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UPTAKE OF PGRs INTO DETERMINATE VERSUS INDETERMINATE INFLORESCENCES OF THE 'HASS' AVOCADO (*PERSEA AMERICANA* MILL.)

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Abstract

The development of the vegetative shoot apex of the indeterminate inflorescence of the avocado potentially renders transpiration, water flux, and sink-source relationships within this type of inflorescence different from those of the determinate inflorescence. The influence of indeterminate inflorescence leaves on the import and distribution of xylem-transported PGRs within the inflorescence is not known. Thus, in this study, the uptake of tritiated PGRs into flowers, setting fruit, and small fruit of 'Hass' avocado *(Persea americana* Mill.) was contrasted in the two inflorescence types.

The main axis of intact determinate and indeterminate inflorescences at advancing stages of development were placed into small plastic jars containing one of the following tritiated PGRs: abscisic acid, indole-3-acetic acid, gibberellic acid, isopentenyl adenosine or zeatin riboside. Transport and allocation to the different organs of the inflorescences was determined.

At flower opening, greater amounts of IAA and ABA (on a per g fresh weight basis) were taken up by the developing leaves of the indeterminate inflorescence, but the amounts allocated to the flowers of either inflorescence type were not statistically different. At early fruit set, the vegetative flush continued to have a greater concentration of ABA than other organs. Indeterminate fruitlets accumulated GA_3, IPA, and ZR at concentrations equal to the leaves, but greater than fruitlets of determinate inflorescences. At later stages of fruit development, leaves still had greater concentrations of GA and IPA, but fruit on indeterminate and determinate inflorescences had equal concentrations of all PGRs.

Taken together, the results suggest that the vegetative flush does not deprive the flowers borne on indeterminate inflorescences of PGRs during early fruit development and that PGRs are allocated to flowers and fruit on the basis of a sink strength rather than transpirational flux.

1. Introduction

Interactions between the different organs of a fruit tree are complex. In avocado, competition between young developing fruit and the spring flush of vegetative growth has been implicated in reducing fruit set (Kalmar and Lahav, 1976; Köhne, 1987; Cutting and Bower, 1989). Conversely, a heavy fruit set reduces the intensity of the subsequent summer and fall vegetative flushes (Whiley et al., 1988). In addition, fruit compete for resources among

themselves (Wright, 1989). The involvement of plant growth regulators in these regulatory processes has been long established (Naylor, 1984).

The two inflorescence types of avocado (the determinate, totally floral, shoot and the indeterminate floral shoot terminating in a vegetative apex), provide a useful system to investigate the effect of the vegetative apex on the transport and distribution of plant growth regulators within the inflorescence.

Our objective was to determine quantitatively if the partitioning of PGRs supplied via the vascular system to flowers and fruit of an inflorescence is influenced by the presence of leaves, and if this partitioning changes during development.

2. Material and methods

Adult avocado trees of the cultivar 'Hass' located at the University of California, Riverside, were selected for the experiment. Determinate and indeterminate inflorescences were collected from trees and placed into plastic receptacles containing 6 ml of a 0.01 M 2-(N-Morpholino)ethanesulfonic acid (MES) solution, pH 6.4. To this solution, 2x105 dpm of one of the following tritiated plant growth regulators was added: indole-3-acetic acid (IAA), abscisic acid (ABA), gibberellic acid (GA3), zeatin riboside (ZR), and isopentenyl adenosine (IPA). Each PGR was previously demonstrated to occur in the vascular system (Bertling and Lovatt, in prep.)

The experiment was carried out at three different stages of development: (*i*), at full bloom when most of the flowers were open and the vegetative flush had just started to grow; (*ii*), at petal fall when the first signs of fruit set were visible and the inflorescence leaves were rapidly expanding; and *(iii),* when fruit were 2 by 3 cm (w x 1) in size and the oldest leaf was fully expanded.

After an incubation period of 24 h under constant light at 500 μmol/mm^2/s and 30°C, flowers/fruit and leaves were detached from the inflorescence and immediately shock frozen. Samples were homogenized, extracted in methanol over night, and thereafter the methanol removed in a rotary evaporator. The residue was dissolved in 0. 1 M acetic acid, centrifuged at 15x10^3 rpm for 15 min. The supernatant fraction was further purified through a C18 SepPak cartridge and the filtrate dried in a vacuum concentrator. The dried extract was dissolved in methanol, diluted with liquid scintillant, and the content of radioisotope measured with a liquid scintillation spectrophotometer.

3. Results

The uptake and translocation of GA_3 into flowers and fruit was greater than any other PGR at all stages of inflorescence development with the single exception of the concentration of IAA observed for fruit at stage III (Table 1). At stage I, GA_3 concentrations in flowers in either inflorescence type were not significantly different. After petal fall (stage II), indeterminate fruitlets contained GA_3 concentrations equal to those of the leaves and significantly greater than fruit borne on determinate inflorescences. At stage III, GA_3 concentrations were the same in fruit borne on both determinate and indeterminate inflorescences, but significantly greater in the leaves despite the fact that they were approaching full expansion.

Through all stages of inflorescence development, leaves of indeterminate inflorescences exhibited significantly greater concentrations of ABA than flowers or fruit of either

inflorescence type (Table 1). The accumulation of ABA by leaves, which decreased from stage I to III as the leaves expanded, had no impact on the uptake, translocation or distribution of ABA into flowers or fruit borne on the two types of inflorescences, i.e., their ABA concentrations were not statistically different at any stage of development.

Transport of ZR into leaves of indeterminate inflorescences was significantly greater than into flowers and fruit of these inflorescences at stages I and III. ZR was the only PGR that accumulated in flowers and fruit of determinate inflorescences to a concentration equaling that of the leaves of indeterminate inflorescences (stages I and III). Relative to ZR, the uptake and translocation of the cytokinin IPA was consistently lower. At stage II, fruit and leaves of indeterminate inflorescences had similar concentrations of ZR and IPA, respectively. These ZR and IPA concentrations were significantly greater than those of fruit borne on determinate inflorescences. By stage III, fruit borne on indeterminate inflorescences had ZR and IPA concentrations equal to fruit of determinate inflorescences and significantly lower than their leaves.

IAA uptake and translocation into leaves was initially high (stage I) and greater than in the flowers of either inflorescence type. At later stages of development, no significant differences between organs could be detected.

By stage III, PGR concentrations of fruit home on determinate versus indeterminate inflorescences were not significantly different. Consistent with this, the number of fruit retained by each inflorescence type was not significantly different: compare 3.9+/-1.5 to 2.6+/-0.9 fruitlets per determinate and indeterminate inflorescences, respectively.

4. Conclusions

In general, uptake and translocation of the PGRs analyzed in this study was greater into leaves of the vegetative apex of the indeterminate inflorescences than into flowers or fruit borne on either inflorescence type over the various stages of development. An unusual but consistent exception was the concurrent accumulation of PGRs (GA_3, ZR, and IPA) in fruit of indeterminate inflorescences at stage II of development. These differences disappear by stage III, resulting in leaf concentrations of GA3, ZR, and IPA that were greater than those determined for the indeterminate fruit. The relatively high leaf concentrations of GA3, ZR, IPA, and ABA at stage III are of interest as the leaves were approaching full expansion and maturation, consistent with the well known movement of these PGRs in the transpiration stream. Worthy of note is the fact that IAA, which is not known to move by transpirational flux, was somewhat lower in the leaves of indeterminate inflorescences at stage III.

The greater translocation of PGRs into indeterminate inflorescences due to the presence of leaves, resulted in greater PGR concentrations in the fruit borne on indeterminate inflorescences in several cases cited above. Reduced levels of PGRs in these fruit were not observed at any stage. This result is consistent with the fact that reproductive organs are greater sinks than vegetative organs (Cannell, 1985).

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References

Canell, M.G.R. 1985. Dry matter partitioning in tree crops. In: Attributes of trees as crop plants. eds. Canell, M.G.R. and Jackson, J.E., Natural Environment Research Council.

Cutting, J.G.M. and Bower, J.P., 1989. The relationship between basipetal auxin transport and calcium allocation in vegetative and reproductive Rushes in avocado. Scientia Horticulturae 41:27-34.

Kalmar, D. and Lahav, E., 1976: Water requirement of the avocado tree in the Western Galilee (1968-1974). Div. Sc. Publ. Bet Dagan. Pamphlet No. 157.

Köhne, S.J. and Kremer-Köhne, S., 1987: Vegetative growth and fruit retention in avocado as affected by a new plant growth regulator (Paclobutrazol). South African Avocado Growers' Yearbook. 10:64-66.

Naylor, A.W., 1984: Functions of hormones at the organ level of organization. In: Hormonal regulation of development II. Encyclopedia of plant physiology. New series. vol. 10:172-218.

Whiley, AW., Saranah, J-B., Cull, B.W. and Pess K.G., 1988: Manage avocado tree growth cycles for productivity gain. Queensland agricultural journal. 114 (1).

Wright, C.J., 1989: Interactions between vegetative and reproductive growth. In: Manipulation of fruiting ed.: Wright, C.J., Butterworths, London, Boston, Singapore, Toronto, Wellington, 15-27.

Table 1 - Uptake, translocation and distribution of ^{3}H-PGRs in determinate (D) and indeterminate (I) inflorescences of 'Hass' avocado from flowering to fruit set. Data are presented in dpm per g flowers, fruit or leaves per inflorescence, and are the average from 6 separate experiments of 6 inflorescences, at 3 different dates.

Developmental stage	I	II	III
	Most flowers open: first leaves emerging	Petal fall and early fruit set; oldest leaf appr. 6 cm long	Later fruit set, fruit 2x3 cm (w x l); oldest leaf fully expanded
PGR Inflorescence type		dpm/g	
GA_3			
D flowers/fruit	5423 a	3671 a	1375 a
I flowers/fruit	4424 a	11189 b	1451 a
I leaves	5777 a	6530 b	3396 b
ABA			
D flowers/fruit	1401 a	2540 a	233 a
I flowers/fruit	819 a	2425 a	414 a
I leaves	9306 b	5581 b	698 b
ZR			
D flowers/fruit	1794 ab	572 a	683 ab
I flowers/fruit	1453 a	1098 b	589 a
I leaves	2728 b	1744 b	1403 b
IPA			
D flowers/fruit	281 a	310 a	126 a
I flowers/fruit	379 a	809 b	88 a
I leaves	267 a	890 b	477 b
IPA			
D flowers/fruit	315 a	476 a	1871 a
I flowers/fruit	861 a	639 a	2897 a
I leaves	3587 b	465 a	1055 a