

GIBBERELLIN AND GROWTH IN STONE FRUITS: INDUCTION OF PARTHENO-CARPY IN PLUM

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Summary

Gibberellic acid and a mixture of gibberellin A₄ and gibberellin A₇ each induced seedless fruit development in plum. Parthenocarpic fruits grew more rapidly early in the season but their final diameters were only 60% of control. Hormones applied only to developing vegetative shoots and not to neighbouring flowers did not induce parthenocarp. The role of hormones in fruit growth is discussed.

I. INTRODUCTION

Most stone fruits have been induced to set parthenocarpically with hormones, but the plum has resisted attempts with auxins, gibberellins, and cytokinins, separately or in combination (Crane 1964). This report describes the induction of parthenocarp in plum (*Prunus salicina* cv. Sultan) with either gibberellic acid (GA₃) or a mixture of gibberellin A₄ and gibberellin A₇ (GA₄₊₇).

II. METHODS

Ten treatments were applied to 10 branches (40–60 cm long) on each of five mature plum trees. Pollination was prevented by cutting away the distal end of flowers containing stigmas and anthers 2 days before full bloom. Hormone solutions were then applied to the cup formed by emasculation, to the sepals and petals of non-emasculated flowers, or to shoots (0.5–1.5 cm long) from vegetative buds, using a camel-hair brush. Flowers, of which there were initially 200–300 per branch, were thinned to 50 per branch just before treatment. The diameters of four fruits per branch were measured at intervals during growth using vernier calipers or a circummeter (Batjer *et al.* 1957).

III. RESULTS

Table 1 shows the treatments applied and the percentage of fruits retained at different times after full bloom. During the 1967–68 season pollination and set of Sultan plums was generally poor and this was reflected in treatment 1 where all fruits dropped between 27 and 39 days after full bloom. However, on the same trees some similar but unthinned branches set as many fruits as treatments 6 and 9. To indicate the growth of non-emasculated, untreated fruits one such branch on each of the five trees was selected and fruit diameters measured as previously described. Growth of fruits from these untreated fruits and certain other treatments are shown in Figure 1.

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Despite the fact that non-emasculated fruits in treatment 1 all dropped, two treatments induced emasculated fruits to develop until maturity, viz. GA₄₊₇ applied to emasculated flowers and GA₃ applied to emasculated flowers and to shoots. Gibberellin A₁₃ (GA₁₃) was the least and GA₄₊₇ the most effective gibberellin. GA₃ applied to shoots alone did not increase set, yet applied to shoots and ovaries it was more successful than GA₃ applied only to ovaries. Zeatin did not induce parthenocarp.

TABLE 1
EFFECT OF HORMONES ON FRUIT DROP IN PLUMS
Values without a common letter are significantly different at the 5% level

Treatment	Hormone* and Concn. (p.p.m.)	Organ to which Hormone was Applied	Percentage of Fruits Retained at the Following Days after Full Bloom†:				
			27	39	54	68	98
1 (not emasculated)	—	—	51abc	0b	0c	0b	0b
2 (not emasculated)	Zeatin (400)	Petals and sepals	69a	0b	0c	0b	0b
3 (not emasculated)	GA ₃ (500)	Petals and sepals	61abc	25a	4c	0b	0b
4 (emasculated)	—	—	37bcd	0b	0c	0b	0b
5 (emasculated)	Zeatin (400)	Ovaries	22d	0b	0c	0b	0b
6 (emasculated)	GA ₄₊₇ (500)	Ovaries	53abc	51a	45a	32a	29a
7 (emasculated)	GA ₁₃ (500)	Ovaries	53abc	27a	0c	0b	0b
8 (emasculated)	GA ₃ (500)	Ovaries	67ab	58a	18b	4b	0b
9 (emasculated)	GA ₃ (500)	Ovaries and young shoots	70a	58a	51a	33a	23a
10 (emasculated)	GA ₃ (500)	Young shoots	41cd	4b	0c	0b	0b

* "Agral LN" (0.5%) was included with all hormone treatments.

† Full bloom was on September 12, 1967.

Analyses (not presented) of the data for fruit growth indicated that all treatments where gibberellins were applied to ovaries or to petals and sepals significantly increased fruit size 27 days after full bloom, but GA₃ applied to shoots only and all other treatments, including zeatin, were without effect. These latter data are not included in Figure 1. There were no significant fruit-size differences between GA₄₊₇ applied to ovaries and GA₃ applied to ovaries and shoots and the graph of the former only is shown. Despite the early stimulation to fruit growth the two successful treatments produced fruits whose final diameter was only 60% of control. Although seedless their overall shape was not unusual. They ripened about 1 week earlier than untreated, open-pollinated fruits.

Gibberellin applications in all cases induced elongated shoot growth, although the stimulation by GA₁₃ was less than by GA₃ or GA₄₊₇. This increased growth occurred even when the gibberellin was applied only to ovaries and not to young shoots.

IV. DISCUSSION

Considerable increase in our knowledge of the role of hormones in fruit growth has been gained in recent years. To explain the fact that either auxin, gibberellin, or cytokinin can promote parthenocarpic development in certain fruits, Crane and van Overbeek (1965) proposed that regulators synthesized in the seed "trigger mobilization into the fruits of metabolites that are produced in other parts of the plant". More recent work generally supports this view, although two further points can now be made. Firstly, it seems that the ultimate attraction for metabolites comes from auxin, although gibberellin and cytokinin may promote this effect.

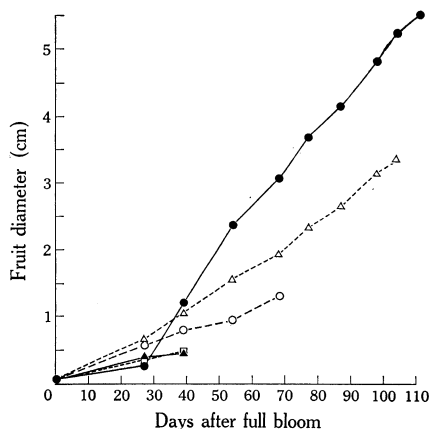


Fig. 1.—Effect of gibberellins on fruit diameters in emasculated and non-emasculated plum. ● Not emasculated, untreated. △ Emasculated, GA₄₊₇ to ovaries. ○ Emasculated, GA₃ to ovaries. □ Not emasculated, GA₃ to petals and sepals. ▲ Emasculated, GA₁₃ to ovaries.

Thus, when 3-indolylacetic acid was applied to the peduncles of *Phaseolus vulgaris* from which the fruit had been removed, ³²P- and ¹⁴C-labelled photosynthates were attracted to the treated stump. Kinetin and GA₃ alone provided no attraction but each enhanced the effect of the auxin, and the maximum effect was achieved by the three applied together (Seth and Wareing 1967). Gibberellins and cytokinins could affect this system by specific effects on auxin. For example, GA₃ may enhance auxin production (Valdovinos and Ernest 1967), and kinetin (Davies, Seth, and Wareing 1966) and GA₃ (Pilet 1965) may promote auxin movement. Secondly, it now appears likely that the seed is not entirely responsible for the synthesis of regulators in the fruits. Work with apricots (Jackson and Coombe 1966) and peaches (Jackson 1968) has shown that the seed as a source of gibberellin is superseded by the mesocarp later in the season, and this period coincides with the time at which the seed of peach may be artificially destroyed without deleteriously affecting fruit growth (Tukey 1936).

The following suggested role of hormones in stone fruit growth is an elaboration of earlier hypotheses by Crane and van Overbeek (1965) and Jackson (1968).

Immediately after flowering intense competition for reserve metabolites exists between developing ovaries and vegetative shoots. High gibberellin concentrations in the seeds possibly assists production of auxin in, or its movement to, the surrounding tissues. This auxin attracts metabolites in competition with surrounding shoots.

The production of gibberellin in the seed is associated with rapid cell expansion in its component tissues (Jackson 1968). For about 30 days after flowering seed growth in Sultan plum is primarily due to the nucellus, a tissue present at flowering and not reliant on fertilization for its continued development; after this time expansion results from growth of fertilization-dependent endosperm and embryo. This explains why, in these experiments, most fruits dropped between 27 and 39 days unless supplied with gibberellin (Table 1). It seems clear that gibberellin produced by the nucellus is responsible for growth of ovaries during and immediately after flowering, that applied gibberellin will enhance this effect, and that failing fertilization this gibberellin will partially replace the promotive effects of gibberellin normally produced in the endosperm and embryo of fertilized fruits (Fig. 1).

The necessity of applying hormones directly to the ovary, clearly indicated by the present experiments, is now obvious; gibberellin applied to other parts of the tree will promote movement of metabolites to these areas possibly at the expense of the fruits. This may be one reason why many attempts to induce parthenocarp have failed; another reason suggested by the present experiments is that the type of hormone may be quite specific for each plant. Thus, in the plum the GA₄₊₇ mixture was most effective, GA₃ was less so, and GA₁₃ was almost without effect.

The presence of seeds or an application of hormone is mandatory early in the growth of stone fruits. Later, as shoot growth is reduced and leaves begin to export photosynthates, competition becomes less and hormones produced in the mesocarp are adequate to attract metabolites to this tissue.

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VI. REFERENCES

- BATJER, L. P., BILLINGSLEY, H. D., WESTWOOD, M. N., and ROGERS, B. L. (1957).—Predicting harvest size of apples at different times during the growing season. *Proc. Am. Soc. hort. Sci.* **70**, 46–57.
- CRANE, J. C. (1964).—Growth substances in fruit setting and development. *A. Rev. Pl. Physiol.* **15**, 303–26.
- CRANE, J. C., and OVERBEEK, J. VAN (1965).—Kinin-induced parthenocarp in the fig, *Ficus carica* L. *Science, N.Y.* **147**, 1468–9.
- DAVIES, C. R., SETH, A. K., and WAREING, P. F. (1966).—Auxin and kinetin interaction in apical dominance. *Science, N.Y.* **151**, 468–9.
- JACKSON, D. I. (1968).—Gibberellin and the growth of peach and apricot fruits. *Aust. J. biol. Sci.* **21**, 209–15.
- JACKSON, D. I., and COOMBE, B. G. (1966).—Gibberellin-like substances in the developing apricot fruit. *Science, N.Y.* **154**, 277–8.
- PILET, P. E. (1965).—Action of gibberellic acid on auxin transport. *Nature, Lond.* **208**, 1344–5.
- SETH, A. K., and WAREING, P. F. (1967).—Hormone-directed transport of metabolites and its possible role in plant senescence. *J. exp. Bot.* **18**, 65–77.
- TUKEY, H. B. (1936).—Development of cherry and peach fruits as affected by destruction of the embryo. *Bot. Gaz.* **98**, 1–24.
- VALDOVINOS, J. G., and ERNEST, L. C. (1967).—Effect of gibberellic acid and cyclocel on tryptophan metabolism and auxin destruction in the sunflower seedling. *Physiologia Pl.* **20**, 682–7.