PLANT PHYSIOLOGY AND ECOLOGY

PHENOLOGY OF FLOWERING IN *Citrus sinensis* [L.] OSBECK, cv. 'WASHINGTON NAVEL ORANGE

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Abstract. **In preparation for developing a model for use in predicting 10% anthesis in the southwest quadrant and 75% petal fall in the northeast quadrant of commercial 'Washington' navel orange trees (*Citrus sinensis* [L.] Osbeck), we determined the time of budbreak and growth rates of developing flowers. Flower buds borne on leafless flowering shoots (less than 1 leaf per flower) undergo budbreak and anthesis earlier in the bloom period than flowers borne on leafy inflorescences (greater than 1 leaf per flower). Flower buds which undergo budbreak (or anthesis) progressively later in the bloom period: 1) are borne on inflorescences with an increasing number of organs of which a larger proportion are leaves; 2) have a higher probability of being positioned in the axil of a leaf that develops to maturity; and 3) undergo faster calyx, corolla, and ovary growth. Faster-growing flowers and ovaries persist on the tree longer and contribute proportionally more fruit to harvest. Physiological differences between leafless and leafy inflorescences are manifest by the time the inflorescence undergoes budbreak. Subsequent flower development to anthesis or petal fall is a function of temperature only.**

Introduction

In the San Joaquin Valley of Central California, citrus flowers produced during the spring bloom fulfill an important niche in the beekeeping industry. Citrus flowers are the only "pasture" available to pollinator bees between the end of the flowering period in the deciduous tree crops and the beginning of bloom in the next pollinated crop, seed alfalfa. In addition, citrus flowers provide a source of nectar which in some years is of commercial value to the California honey industry. Laws prohibiting the use of pesticides on citrus from the time the trees are at 10% anthesis in the southwest tree quadrant through the time the trees reach 75% petal fall in the northeast tree quadrant protect bees so they can safely forage during this period. The time at which the citrus trees in the various districts in the citrus-growing areas of the San Joaquin Valley meet these requirements has been difficult to predict. Problems of economic consequence have resulted when 10% anthesis has been called too early in the bloom period to permit effective control of fruittree leafroller (*Archips argyrospilus*) or citrus cutworm (*Xylomyges curialis*), or when 75% petal fall has been called too long after petal drop to adequately protect the developing fruit from citrus thrips (*Scirtothrips citri*).

In order to determine when these two events marking the bloom period will occur each year, considerable man hours are spent every spring making visual observations at a number of key orchards in each district. Announcement of the two calendar dates which officially mark the beginning and end of the citrus

bloom is made 72 hours in advance of each event, respectively; a longer period of advance notice is desirable.

It is our objective to develop a temperature-dependent model of citrus bloom phenology to predict 10% anthesis in the southwest quadrant of the tree and 75% petal fall in the northeast tree quadrant. Such a model will eliminate the need for visual data collection and remove the subjectivity that is inherent in the current prediction process. Development of the model is supported by funds from the California Statewide Integrated Pest Management Program for citrus. Thus, the model will be available through the state IPM program to farm advisors, citrus growers, beekeepers, and area pest control advisors alike so that they can monitor for themselves the approach of both critical bloom dates by simple computation of degree-days.

In preparation, for developing a temperature-dependent phenology model of flowering in the 'Washington' navel orange variety (*Citrus sinensis* [L.] Osbeck), we studied tne influence of environmental and tree factors on the phenology and physiology of the flowering process. Potential topophysical effects on flowering, fruit set, and yield were also examined. While suspected, such effects have not been demonstrated or quantified for the 'Washington' navel orange.

Materials and Methods

'Washington' navel orange trees (*Citrus sinensis* [L.] Osbeck) in commercial production were selected to represent areas of the Central Valley with potentially different temperature patterns both prior to and during the citrus flowering period. Sites included: Lindcove, Lindsay, Visalia, and Fresno. Riverside was included to provide a site typically warmer in the spring than those in the Central Valley. Approximately 25 inflorescences were tagged, ideally before any of the flower buds reached 1 mm in length, in both the southwest and northeast quadrants of each of 20 trees. Typical inflorescences contained from 1 to 5 flowers with 0 to 5 developing leaves. The position of each flower and each leaf within the inflorescence was recorded. Each inflorescence was checked 2 times a week, and the following data were recorded: 1) for each flower in an inflorescence, bud length to the nearest 0.1 mm, date of anthesis (flower opening), date of petal fall, and date of flower abscission; 2) date of abscission for each leaf in the inflorescence; and 3) date of inflorescence abscission. After petal fall, the diameter of each remaining ovary (fruit) was measured once a week until mid-July (end of the June-drop period in Calif.) and then once a month until harvest. At each site, ambient air temperature, air temperature within the canopy, and soil temperature below the canopy were recorded. In addition, irrigation. precipitation. relative humidity, and solar radiation were monitored. Data were collected for both 1983 and 1984.

Degree-days were calculated using a double sine wave above the threshold temperature 9.4°C (49°F)[1,7]. Using this threshold, the start date which minimized the coefficient of variation for the mean number of degree-days was determined.

Results

In this paper. the term inflorescence applies to all flowering shoots arising from axillary buds as defined by Reece[7] The range of inflorescence types observed in this study was consistent with those described by Sauer[10]. At the time of visual (macroscopic) budbreak. inflorescences had from 1 to many flower buds. Each flower was borne in the axil of a leaf primordium. By the time of macroscopic budbreak, it was apparent that some leaf primordia had aborted, while others had continued to develop into small leaves[5]. Thus. when inflorescences became

Table 1 Influence of flower position within the inflorescence on time of budbreak and anthesis[z]

Site	Year	Mean date of budbreak			Mean date of anthesis		
		Position			Position		
		1	2	3-7	1	2	3-7
Riverside	1984	Feb. 27 a	Mar. 6 c	Mar. 5 b	Mar. 20 a	Mar. 26 c	Apr. 24 b
Lindsay	1983	Apr. 1 a	Apr. 6 b	Apr. 3 a	Apr. 27 a	May 9 c	May 7 b
Lindcove	1983	Apr. 2 a	Apr. 9 b	Apr. 15 b	Apr. 26 a	May 7 b	May 6 b
Lindcove	1984	Mar. 15 a	Mar. 27 b	Mar. 28 c	Apr. 9 a	Apr. 19 b	Apr. 19 b
Visalia	1984	Mar. 9 a	Mar. 23 b	Mar. 22 b	Apr. 14 a	Apr. 25 c	Apr. 23 b
Fresno	1983	May —	— —	— —	May 2 a	May 12 c	May 10 b
Fresno	1984	Mar. 21 a	Mar. 30 b	Apr. 2 c	Apr. 17 a	Apr. 25 b	Apr. 24 c

z   For budbreak or anthesis, dates followed by different letters are significantly different at the 5% level by Duncan's multiple range analysis.
y   Data not available; the population of flowers tagged for observation before the bud reached 3 mm in lenght was too small to provide statistically valid results.

Table 2 Relationship between leaf to flower ratio of the inflorescence and the time of flower budbreak and anthesis

Site	Year	Mean date of for position 1 flowers		Mean date of anthesis for position 1 flowers	
		< 1	> 1	< 1	> 1
Riverside	1984	Feb. 27	Mar. 3	Mar. 19	Mar. 23*[z]
Lindsay	1983	Mar. 29	Apr. 2	Apr. 26	Apr. 30*
Lindcove	1983	Mar. 25	Mar. 30	Apr. 24	Apr. 30*
Lindcove	1984	Mar. 8	Mar. 9	Apr. 9	Apr. 8
Visalia	1984	Mar. 14	Mar. 16	Apr. 14	Apr. 16
Fresno	1983	May	—	Apr. 30	May 6*
Fresno	1984	Mar. 20	Mar. 25*	Apr. 16	Apr. 19*

z   Paired dates followed by an asterisk (*) are significantly different (p < 0.05 by Student's t test).
y   Data not available; the population of flowers tagged for observatoin before the bud reached 3 mm in length was too small to provide statistically valid results.

visible on the tree, they had from 0 to many developing leaves. It is in this context that we use the relative terms "leafless" and "leafy" to describe inflorescences with leaf to flower ratios of less than 1 leaf per flower or greater than 1 leaf per flower, respectively, since both leaves and flowers abscice throughout the bloom period.

The position within the inflorescence occupied by a flower had considerable influence on when budbreak and anthesis occurred (Table 1). For this study, budbreak is defined as the date on which the flower bud reached 3 ± 0.1 mm in length. For all inflorescence types, apical flowers (position 1) were precocious; position 2 flowers, just below the apex, were typically delayed in their development relative to position 1 and most other positions. This situation is consistent with apical dominance often observed in flowering shoots. Development of flowers in position other than 1 and 2 was highly variable. Position 3 flowers were often as delayed in their development as position 2 flowers. Flowers more basal in the inflorescence appeared to be influenced to a lesser degree by apical dominance and were often intermediate in their development to both positions 1 and 2. The results provided evidence of other sites of dominance. In inflorescences with 7 or more flowers, the flower in position 6 typically reduced the rate of development of the flower immediately below it and, to a lesser extent, the other flowers basal to it. Thus, flowers in position 7 often had budbreak dates as late as those in position 2. The variability associated with the development of flowers in positions 3 through 7 is evident even when the data are averaged for these positions (Table 1). These results were consistent for all site for both years of the study.

The development of flowers in each position within inflorescences having different leaf to flower ratios was examined to determine the influence exerted by the inflorescences type on flower development. Generally, flowers in all positions of leafy inflorescences were delayed in their development by approximately 4 days over their counterparts in leafless

inflorescences. This delay was not significant at the 5% level (Student's t test) at budbreak but was for anthesis (Table 2). Only data for the apical (position 1) flowers are reported; the influence of inflorescence type was similar for all positions.

To examine whether leaf to flower ratio influenced flower development before budbreak, from budbreak to anthesis, or postanthesis, we analyzed the rate of development of individual flowers as a function of temperature. Calculation of the number of degree-days above the threshold temperature of 12.7°C (55°F) required by individual flowers to develop from budbreak to anthesis or petal fall for 3 sites studied in 1983 confirmed that the rate of flower development during this period was solely dependent on the daily temperatures experienced; the number of degree-days was the same at the 5% level (Student's t test) regardless of the type of inflorescence on which the flower was borne or its position within the inflorescence (Table 3). Thus, the effect of "leafiness" on flower development occurred prior to budbreak of the apical flower, e.g., inflorescence budbreak.

The delay in development associated with "leafness" of an inflorescence is consistent with the fact that shoot development in citrus is a continuum; the shoot apex continues to initiate new leaf primordia until it differentiates into a flower. Sometime later, flowers are initiated in the axil of each leaf below the apex of what is now an inflorescence. These events occur prior to visual (macroscopic) budbreak[5]. Since inflorescence leaves do not influence flower development from budbreak to petal fall, the date of budbreak of the apical flower of an inflorescence is a good indicator of the relative date that an apex became "committed" to flowering. Thus, the later the date for budbreak, the more leaves per flower.

Since flowering shoots have the potential to have a leaf and a flower at every node, which would give a leaf to flower ratio of just under 1 (the apical flower is not borne in the axil of a leaf)[5], the observation that early developing inflorescences (early date of budbreak or anthesis) were predominantly leafless while later ones were leafy suggests that an early commitment to flowering by the apex causes leaf primordia to abort, while a later commitment to flowering inhibits development of the axillary flowers.

Comparison of the mean number of leaves and mean number of flowers for leafless and leafy inflorescences confirms that there is both a loss in flowers and an increase in leaves to achieve the higher leaf to flower ratio observed for later-developing inflorescences (Table 4). Consistent with these changes, flowers borne on later-developing inflorescences typically had a higher probability of being in the axil of a leaf that developed to maturity (Table 4).

After petal fall, leaf to flower ratio had considerable influence on the growth rate of the young ovary. Flowers borne on leafy inflorescences exhibited faster ovary growth postanthesis (Table 4). This latter observation is of interest since fruit of the 'Washington' navel orange which have higher growth rates during the 2nd week after petal fall have a higher probability of persisting on the tree to harvest[2].

The results of the field studies provide evidence that in any

Table 3 Mean number of degree-days required by individual flowers to go grom budbreak to anthesis (A) or petal fall (PF) as a function of flower position and inflorescences type

Leaf to flower ration	Event	$\bar{X}$ degree-days + std. dev. (number of flowers)		
		Flower position within the inflorescence		
		1	2	> 2
		Lindsay – 1983		
L/F 0 <	A	228 ± 2i (65)	240 ± 29 (26)	243 ± 29 (41)
	PF	37 ± 11 (65)	41 ± 17 (26)	41 ± 16 (41)
L/F 1 <	A	238 ± 29 (47)	244 ± 34 (30)	248 ± 35 (71)
	PF	40 ± 15 (43)	42 ± 17 (30)	45 ± 18 (71)
L/F ⩾ 1	A	246 ± 34 (42)	–	247 ± 34 (16)
	PF	44 ± 17 (42)	–	45 ± 18 (16)
		Lindcove – 1983		
L/F 0 <	A	276 ± 21 (109)	276 ± 22 (11)	277 ± 22 (6)
	PF	30 ± 8 (106)	31 ± 11 (11)	32 ± 12 (6)
L/F 1 <	A	275 ± 23 (27)	275 ± 23 (10)	277 ± 25 (31)
	PF	33 ± 13 (26)	34 ± 15 (10)	37 ± 22 (31)
L/F ⩾ 1	A	274 ± 27 (33)	–	274 ± 27 (7)
	PF	37 ± 21 (33)	–	38 ± 21 (7)
		Fresno – 1983		
L/F 0 <	A	259 ± 34 (10)	277 ± 46 (12)	283 ± 48 (6)
	PF	33 ± 17 (10)	43 ± 20 (5)	–
L/F 1 <	A	276 ± 44 (10)	279 ± 42 (8)	283 ± 41 (14)
	PF	44 ± 19 (8)	–	48 ± 19 (5)
L/F ⩾ 1	A	277 ± 42 (9)	–	279 ± 41 (3)
	PF	49 ± 20 (8)	–	–

Table 4 Characteristics associated with leafless (less than 1 leaf per flower) and leafy (greater than 1 leaf per flower) inflorescences

Site	Year	Mean number leaves / Mean number of flowers			Flowers in leaf axils (%) [x]		Ovary (fruit) growth rate [z] (mm per day)	
		< 1	> 1		< 1	> 1	< 1	> 1
Riverside	1984	$\frac{1}{4}$	$\frac{4}{3}$	$\frac{*}{*}$[y]	22	50	0.09	0.11*
Lindsay	1983	$\frac{2}{4}$	$\frac{5}{3}$	$\frac{*}{*}$	34	48	0.28	0.30*
Lindcove	1983	$\frac{1}{3}$ <	$\frac{4}{1}$	$\frac{*}{*}$	17	21	0.13	0.17*
Lindcove	1984	$\frac{3}{5}$	$\frac{4}{2}$	$\frac{*}{*}$	68	55		
Visalia	1984	$\frac{3}{5}$	$\frac{4}{4}$	$\frac{*}{*}$	67	47	NE[w]	–
Fresno	1983	$\frac{2}{4}$	$\frac{6}{3}$	$\frac{*}{*}$	39	83	NE	–
Fresno	1984	$\frac{3}{5}$	$\frac{5}{4}$	$\frac{*}{*}$	55	67	NE	–

[z] Growth rate of the ovary (fruit) was determined by measuring fruit transverse diameter 2 times a week beginning at pedal fall. Growth rate during the 2nd week after petal fall is reported.
[y] Paired values followed by an asterisk (*) are significantly different ($p < 0.05$ by Student's t test).
[x] Statistical analysis was not done.
[w] Data have not been entered into the computer for analysis at this time.

population of flowers of the 'Washington' navel orange variety, the first 10% of the flower population to reach anthesis will be dominated by apical flowers borne on leafless inflorescences (Table 5).

Using 9.4°C as the threshold temperature, the best dates to initiate the accumulation of degree-days were determined: January 29, which gave a mean value of 505.5 degree-days to 10% anthesis in the southwest tree quadrant, and February 1 which gave a mean value of 744.4 degree-days to 75% petal fall in the northeast tree quadrant. Comparison of the observed and predicted dates for these two bloom events is presented in Table 6. The results are preliminary; actual petal fall has

not yet been calculated for two sites for the 1984 season. The model will be field-tested in the spring of 1985; subsequent modification may be required.

Discussion

The topophysical effects on flower development observed during bloom of the 'Washington' navel orange variety in California have been reported previously for the 'Valencia'[3,4] and 'Hamlim'[3] sweet orange varieties (*C. sinensis*) and for 'Marsh' grapefruit (*C. paradisi*)[3]. Differentiation between the effects that inflorescence type and flower position within the inflorescence have on flower development in the "Washington' navel orange along with subsequent determination of the degree to which flower development in this variety was affected makes it possible to predict bloom phenology for this crop. For example, in our particular case, the flowers comprising 10% anthesis on the southwest quadrant of the tree for most sites

Table 5 Characteristics of the flowers comprising 10% anthesis in the southwest tree quadrant

		At 10% anthesis in the southwest quadrant	
		Characteristics of the flowers that have opened	
Site	Year	% in position 1	% borne on leafless inflorescences (L/F < 1)
Riverside	1984	93	93
Lindsay	1983	100	81
Lindcove	1983	100	83
Lindcove	1984	100	25
Fresno	1983	100	97
Fresno	1984	100	88

Table 6 Use of degree-days to predict the beginning and end of the flowering period in the 'Washington' navel orange variety

		10% anthesis			75% petal fall		
		Southwest tree quadrant			Northeast tree quadrant		
		Observed Predicted Error (calendar date)		(days)	Observed Predicted Error (calendar date)		(days)
Site	Year						
Riverside	1981	NA[z]	—		Apr. 20	Apr. 16	− 4
Riverside	1982	Apr. 12	Apr. 17	+ 5	Apr. 30	Apr. 3	+ 3
Riverside	1983	Apr. 11	Apr. 5	− 6	Apr. 28	May 2	+ 4
Riverside	1984	Mar. 15	Mar. 13	− 2	Apr. 4	Apr. 4	0
Lindsay	1983	Apr. 22	Apr. 20	− 2	May 13	May 11	− 2
Lindcove	1983	Apr. 20	Apr. 12	− 8	May 9	May 5	− 4
Lindcove	1984	Mar. 31	Apr. 1	+ 1	Apr. 25	Apr. 22	− 3
Visalia	1984	Apr. 9	Apr. 14	+ 5	NE[y]	—	
Fresno	1983	Apr. 24	Apr. 21	− 3	May 13	May 14	+ 1
Fresno	1984	Apr. 12	Apr. 15	+ 3	NE	—	
Mean ± standard deviation				4 ± 2			3 ± 1
Coefficient of variation				0.8			1.2

[z] Data not available for the early part of the bloom period in 1981.
[y] Data have not been entered into the computer for analysis at this time.

in California will be predominantly apical flowers in relatively leafless inflorescences. Any environmental parameters or cultural practice that significantly decreases the population of leafless inflorescences will concomitantly delay bloom. Furthermore, it is apparent that the length of the bloom period is a function of 1) the proportion of flowers borne on leafy inflorescences in the total flower population and 2) daily temperatures just prior to or during this period. For the 2 years of this study, the length of the bloom period from 10% anthesis in the southwest tree quadrant to 75% petal fall in the northeast tree quadrant averaged 20 ± 2.5 days.

Because the period of flowering in this variety is relatively long, accuracy is needed in predicting the end of bloom. By the time 75% petal fall has been reached in the northeast tree quadrant, flowers on the rest of the tree have already passed this point. Since young fruit are susceptible to damage by citrus thrips from petal fall until they reach 4 cm transverse diameter, the time at which a grower can start thrips population control by the application of pesticides is important.

In addition to providing the data necessary to construct the temperature-dependent phenology model of flowering in the 'Washington' navel orange which will be field-tested for the bloom of 1985, the present study also provided information important to understanding the physiology of the flowering process in citrus.

Demonstration that flower development from flower budbreak to anthesis or petal fall required the same number of degree-days regardless of the inflorescence type on which the flower was borne or its position within the inflorescence has not been reported previouwly. The results of the field studies

and degrees-day analysis support the interpretation that leafy inflorescences arise from a late commitment to flowering by the shoot apex which is accompanied by reduced axillary flower development. As a consequence, flowers in leafy inflorescences undergo anthesis and petal fall later than their counterparts in leafless inflorescences even though their rate of growth from budbreak to anthesis may be faster due to the warmer daily temperatures that occur later in the spring. Since the results of this research demonstrated that flower development during the period from budbreak to anthesis or petal fall was solely dependent on temperature, they rule out the possibilities that inflorescence leaves enhance or inhibit flower development during this period. Thus, contrary to suggestions in the literature, inflorescence leaves do not serve as a significant source[4] nor a competitive sink[9] for photosynthate hormones or mineral elements during this 6- to 8-weeks period in the 'Washington' navel orange variety. However, the results suggest that developing flowers and leaves might be significant competitive sinks prior to budbreak, flowers being the stronger sinks in early-developing inflorescences and leaves the stronger sinks in later-developing inflorescences.

Taken together, our data suggest that the improved fruit set and yield observed for later-opening flowers, i.e., those in position 2 of the inflorescence and those borne on leafy inflorescences, of the 'Washington' navel orange[1,2] and other citrus varieties[1,3,4] is probably due to the more favorable temperatures experienced by these flowers during their development as first proposed by Haas[1]. The warmer temperatures result in faster flower growth, including the calyx, corolla, and ovary. Post-petal fall, leaf to flower ratio of an inflorescence

influences ovary (fruit) growth rate. Faster-growing fruit are borne on leafy inflorescences. Ovaries with higher growth rates during their early development (2 weeks after petal fall) tend to remain faster growing, to persist on the tree longer, and to contribute more fruit to harvest[2,5,8].

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INTER-RELATIONSHIP BETWEEN FLOWERING AND FRUITING IN SWEET ORANGE, CULTIVAR NAVELINA

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Abstract. **Fruit exert an inhibitory effect on bud sprouting the following spring. Nevertheless, at fruiting densities up to 20 fruits/m² cup external area, both parameters are not inter-related. The relation between these two parameters varies with the year and the orchard productive potential, and at constant fruiting, bud sprouting has been observed to be more inhibited in low-bearing orchards. High bud sprouting densities tend to increase the number of leafless one-flower and multi-flower sprouts, while the number of vegetative sprouts decreases. This suggests that a reversion of floral buds to vegetatibe buds occurs with low sprouting densities. Flowering densities lower than 20 flowers/100 nodes restrict the number of fruits at harvest. At higher flowering densities, fruit number is independent of flower number in productive orchards, or is reduced in low-bearing orchards. Total fruit-set per tree was the principal factor determining tree productive potential.**

Introduction

Flowering is a critical phase in the determination of crop yield; without it, fruit formation is impossible. However, fructification is correlated to flowering only when the latter is either too scarce[21] or excessively heavy[1]. As in other species forming a large amount of flowers, fruit set in citrus species occurs only in a very low percentage of the initially formed flowers, thus fruit set is normally the central factor determining final yield[15].

On the other hand, fruit load has an inhibitory effect on flowering[20], in such a way that a large number of fruits (especially in the more sensitive cultivars) may significantly reduce flowering and thus initiate an alternate bearing cycle[17]. Flowering and fruiting are therefore inter-related and an equilibrium between them is necessary to obtain high yields in a continuous manner.

The present work involves a comparative study of flowering, fruit set and crop yield in trees from productive and improductive sweet orange cv. Navelina groves. Observations included differences between groves as well as between trees within the same grove. The study was conducted over a period of 3 years and focused on the following aspects: a) sprouting and flowering

as influenced by fruit load; b) relationships between flowering and fruiting.

Materials and Methods

The investigation was conducted in three adult sweet orange (*Citrus sinensis* [L.] Osbeck) groves of the Navelina cultivar, located in the regions of Picassent (PICASSENT), Quart de les Valls (QUART) and Vila-Real (VILA-REAL), in the Province of Valencia, Spain.

The PICASSENT grove was a low-bearing one, with a fruiting density under 12 fruits/m² of canopy, and with average yields under 42 kg/trees. The QUART and VILA-REAL groves, on the other hand, produced wigh yields, with a fruiting density between 20-30 fruits/m² of canopy, and average yields higher than 65 kg/tree.

Shoot growth (vegetative and floral) characteristics were studied during spring of 1981 and 1982. Fifteen trees were evaluated during 1981 at the PICASSENT and QUART groves, but this number was increased to 30 and 26, respectively, during 1982. Studies at the VILA-REAL grove were conducted on the same 16 trees during both years.

Prior to shoot emergence, four branches were selected from around each tree; each had a diameter between 2.0 and 2.5 cm, and contained from 1500 to 3000 nodes. Imediately before anthesis, once shoot growth had been completed, the following information was recorded: a) total number of nodes per branch; b) number of shoot-forming nodes; c) number and types of shoots formed; d) number of organs (flowers and leaves) per node.

Shoots were classified according to[6] in the following types: a) multiflowered leafless shoots (M. Ls. S); b) one-flowered leafless shoots (O. Ls. S.); c) multiflowered leafy shoots (M. Ly. S.); d) one-flowered leafy shoots (O. Ly. S.), and e) vegetative shoots (V. S.).

In order to compare yields among trees, data were adjusted to tree size, by determining fruiting density as the number of harvested fruits per unitary area of external canopy (number of fruits/m² of canopy). Yields from the PICASSENT and QUART groves were evaluated during 1980, 1981 and 1982, while at VILA-REAL they were evaluated only during 1981 and 1982.

Results and Discussion

Relationship between yield and shoot growth

The percentage of shoot-forming nodes during 1981 was inversely related to the previous year fruiting density (Fig. 1). However, such relationship was not clear during 1982 (Fig. 2), and at the QUART and VILA-REAL groves, where the average fruiting density per tree during 1981 had been higher than