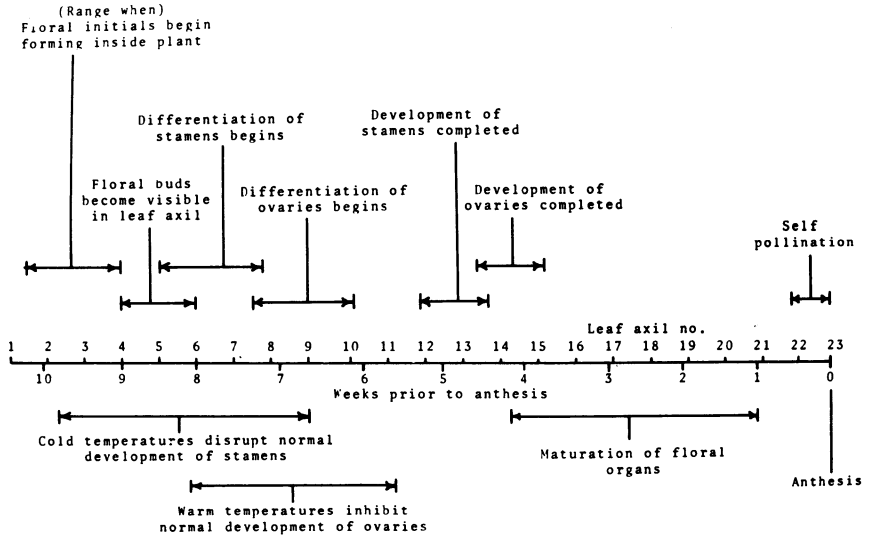

Fig 9. Approximate time sequence of developmental stages of floral organs up to anthesis.

ferentiation, transformation of stamens into carpel-like structures could begin before the ovary is initiated. Examination of histological sections of flower buds showed many stamen carpels with anthers arrested at rather late stages of development, however, and organs resembling stigmatic rays were not recognizable. Stamen development thus is well advanced when transformation occurs, and this change probably occurs simultaneously with ovary differentiation and development.

In the case of female sterile flowers, ovary development was arrested around the 7th and 6th week before anthesis. Aborted ovaries were clearly discernible by the 5th week (Fig. 7).

In Hawaii, warm tempertures and low rainfall prevail during summer and early fall. Female sterility begins to appear (flowers examined at anthesis) around August, peaks in October-November, and declines in December (3). Cool temperatures and increased rainfall occur from late November to March in Hawaii, and carpellodic flowers begin to appear in February, peak in March and decline in April (3).

It seems feasible to increase soil moisture levels by frequent irrigation and to increase short term N levels from June to October in order to minimize female sterility. These same factors could be withheld during the November-March period to reduce stamen carpellody. The practice of withholding moisture may be difficult as rainfall increases during this period in Hawaii. When weather conditions permit, however, these management practices may counteract the effects of seasonal temperature variations to some degree, especially in areas where climatic conditions are similar to the papaya-growing areas in Hawaii. In subtropical areas where the daily and seasonal temperature range is much wider than that found in Hawaii, management practices to counteract temperature effects would most likely be difficult.

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Influence of Within-canopy Shading on Net Photosynthetic Rate, Stomatal Conductance, and Chlorophyll Content of Kiwifruit Leaves

J.A. Grant[1] and Kay Ryugo[2]

Department of Pomology, University of California, Davis, CA 95616

Additional index words. Chinese gooseberry

Abstract. **Levels of incident photosynthetic photon flux density (PPFD), net photosynthetic rate (Pn), and stomatal conductance (g) were monitored on individual intact kiwifruit (*Actinidia chinensis* Planch.) leaves at well-exposed and densely shaded canopy positions. Diurnal fluctuations of Pn and g closely paralleled changes in PPFD for exposed leaves. PPFD reaching shaded leaves were extremely low throughout the day; Pn and g were correspondingly low. Pn ranged between 10 and 12 μmol $CO_2 \cdot m^{-2}s^{-1}$ when exposed leaves were light-saturated at PPFD between 500 and 700 μmol $\cdot m^{-2}s^{-1}$. Exposed and shaded leaves had similar chlorophyll concentrations, though the former had significantly higher chlorophyll a:b ratios. Implications relative to leaf canopy design and management are discussed.**

The relationship between light intensity and leaf photosynthetic activity has been studied on a number of fruit tree species. This relationship varies depending on species (4, 13, 15, 16, 23, 25), leaf age (6, 11, 12, 21, 22), and prior leaf exposure (1, 2, 13). Diurnal changes in leaf photosynthetic activity have been monitored for a number of species under field conditions (10, 25). Abiotic factors known to cause daily fluctuations in Pn include changes in incident light intensity, sub- and supraoptimal leaf temperatures, and changes leaf water status (15, 24).

Leaves are very efficient "filters" of photosynthetically active radiation (PAR); light intensity is attenuated rapidly within plant canopies (3, 7, 8, 17). Notwithstanding the contributions of diffused, reflected, and intermittent light to the PAR environment of interior leaves, the photosynthetic activity of leaves is reduced by natural shading within plant canopies (8, 9, 17).

Leaf canopy management strategies vary greatly among kiwifruit growers in California, ranging from training and pruning systems resulting in leaf canopies with uniformly good exposure of leaves to sunlight, to systems characterized by extremely dense shading of interior leaves by several layers of overlying shoots. The extent to which this mutual shading among leaves may influence the photosynthetic activity of individual leaves (and, therefore, the dry matter production potential of entire vines) has not been investigated. The objectives of this study were to: 1) characterize diurnal changes in kiwifruit leaf CO_2 assimilation rates and stomatal conductances under field conditions, and 2) assess the extent to which within-canopy shading influences these photosynthetic parameters.

A preliminary study was carried out in a 6-year-old kiwifruit planting near Davis, Calif., on 27 Aug. 1981, to quantify "typical" midday levels of incident photosynthetic photon flux density (PPFD), net photosynthetic rate (Pn), and stomatal conductance (g) of randomly selected "exposed" and "shaded" leaves. Two exposed

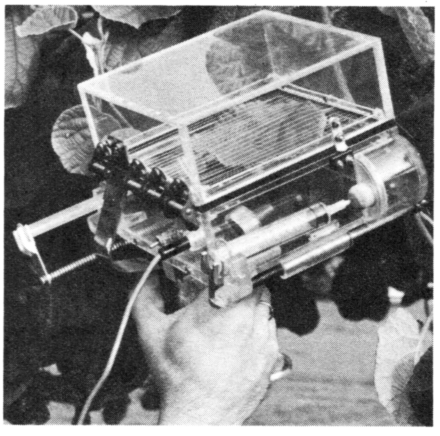

Fig. 1. Plexiglass cuvette used to draw gas samples for assimilation rate studies.

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[1]Postgraduate Researcher. This project was conducted as partial fulfillment for the senior author's MS degree in Horticulture.

[2]Professor.