CALIFORNIA AVOCADO COMMISSION

PROJECT PLAN - RESEARCH GRANT PROPOSAL

Proposal Budget Requested: **$32,331**

CAC Fiscal Year: 2008 - November 1, 2007 - October 31, 2008

Anticipated Duration of Project: 2 years

This project is: Ongoing, year 2 of 2

Project Title: **Developing Field Strategies to Correct Alternate Bearing**

Name of Primary Researcher: Carol J. Lovatt

Address: Department of Botany and Plant Sciences

Telephone: 951-827-4663

Fax: 951-827-4437

Email: carol.lovatt@ucr.edu

Name of Research Institution: University of California, Riverside

Name(s) of Supporting Research Staff (including, if different from preceding, address, telephone, fax and email):

Postdoctoral Research Plant Physiologist (TBA); Elias Serna, Lab. Asst.

Current vitae for all research participants. Please send one vitae per year, not one per project.

Per instructions, Carol Lovatt and Elias Serna's CVs have been sent in a separate file and not attached to each project.

Please provide a list of relevant published research.

Please see Attachment 1.

Provide a review of literature relevant to this research project.

Please see Attachment 2.

Indicate to which, if any, of the listed industry research priorities the proposal relates. (NOTE: Listed industry research priorities are intended as a guideline. Proposals addressing other areas will not be excluded from the review and funding process.)

This proposal addresses the objective of the California avocado industry to develop and implement research programs that lead to increased grower profitability. The research will contribute to our understanding of the role of endogenous growth regulators in avocado, a research area of importance to the California avocado industry.

Provide a review of the literature relevant to the research project.

Annual production data for the last 14 years clearly depict 2- to 3-year on-off cycles for the California avocado industry (Brokaw Nursery Inc., 2002; California Avocado Commission, www.avocado.org). The alternate bearing index [ABI = (year 1 yield – year 2 yield) ÷ (year 1 yield + year 2 yield)] for our numerous research orchards ranged from 0.57 to 0.92 (Lovatt, 1997). By this calculation, every other year grower income is significantly reduced below the orchard's potential. Lower yields (5,700 lbs./a) in the 1990's (Arpaia, 1998) reduced ABI, but reduced yields are not an acceptable solution to alternate bearing. Moreover, it is only a matter of time before climatic conditions initiate alternate bearing in avocado growing areas entraining trees again in on-off cycles. Alternate bearing is initiated by climatic conditions (freeze damage, high temperatures, drought) causing flower or fruit abscission which result in an off-crop year that is followed by an on-crop year, typically the next year depending on how long it takes for the trees to recover. Conversely, climatic conditions that are optimal for flowering and fruit set such that crop thinning fails to take place result in an on-crop that is followed by an off-crop. Once initiated, alternate bearing becomes entrained through the effect of crop load on endogenous tree factors that ultimately impact floral intensity (Salazar-García et al., 1998). Thus, there is a recurring need for a corrective strategy that does not reduce yield.

The results obtained during the last year of a 4-year project on alternate bearing provided three new interesting pieces of information. (1) During an on-crop year, removing all the setting/developing fruit from a set of on-crop trees each month from June to January revealed the date by which fruit must to be removed in order to increase return bloom to a value greater than that of on-crop trees and equal to that of off-crop trees. Fruit removal in June and July were the only treatments that significantly increased the number of vegetative shoots that developed in the summer on the spring flush parent shoots compared to all other treatments, including the off-crop trees ($P = 0.0029$) (Tables 3, 4 and 5). Fruit removal in June and July were the only treatments that significantly increased the number of indeterminate ($P = 0.0673$) and determinate ($P = 0.0007$) floral shoots borne on the summer shoots during the return bloom to a value greater than on-crop trees and equal to that of the off-crop trees. Fruit removal in July and August numerically, but not significantly, increased the number of fall shoots that developed on the spring flush parent shoots ($P = 0.1090$). This resulted in numerically more indeterminate floral shoots and significantly more determinate inflorescences ($P = 0.0431$) borne on fall shoots during the return bloom than on the on- or off-crop trees. Fruit removal in July and August also resulted in a significant increase in the number of indeterminate floral shoots produced by the spring flush parent shoots during the return bloom ($P = 0.0568$) compared to both on- and off-crop trees but trees with fruit removed in July, August or September resulted in significantly more determinate floral shoots ($P = 0.0005$) produced by the spring flush parent shoots than on-crop trees. Trees having their fruit removed in August produced more determinate floral shoots on the spring flush parent shoots than the off-crop trees ($P = 0.0005$). It was of interest that on-crop trees and trees with all fruit removed in December produced significantly more vegetative shoots during the return bloom on the spring flush parent shoots than all other treatments. In contrast, the number of vegetative shoots borne on summer vegetative shoots for trees with their fruit removed in January was equal to that of on-crop trees and trees with fruit removed in December and significantly greater than off-crop trees and trees with their fruit removed from June to October. This observation was consistent with the reciprocity we reported previously between floral versus vegetative shoot development as a function of crop load (Tables 1 and 2) and strongly suggests that the presence of fruit in December or later represses floral shoot development in favor of vegetative shoot development, consistent with the release of buds from rest that had not become irreversibly committed to floral development.

(2) To test this possibility further, we removed all fruit from sets of trees in February and March and compared their current spring bloom with off- and on-crop control trees (on-crop trees were harvested in June after bloom). Removal of fruit at these late dates had no effect on the number of inflorescences produced by the summer or fall vegetative shoots during the return bloom in 2006, which was significantly less than the number produced by the off-crop trees and equal to the number produced by on-crop trees ($P < 0.0001$). However, fruit removal in February or March significantly increased the number of vegetative shoots produced by the summer-fall shoots during the return bloom in spring 2006 compared to both off- and on-crop trees ($P = 0.0031$). Fruit removal at these late dates had no effect on the contribution of vegetative or floral shoots made by the spring flush parent shoots (shoots produced in spring 2005, 1-year old shoots) to return bloom in spring 2006. The results of this experiment confirm that removing fruit after December increases the number of vegetative to floral shoots out of the total pool of shoots that develop during the return bloom. The results confirm that buds released from rest were not irreversibly committed to floral development.

(3) The above results were interesting with regard to our attempts to increase the number of summer-fall shoots produced by on-crop trees in the summer of 2005 in order to increase flowering in the return bloom of spring 2006. Treatments that successfully increased summer or fall vegetative shoot growth significantly increased the number of vegetative, not floral, shoots that developed during the return bloom this spring. These treatments did not reduce the number of floral shoots that developed but instead reduced the number of resting buds to increase the total number of shoots that developed in the return bloom. The treatments had no effect on the number of resting buds on the summer vegetative shoots, but the number of resting buds on fall shoots was consistently numerically, but significantly reduced by the treatments. Whereas we can increase summer-fall shoot growth on on-crop trees, the presence of fruit through the bloom period resulted in increased vegetative shoot development when resting buds underwent bud break, a result consistent with the failure of buds to have achieved irreversible commitment to flowering. This result was unexpected based on our results the previous year showing that fruit did not inhibit the transition of apical buds on summer shoots from transitioning to floral buds. It is clear that we need to follow floral bud development for a longer period of time not only for apical buds, but also for axillary (lateral) buds. In addition, if the treatments release only buds formed on fall flush shoots, this outcome might be expected. However, the possibility that the

presence of fruit interferes with the process by which apical and/or axillary buds become irreversibly committed to flowering and causes the reversion of floral buds on summer shoots to vegetative buds cannot be ruled out. Thus, to overcome alternate bearing in the field, it is essential to determine which buds, apical and/or axillary, on spring, summer and/or fall vegetative shoots become irreversibly committed to flowering in the presence of fruit, such that their release from rest in spring would result in an increased number of floral shoots. It is also essential to determine for buds that do not become irreversibly committed to flowering when the failure to commit occurs and why.

Provide a brief summary of how you believe this project is responsive to the indicated priority, and how it supports industry objectives, expectations and vision.

The proposed research supports the industry objectives, expectations and visions of increasing grower profitability. In orchards exhibiting alternate bearing, yield is reduced below the potential of the orchard and grower income is significantly reduced during off-crop years. The PI has successfully reduced the impact of alternate bearing in pistachio and is working towards mitigating alternate bearing in 'Pixie' mandarin. Similarities in the physiology underlying the mechanisms of entrainment are emerging, but interesting subtle differences in the mechanism are also emerging. For example, for the 'Pixie' mandarin the contribution to return bloom made by the parent (1-year-old wood) shoots is greater than for the 'Hass' avocado. Thus, fruit removal in December results in a greater increase in return bloom for the 'Pixie' mandarin than 'Hass' avocado. Also for 'Pixie' mandarin, the fruit have a stronger effect localized to the branch bearing the fruit than on the whole tree. For the 'Hass' avocado the reverse is true. For both crops, crop load is related to inflorescence number and controls the floral intensity of the return bloom. However, 'Hass' avocado is unique in that crop load also controls vegetative shoot growth in a reciprocal manner, i.e., the fewer floral shoots, the more vegetative shoots. In the 'Pixie' mandarin crop load has no effect on vegetative shoot number. This relationship suggests that for 'Hass' avocado, fruit effect the transition of vegetative shoot apices to floral apices and to commitment to floral development, whereas this is clearly not the case in the 'Pixie' mandarin.

The results of the proposed research will clarify whether treatments that increase summer and/or fall shoot growth can be used to increase floral intensity by establishing which buds, if any, remain floral and for how long. This information is essential to learn whether future PGR treatments can be designed to increase return bloom or whether only fruit thinning strategies will work and how they should be employed, i.e., which shoots should have fruit removed and the deadline by which this must be completed.

In addition, this project will save time in developing the use of exogenous foliar applications of PGRs to increase yield by identifying the specific buds to be targeted and the optimal PGR(s) to use and the correct phenological stage when the PGR should be applied, i.e., correct shoot flush to target to mitigate alternate bearing. We require only 2 years of funding to obtain this critical information before subsequently proceeding with further PGR treatments to overcome alternate bearing. It should be noted that we have already collected and analyzed the PGR concentrations in fruit exudates from fruit collected monthly from June through May and also the corresponding PGR concentrations of buds collected from June to May. So once we identify the critical effect of fruit on floral bud development and the time at which it occurs, we already have the critical information on PGR events related to the negative effect of the fruit on floral development so that we can understand the cause of the negative effect.

A summary of the role of PGRs in alternate bearing from our previous CAC funded research follows. For the 'Hass' avocado in California, the on crop inhibits bud break of vegetative shoots in summer and fall and floral shoots in spring. Monthly fruit removal from on-crop trees from June through September increased return bloom equal to or greater than off-crop trees and greater than on-crop trees. Later fruit removal had no effect. Floral shoot number in April was related to January bud abscisic acid to isopentyladenosine (a cytokinin) (ABA:IPA) (r^2 = 0.24) ($P \leq 0.0074$) concentrations. Fruit removal in June reduced August apical bud indoleacetic acid (IAA) and ABA concentrations and increased summer and fall shoot number. In a second experiment, fruit were removed in February and March with no effect on floral intensity in April. Floral shoot number per shoot was related to March ABA:IPA (r^2 = 0.43, P = 0.0234) concentrations. In both experiments, summer-fall shoots contributed more floral shoots per shoot than spring shoots, with floral intensity related to January bud ABA:IPA (r^2 = 0.22) ($P \leq 0.0119$) and March bud ABA:IPA (r^2 = 0.38, $P \leq 0.0350$) concentrations, respectively. The results suggest that increasing the IPA cocntration of the buds in June and also in January-February (March is likely too late) should increase the floral intensity of the return bloom of on-crop trees.

Provide research summary indicating how research will be conducted (design/methodology), hypotheses or research questions to be addressed, and any other information you believe should be taken into account in review of this proposal (include here milestones against which you expect research will be evaluated at quarterly intervals. Note that research will be rigorously evaluated for progress, cost efficiency and quality of results. Written quarterly status reports (see attached form) will be required for all research funded, and continued funding will be contingent upon satisfactory progress. Similar annual evaluations will be conducted for any approved multi-year research projects.)

Specific goals of the proposed research are (*i*) to determine which buds, apical and/or axillary, on spring, summer and/or fall vegetative shoots become irreversibly committed to flowering in the presence of fruit, such that their release from rest in spring would result in an increased number of floral shoots, (*ii*) to determine for buds that do not become irreversibly committed to flowering when the failure to commit occurs, and (*iii*) to use our fruit exudates and bud PGR, carbohydrate, and nitrogen analyses to identify the cause of the negative effect. The results will be used to design PGR strategies to overcome alternate bearing in the field.

Objectives are: (*i*) to determine which buds, apical and/or axillary, on spring, summer and/or fall vegetative shoots become irreversibly committed to flowering in the presence of fruit, such that their release from rest in spring would result in an increased number of floral shoots, (*ii*) to determine for buds that do not become irreversibly committed to flowering when the failure to commit occurs, (*iii*) to use our fruit exudates and bud PGR, carbohydrate and nitrogen analyses to identify the cause of the negative effect, and (*iv*) to use the results to design PGR strategies to overcome alternate bearing for future field testing.

To meet the above objectives, spring flush branches with and without fruit on on-crop trees will be tagged and the following treatments applied to sets of 20 trees each, five each apical and axillary buds will be collected from spring, summer and fall flushes from 5 of 15 trees in a rotating pattern each month from July to February to have enough buds for the 8 months; the remaining five trees with no buds removed will be evaluated for the number of summer and fall shoots they produce and for the contribution of each flush to return bloom in spring: (1) all fruit removed in July, (2) trees with setting fruit removed in July but the mature on-crop fruit left through October, (3) on-crop control trees and (4) off-crop control trees. Treatments will be arranged in randomized complete block design.

All data will be statistically analyzed by analysis of variance using SAS at P = 0.05.

Provide a brief summary of how work contemplated by this proposal will enhance what is already known about the topic. Indicate here how the proposed project will complement or can be integrated with other research.

As discussed above, our results strongly suggest that fruit of the 'Hass' avocado interfere with the irreversible commitment of buds to floral development. Our previous analysis of apical buds from summer shoots on on-crop trees indicated that the apical buds transitioned from vegetative to floral in August and reached stage four of floral development on the scale of Salazar-García et al. (1998) in September and remained at this stage through February. These are the likely source of the floral shoots produced by on-crop trees during return bloom. It is possible that either axillary buds of summer shoots or apical and/or axillary buds of fall shoots are the buds negatively affected by the presence of fruit that subsequently grow as vegetative shoots during the return bloom. If the fruit prevent these buds from undergoing phase transition from vegetative to reproductive growth or reaching irreversible commitment to flowering, it is the first evidence that this mechanism, which is frequently proposed and discussed in the literature, actually functions as a mechanism contributing to alternate bearing. In addition, this research will determine whether the mechanism is restricted only to the branch bearing fruit or a whole tree effect related to crop load. It will also identify the effect of holding mature fruit on the tree through October independent of the current setting crop. As discussed above, the results of this research will provide the basis for designing strategies to mitigate alternate bearing and, thus, should be integrated into PGR treatments, pruning strategies, fruit thinning strategies, or harvesting strategies.

Provide a statement of objectives and a schedule of expected accomplishments for the funded year (November 1, 2007-October 31, 2008).

Because this project is examining the effect of crop load on flowering, it continues through harvest in year 2, with final analysis of buds and data analysis completed by the end of year 2. In year 1, the orchard will be selected, the trees for each treatment will be selected, branches will be selected and tagged on each tree per treatment, apical and axillary buds on each branch will be selected and tagged and the treatments will be imposed. Tree growth on treated trees will be evaluated monthly and bud samples will be collected monthly and analyzed. The productivity of buds on spring summer and fall flush shoots will be determined as a percent of the total buds produced per shoot times the total number of shoots in each flush just prior to commercial harvest in late summer 2008.

Indicate expected duration of project:

We are requesting funding for one crop year, 2 funding years.

2007-08 PROJECT BUDGET

Salaries & Benefits:

Project Leader: Carol Lovatt	0
Postdoctoral Researcher I 1 TBA (11 mo. @ $2,750/mo., 50% plus 1 mo. @ $2,833/mo., 50%)	16,542
Laboratory Assistant: Elias Serna ($12.57/h x 40 h/mo. x 7 mos., plus 1 mo. @ $12.95/h x 40 h/mo. To provide help with treatment applications, monthly data collection)	4,038
SRAs:	0
Benefits:	
TBA 32%	5,293
ES 44%	1,777
Subtotal:	**27,650**
Supplies/Expenses: Supplies for bud collection, preparation and analysis	**2,700**
Equipment:	**0**
Operating Expenses:	**0**
Travel: 32 roundtrips to Irvine; 90 mi. x $0.41/mi. =$1181 32-car days x $25/day = $800	**1,981**
Other:	**0**
Total:	**32,331**

Approximate total support funds for this project expected from other sources (include in kind contributions or other "soft money"; indicate source of all funds, in kind or otherwise)

Indicate whether support funds are guaranteed, provisional. If provisional, indicate conditions under which funds will/be provided/denied.

CAC payment/Disbursement Schedule is quarterly. (If 35% or more of project costs accrue at the front end of the project, please so indicate. A minimum of 20% of approved funding will be withheld pending receipt and approval of final report.)

Dates	Amounts
January 31, 2008	$6,466
April 30, 2008	$6,466
July 31, 2008	$6,466
October 31, 2008	$6,466

The remaining 20% ($6,467) due upon receipt of the final report for year 2 on October 31, 2008.

Is satisfactory execution/completion of research project(s) contingent upon receiving support funding *in addition to* CAC funding?

No

Projected budget for FY

All approved researchers will be required to sign a CAC Research Agreement for each year CAC funding is provided.

Signature (Project Leader): ____

Date: ___________

Approved By:

(Organization's Authorized Representative): ________________________________

Date: ___________

CALIFORNIA AVOCADO COMMISSION Approval:

____ __________________

Tom Bellamore, Corporate Counsel/Senior Vice President Date

ATTACHMENT 1

Salazar-García, S., L.E. Cossio-Vargas, I.J.L. González-Durán and C.J. Lovatt. 2007. Foliar- fruit applied GA_3 advances maturity and allows off-season harvest of 'Hass' avocado. HortScience 42:257-261.

Salazar-García, S., L.E. Cossio-Vargas, C.J. Lovatt, I.J.L. González-Durán, and M.H. Pérez-Barraza. 2007. Crop load affects vegetative growth flushes and shoot age influences irreversible commitment to flowering of 'Hass' avocado. HortScience 41:1541–1546.

Violi, H.A., K.K. Treseder, J.A. Menge, S.F. Wright, and C.J. Lovatt. 2007. Density dependence and interspecific interactions between arbuscular mycorrhizal fungi mediate plant growth, glomalin production, and sporulation. Can. J. Bot. 85:63–75.

Salazar-García, S., L.E. Cossio-Vargas, I.J.L. González-Duran, and C. J. Lovatt. 2006. Effect of canopy sprays with plant bioregulators on 'June fruit drop', yield and fruit size of 'Hass' avocado. Acta Hort. 727:197-202.

Lovatt, C.J. 2006. Plant growth regulators for avocado production. Calif. Avocado Soc. Yrbk. 88:81–91.

Lovatt, C.J. and G. Witney. 2001. Nitrogen fertilization of the 'Hass' avocado in California. AvoResearch 1(3):1-4,11.

Lovatt, C.J. 2001. Properly timed soil-applied nitrogen fertilizer increases yield and fruit size of 'Hass' avocado. J. Amer. Soc. Hort. Sci. 126:555-559.

Salazar-Garcia, S. and **C.J. Lovatt.** 2000. Use of GA_3 to manipulate flowering and yield of the 'Hass' avocado. J. Amer. Soc. Hort. Sci. 125:25-30.

Lovatt, C.J. 1999. Timing citrus and avocado foliar nutrient applications to increase fruit set and size. HortTechnology 9:607-612.

Salazar-Garcia, S. and **C.J. Lovatt.** 1999. Winter trunk injections of gibberellic acid altered the fate of 'Hass' avocado buds: Effects on inflorescence type, number, and rate of development. J. Hort. Sci. and Biotech. 74:69-73.

Salazar-Garcia, S., E.M. Lord, and **C.J. Lovatt.** 1999. Inflorescence development of the 'Hass' avocado: Commitment to flowering. J. Amer. Soc. Hort. Sci. 124:478-482.

Bertling, I. and C.J. Lovatt. 1998. Uptake of PGRs into determinate versus indeterminate inflorescences of the 'Hass' avocado (*Persea americana* Mill.). *In* Proc. Third World Avocado Congr., Tel Aviv, Israel, Oct. 21-27, 1995. Acta Hort. 1:3-6.

Jaganath, I. and C.J. Lovatt. 1998. Efficacy studies on prebloom canopy applications of boron and/or urea to 'Hass' avocado. *In* Proc. Third World Avocado Congr., Tel Aviv, Israel, Oct. 21-27, 1995. Acta Hort. 1:181-184.

Lovatt, C.J. 1998. Successful use of foliar applications of essential mineral nutrient elements to increase fruit set and yield of citrus and avocado. Subtropical Fruit News 6:21-24. [Invited contribution]

Lovatt, C.J. 1998. Nitrogen nutrition of the 'Hass' avocado--*Where does all the N go*? *In* Proc. Third World Avocado Congr., Tel Aviv, Israel, Oct. 21-27, 1995. Acta Hort. 1:152-159. [Invited contribution]

Lovatt, C.J. 1998. November or April soil-applied nitrogen fertilizer increases Hass avocado yield and fruit size. Calif. Avocado Grower, Oct. 1998(4):4-7. [Invited contribution]

Salazar-Garcia, S. and C.J. Lovatt. 1998. GA_3 application alters flowering phenology of 'Hass' avocado. J. Amer. Soc. Hort. Sci. 123:791-797.

Salazar-Garcia, S. and C.J. Lovatt. 1998. Effect of gibberellic acid on inflorescence phenology of the ‘Hass’ avocado. *In* Proc. Third World Avocado Congr., Tel Aviv, Israel, Oct. 21-27, 1995. Acta Hort. 1:37-41.

Salazar-Garcia, S., E.M. Lord and C.J. Lovatt. 1998. Inflorescence and flower development of the ‘Hass’ avocado (*Persea americana* Mill.) during "on" and "off" crop years. J. Amer. Soc. Hort Sci. 123:537-544.

Lovatt, C.J. 1997. Pollination biology and fruit set in avocado. *In* Proc. Austral. Avocado Grower’s Federation Inc. and N.Z. Avocado Growers Assoc. Inc., Conf. ’97: Searching for Quality, Rotorua, N.Z., Sept. 23-26, 1997. 1:98-105. [Invited contribution]

Salazar-Garcia, S. **and C.J. Lovatt.** 1997. Use of gibberellic acid to manipulate flowering in the ‘Hass’ avocado: a preliminary report. *In* Proc. Austral. Avocado Grower’s Federation Inc. and N.Z. Avocado Growers Assoc. Inc., Conf. ’97: Searching for Quality, Rotorua, N.Z., Sept. 23-26, 1997. 1:106-111.

Casale, W.L., V. Minassian, J.A. Menge, C.J. Lovatt, E. Pond, E. Johnson, **and F. Guillemet**. 1995. Urban and agricultural wastes for use as mulches on avocado and citrus for delivery of microbial biocontrol agents. J. Hort. Sci. 70:315-332.

Lovatt, C.J. 1994. Does an avocado early bloom spray make dollars and sense? Calif. Grower 18:13-15.

Blanke, M.M. **and C.J. Lovatt.** 1992. Anatomy and transpiration of the avocado inflorescence. Ann. Bot. 71:543-547.

Lovatt, C.J. 1991. Factors affecting fruit set/early fruit drop in avocado. 1990 Calif. Avocado Soc. Yrbk. 74:193-199. [Invited contribution]

Lovatt, C.J. and A.H. Cheng. 1990. Comparison of some aspects of nitrogen metabolism of avocado with citrus. Acta Hort. 2:489-495. [Invited contribution]

Nevin, J.M., C.J. Lovatt, and T.W. Embleton. 1990. Problems with urea-N foliar fertilization of avocado. Acta Hort. 2:535-541. [Invited contribution, through T.W. Embleton]

Nevin, J.M., C.J. Lovatt, I.L. Eaks, and H.D. Ohr. 1990. Separation of the effects of drought and infection by *Phytophthora cinnamoni* on ‘Hass’ avocado. Acta Hort. 2:729-736. [Invited contribution, through H.D. Ohr]

Nevin, J.M. and C.J. Lovatt. 1989. Changes in starch and ammonia metabolism during low temperature stress-induced flowering in ‘Hass’ avocado. A preliminary report. S. Afr. Avocado Growers' Assoc. Yrbk. 12:21-25. [Invited contribution]

ATTACHMENT 2

Arpaia, M.L. 1998. California Avocado Grower. Vol. 2 (April), p. 1.

Lovatt, C.J. 1997. Pollination biology and fruit set in avocado. Proc. Austral. Grower's Avocado Federation and N.Z. Avocado Growers Assoc. Conf. '97. 1:98-105.

Salazar-García, S., E.M. Lord, and C.J. Lovatt. 1998. Inflorescence and flower development of the 'Hass' avocado during "on" and "off" crop years. J. Amer. Soc. Hort. Sci. 123:537-544.

Table 1. Effect of crop load on spring 2004 growth.

Treatment	Branch	Yield 2004	Inflorescence Indeterminate	Inflorescence Determinate	Vegetative shoot	Inactive buds
		Kg/tree	%			
On-crop trees	+ fruit	36.82 a	15.71 b[z]	0.70	61.47 a	22.11 a
	– fruit		15.79 b	0.00	61.80 a	22.41 a
Off-crop trees	– fruit	1.95 b	29.77 b	0.00	64.97 a	5.26 b
Fruit removed in June	– fruit	2.68 b	71.14 a	0.44	23.58 b	4.92 b

[z]Means followed by different letters within a vertical column are significantly different by Tukey HSD test, *P* = 0.05.

Table 2. Effect of crop load on total spring 2004 growth borne on spring and summer-fall 2003 shoots.

Treatment	Inflorescence Indeterminate	Inflorescence Determinate	Vegetative shoot	Inactive buds
	%			
Total shoots				
+ fruit	25.00	1.39	53.29	24.30
– fruit	64.20	0.00	32.33	3.46
Spring shoots				
+ fruit	4.17	1.39	16.67	8.33
– fruit	18.00	0.00	4.00	0.80
Summer-fall shoots				
+ fruit	20.83	0.00	32.62	15.97
– fruit	46.20	0.00	28.33	2.66

Table 3. Effect of removing setting/developing fruit from on-crop trees compared to on- and off-crop control trees on the number of vegetative, indeterminate and determinate floral shoots and resting buds produced during the 2005 return bloom by the spring 2004 vegetative shoots.

	Vegetative	Indeterminate	Determinate	Resting buds
On-crop trees	4.1 ab	3.1 bc	1.4 ef	3.1
Off-crop trees	0.7 c	2.2 c	8.4 bcd	0.8
Fruit removed				
June	2.9 bc	6.8 abc	7.6 cde	2.3
July	2.0 bc	8.8 a	13.0 abc	1.6
August	2.1 bc	5.5 abc	16.3 a	0.8
September	1.4 c	9.0 a	14.8 ab	0.6
October	0.8 c	6.4 abc	7.5 cde	1.9
November	2.1 bc	7.9 ab	5.9 def	1.5
December	5.9 a	4.4 abc	0.6 f	2.4
January	2.6 bc	2.1 c	0.8 f	2.8
P-value	0.0036	0.0568	0.0005	0.1388

[z]Means followed by different letters within a vertical column are significantly different by Fisher's Protected LSD test, *P* = 0.05.

Table 4. Effect of removing setting/developing fruit from on-crop trees compared to on- and off-crop control trees on the number summer shoots produced by the spring 2004 vegetative shoots and on the number of vegetative, indeterminate and determinate floral shoots and resting buds produced by these summer shoots during the 2005 return bloom.

	Summer	Vegetative	Indeterminate	Determinate	Resting buds
On-crop trees	20.4 b	10.9 ab	11.4 c	6.2 d	1.6
Off-crop trees	28.0 b	3.8 bcd	16.9 bc	42.9 ab	0.5
Fruit removed					
June	40.8 a	2.0 bcd	37.1 ab	39.8 abc	1.1
July	44.0 a	2.4 bcd	40.4 a	56.8 a	1.3
August	27.1 b	2.0 bcd	14.3 c	52.9 a	0.4
September	21.5 b	1.3 cd	27.1 abc	25.0 bcd	0.1
October	17.0 b	0.6 d	13.8 c	18.0 bcd	0.3
November	19.1 b	8.0 abcd	11.5 c	15.5 cd	1.9
December	16.4 b	10.4 abc	7.4 c	0.1 d	2.6
January	24.5 b	13.5 a	14.1 c	5.1 d	2.0
P-value	0.0029	0.0487	0.0673	0.0007	0.4251

[z]Means followed by different letters within a vertical column are significantly different by Fisher's Protected LSD test, $P = 0.05$.

Table 5. Effect of removing setting/developing fruit from on-crop trees compared to on- and off-crop control trees on the number of fall shoots produced by the spring 2004 vegetative shoots and on the number of vegetative, indeterminate and determinate floral shoots and resting buds produced by these fall shoots during the 2005 return bloom.

	Fall	Vegetative	Indeterminate	Determinate	Resting buds
On-crop trees	2.2	2.5	1.3	0.3 bc	0.1
Off-crop trees	2.7	0.5	4.3	2.7 bc	0.0
Fruit removed					
June	2.0	1.3	2.6	1.0 bc	0.0
July	6.1	0.0	11.1	10.8 ab	0.0
August	8.5	0.1	7.9	17.5 a	0.0
September	3.1	0.1	3.9	6.4 bc	0.0
October	1.0	0.1	0.8	0.5 bc	0.1
November	2.0	1.5	1.6	0.0 c	0.0
December	1.1	2.3	0.1	0.0 c	0.0
January	2.9	4.0	0.1	0.0 c	0.1
P-value	0.1090	0.2896	0.3037	0.0431	0.5891

[z]Means followed by different letters within a vertical column are significantly different by Fisher's Protected LSD test, $P = 0.05$.